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PROCEEDINGS - VOLUME I

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EBES aims to bring worldwide researchers and professionals together through organizing conferences and publishing academic journals, and increase economics, finance, and business knowledge through academic discussions. Any scholar or professional interested in economics, finance, and business is welcome to attend EBES conferences. Since our first conference in 2009, around *20,081* colleagues from *102* countries have joined our conferences, and *10,669* academic papers have been presented. *EBES has reached 3,488 members from 87 countries.*

Since 2011, EBES has been publishing two journals. One of those journals, ***Eurasian Business Review*** - *EABR*, is in the fields of industrial organization, innovation and management science, and the other one, ***Eurasian Economic Review*** - *EAER*, is in the fields of applied macroeconomics and finance. Both journals are published quarterly by ***Springer*** and indexed in ***Scopus***. In addition, EAER is indexed in the ***Emerging Sources Citation Index*** (*Clarivate Analytics*) and EABR is indexed in the ***Social Science Citation Index (SSCI)***. EABR's 2024 CiteScore is 7.8 (Q1) & 2024 JCR IF is 3.5 (Q1). EAER's 2024 CiteScore is 5.4 (Q1) & 2024 JCR IF 2024 is 2.3 (Q2).

Furthermore, since 2014, Springer has started to publish a new conference proceedings series (***Eurasian Studies in Business and Economics****),* which includes selected papers from the EBES conferences. The series has been recently indexed by **SCOPUS**. In addition, the 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22nd, 23rd, 24th, 25th, 26th & 27th, 28th, 29th (Vol. 1), 30th, 33rd, and 34th EBES Conference Proceedings have already been accepted for inclusion in the ***Conference Proceedings Citation Index - Social Science & Humanities (CPCI-SSH).*** Other conference proceedings are in progress.

On behalf of all EBES officers, I sincerely thank you for all your support in the past. We look forward to seeing you at our forthcoming conferences. We very much welcome your comments and suggestions in order to improve our future events. Our success is only possible with your valuable feedback and support!

I hope you enjoy the conference!

With my very best wishes,

Klaus F. ZIMMERMANN
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Welcome to the 52nd EBES Conference

We are excited to organize our 52nd EBES Conference, which will take place on July 3rd, 4th, and 5th, 2025, in Istanbul, Türkiye. The conference is hosted by Bahçeşehir University, Istanbul, Türkiye. The conference will be hybrid (with two days in person), allowing participants to join the conference in person or *virtually.*

We are honored to have received top-tier papers from distinguished scholars from all over the world. We regret that we were unable to accept more papers. 215 papers will be presented, and 471 colleagues from 59 countries will attend the conference. We are pleased to announce that distinguished colleagues **Justin Yifu Lin** from Peking University, China; **Marco Vivarelli** from Università Cattolica del Sacro Cuore in Milano, Italy; **Wolfgang Karl Härdle** from Humboldt-Universität zu Berlin, Germany; and **Klaus F. Zimmermann** from EBES & GLO & UNU-MERIT, The Netherlands & Free University Berlin, Germany will join the conference as invited keynote speakers.

Throughout the years, EBES conferences have been an intellectual hub for academic discussion. Participants have found it an excellent opportunity to present new research, exchange information, and discuss current issues. We believe our future conferences will further improve knowledge development in our fields. In addition, based on the paper's contribution to the field, the *EBES Award Committee* has selected one of the papers for the *John P. Rust Best Paper Award* sponsored by *Springer Nature*. The *Best Paper Award* winner will be announced during the conference. EBES Executive Board decided to give *2025 EBES Fellow* to **Justin Yifu Lin** from Peking University, China.

On behalf of EBES, I would like to thank all presenters, participants, board members, and keynote speakers. I am looking forward to meeting you at the conference and seeing you all again at the upcoming EBES conferences.

Best regards,

Ender Demir, PhD
Conference Coordinator

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Intangible Capital, Financial Friction and the Laffer Curve

Kazuki Hiraga[1]
Xinyu Ma[2]

Abstract

This research investigates how the shapes of Laffer curves for income and corporate tax affects the financial friction which arises from collateral constraint and uncollateralized intangible capital. We are particularly interested in analyzing the extent to which the shape of the Laffer curve and peak tax revenues are affected by the degree of imperfections in financial markets and the increased contribution of production to intangible capital. We find that the peak tax rate and maximum tax revenue changes as the financial market imperfection does.

Key words: Laffer curve, financial friction, tangible and intangible capital
JEL Classification Code: E60, H20, E44

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1. Introduction

This research investigates how the shapes of Laffer curves for income and corporate tax affects the financial friction which arises from collateral constraint and uncollateralized intangible capital. We are particularly interested in analyzing the extent to which the shape of the Laffer curve and peak tax revenues are affected by the degree of imperfections in financial markets and the increased contribution of production to intangible capital.

This study analyzes the shape of the Laffer Curve and its impact on the tax revenue structure in a dynamic general equilibrium model that includes financial market imperfections and non-collateralizable intangible capital. The main results are two-fold. First, Laffer Curves for corporate and labor income taxes are hump-shaped, but that for capital income tax monotonically increasing.

There exists a related literature which discuss the Laffer curve in new classical growth framework (Trabandt and Uhlig (2011), Strulik and Trimborn (2012) and Hiraga and Nutahara (2022)). Tax policy focused on intangible capital, Quadrini and Rios-Rull(2023) studies the international tax competition model with intangible capital which the governments use profit (corporate) of income taxes in two-country model. This paper differs from this literature in that we discuss the role of intangible capital and financial friction.

The second strand of the literature to which our work is relevant focuses on intangible capital. Corrado et al.(2009) and Corrado and Hulten (2010) document a secular increase in the aggregate investment of intangible capital in the U.S. since the 1950s. Hall (2001) and McGrattan and Prescott (2012) use the stock market and aggregate accounting data to infer from a standard investment model the dynamics of intangible capital in the U.S. As for Japan, Arato and Yamada (2012) estimates the intangible capital stock owned by companies from financial statement data, and report Japan's ratio of intangible capital to tangible capital as being close to the ratios estimated for the United States and the United Kingdom. Falato et al. (2013) study external financing and cash holdings using a model featuring both financial frictions and investment in intangible assets, while Chen (2014) analyzes the effects of asset intangibility on firm dynamics when endogenous financial constraints are present. Finally, Lopez and Oliveira (2018) studies the role of intangible capital in the transmission of financial shocks in a general equilibrium model with two types of capital, tangible and intangible, and labor and financial frictions. This paper differs from this literature in that we discuss about the Laffer curve.

This paper is organized as follow. Section 2 explains the dynamic general equilibrium model with two-agents and two-types of capitals. Section 3 analyzes the model at steady-states with respect to changes in corporate, labor and capital income taxes. Section 4 shows the numerical simulation and discussed policy implication. Section 5 concludes.

2. The Model

We use the dynamic general equilibrium model with two-agents (entrepreneur and worker) and two-types of capitals (tangible and intangible) following. Our model introduces four tax instruments: labor and capital income (τ_t^w and τ_t^r), corporate and consumption taxes (τ_t^E and τ_t^c, respectively).

2.1. Entrepreneurs

Each entrepreneur owns capital and produce final goods that combined the former with labor. We distinguish between two types of capital, tangible and intangible, which we denote $K_{T,t}$ and $K_{I,t}$, receptively. This distinction becomes relevant when discussing the borrowing problem of entrepreneurs which only tangible capital is used as collateral. The involved in the production of the final good is denoted by n_t. Each entrepreneur has the constant returns to scale production technology exhibits as follow:

$$F\left(K_{T,t}, K_{I,t}, n_t\right) = Z_t K_{T,t}^{\alpha_{K_T}} K_{I,t}^{\alpha_{K_I}} n_t^{1-\alpha_{K_T}-\alpha_{K_I}}, \quad (1)$$

where the α_{K_T} and α_{K_I} are the income shares of tangible and intangible capital, respectively and Z_t is aggregate productivity[3].

Entrepreneurs maximize their expected discounted flow of instantaneous utility, derived from consumption, c_t^E, by choosing their investment in tangible and intangible capital, the number of vacancies, and the amount of households' external funds, B_{t+1}, at an interest rate r_t. Entrepreneurs are borrowing constrained and relatively impatient, as their discount factor, denoted by γ, is smaller than the representative household's discount factor, denoted by β.

The optimization problem of an entrepreneur is thus summarized as:

$$\max_{c_t^E, K_{T,t+1}, K_{I,t+1}, B_{t+1}} E_0 \sum_{t=0}^{\infty} \gamma^t \, log(c_t^E) \quad (2)$$

subject to the budget (Eq. (3)) and borrowing constrains (Eq. (4)):

[3] We assume $Z_t = 1$.

$$(1+\tau_t^c)c_t^E + K_{T,t+1} - K_{T,t}$$
$$= (1-\tau_t^E)\left[Y_t - r_t B_t - K_{I,t+1} + (1-\delta_I)K_{I,t} - \delta_T K_{T,t} - W_t n_t\right] + B_{t+1} - B_t, \quad (3)$$
$$(1+r_{t+1})B_{t+1} \leq \chi K_{T,t+1}, \quad (4)$$

where τ_t^c is consumption tax rate, τ_t^E is corporate tax rate, δ_T and δ_I are depreciation rate o tangible and intangible capitals, and χ is collateralized ratio of tangible capital, respectively.

In calculating corporate profits for accounting purposes in Eq. (3), two points should be noted. First, all net investments in intangible capital are expensed, but only capital depletion is included for tangible capital. Second, interest payments on borrowing is expensed.

Let μ_t be the multiplier associated with the borrowing constraint (equation (4)). The Euler equation for tangible investment is described by:

$$1 - \mu_t \chi_t = \gamma E_t \left[\frac{(1+\tau_t^c)c_t^E}{(1+\tau_{t+1}^c)c_{t+1}^E}\left((1-\tau_{t+1}^E)(r_{T,t+1} - \delta_T) + 1\right)\right] \quad (5)$$

where $r_{T,t+1}$ is the return on tangible capital, in terms of the final good, and it is defined by the tangible capital-output ratio: $r_{T,t+1} = \alpha_{K_T} Y_{t+1}/K_{T,t+1}$. Note that the borrowing constraint's multiplier directly affects tangible investment. In particular, whenever the constraint binds, entrepreneurs have an incentive to increase their tangible capital in order to relax their borrowing constraint.

The Euler equation for intangible capital is obtained as follow:

$$1 = \gamma E_t \left[\frac{(1+\tau_t^c)(1-\tau_{t+1}^E)c_t^E}{(1+\tau_{t+1}^c)(1-\tau_t^E)c_{t+1}^E}\left(r_{I,t+1} + 1 - \delta_I\right)\right], \quad (6)$$

where $r_{I,t+1}$ is the return on intangible capital, defined as: $r_{I,t+1} = \alpha_{K_I} Y_{t+1}/K_{I,t+1}$.

The Euler equation for debt can be written as:

$$\mu_t = \frac{1}{1+r_{t+1}} - \gamma E_t \frac{1+(1-\tau_{t+1}^E)r_{t+1}}{1+r_{t+1}}\left[\frac{c_t^E}{c_{t+1}^E}\right]. \quad (7)$$

Factor prices (wage and returns of tangible and intangible capitals) can be written as:

$$W_t = (1-\alpha_{K_T}-\alpha_{K_I})Z_t K_{T,t}^{\alpha_{K_T}} K_{I,t}^{\alpha_{K_I}} n_t^{-\alpha_{K_T}-\alpha_{K_I}}$$

$$r_{T,t+1} = \alpha_{K_T} Z_t K_{T,t}^{\alpha_{K_T}-1} K_{I,t}^{\alpha_{K_I}} n_t^{1-\alpha_{K_T}-\alpha_{K_I}},$$

$$r_{I,t+1} = \alpha_{K_I} Z_t K_{T,t}^{\alpha_{K_T}} K_{I,t}^{\alpha_{K_I}-1} n_t^{1-\alpha_{K_T}-\alpha_{K_I}}.$$

2.2. (Representative) Households

There is a representative household composed of a unit measure of infinitely lived individuals with the same preferences for consumption and leisure (the disutility of working). The representative household supplies funds to entrepreneurs in the form of non-contingent one-period bonds, D_t. There is a household-level budget constraint, which states that the consumption of all family members, ct, and the amount of funds supplied to firms should be equal to the total labor income of the household plus the return on the previous period's bond holdings.

The optimization problem of the representative household can be written as:

$$\max_{c_t, n_t, D_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t \left[log(c_t) - \varphi \frac{n_t^{1+\theta}}{1+\theta} \right] \quad (8)$$

subject to the household's budget constraint:

$$(1+\tau_t^c)\, c_t + D_{t+1} = (1-\tau_t^w) W_t n_t + (1+(1-\tau_t^r) r_t) D_t \quad (9)$$

The first-order optimal condition for the household problem is summarized by the standard Euler equation and intra-temporal optimal condition as follows:

$$1 = \beta E_t \left[\frac{(1+\tau_t^c) c_t}{(1+\tau_{t+1}^c) c_{t+1}} (1+(1-\tau_{t+1}^r) r_{t+1}) \right] \quad (10)$$

$$c_t = \frac{(1-\tau_t^w) W_t}{\varphi (1+\tau_t^c) n_t^{\theta}}. \quad (11)$$

2.3. Government

The government collect tax revenue for (wasteful or independent of agents' behavior) government consumption G_t:

$$\tau_t^c (c_t^E + c_t) + \tau_t^w W_t n_t + \tau_t^r r_t D_t + \tau_t^E \left[Y_t - r_t B_t - K_{I,t+1} + (1-\delta_I) K_{I,t} - \delta_T K_{T,t} - W_t n_t \right] = G_t \quad (12)$$

2.4. Equilibrium

An equilibrium in this economy is defined by a sequence of prices and allocations to the household and entrepreneurs, such that these allocations are optimal and markets clear:

$$D_{t+1} = B_{t+1} \quad (13)$$

$$c_t^E + c_t + K_{T,t+1} - (1-\delta_T) K_{T,t} + K_{I,t+1} - (1-\delta_I) K_{I,t} + G_t = Z_t K_{T,t}^{\alpha_{K_T}} K_{I,t}^{\alpha_{K_I}} n_t^{1-\alpha_{K_T}-\alpha_{K_I}}. \quad (14)$$

2.5. Steady State

This paper mainly focuses on the steady-state Laffer curves on each tax

instruments. Therefore, we solve the explicitly solutions of the steady-state values as follows:

$$1 = \beta[(1 + (1 - \tau^r)r)] \Rightarrow r = \frac{1-\beta}{\beta(1-\tau^r)} \quad (15)$$

$$\mu = \frac{1}{1+r} - \gamma\frac{1+(1-\tau^E)r}{1+r} = \frac{\beta(1-\gamma)(1-\tau^r) - (1-\beta)\gamma(1-\tau^E)}{1-\beta\tau^r} \quad (16)$$

$$1 = \gamma\left[\left(\alpha_{K_I} Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}-1} + 1 - \delta_I\right)\right] \quad (17)$$

$$1 - \mu\chi = \gamma\left[(1-\tau^E)\left(\alpha_{K_T} Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}-1}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}} - \delta_T\right) + 1\right] \quad (18)$$

$$\frac{K_I}{n} = \left[\frac{Z\alpha_{K_T}\gamma(1-\tau^E)}{1-\gamma+\gamma(1-\tau^E)\delta_T - \mu\chi}\right]^{\frac{\alpha_{K_T}}{1-\alpha_{K_T}-\alpha_{K_I}}} \times \left[\frac{\gamma Z\alpha_{K_I}}{1-\gamma(1-\delta_I)}\right]^{\frac{1-\alpha_{K_T}}{1-\alpha_{K_T}-\alpha_{K_I}}}, \quad (19)$$

$$\frac{K_T}{n} = \left[\frac{Z\alpha_{K_T}\gamma(1-\tau^E)}{1-\gamma+\gamma(1-\tau^E)\delta_T - \mu\chi}\right]^{\frac{1-\alpha_{K_I}}{1-\alpha_{K_T}-\alpha_{K_I}}} \times \left[\frac{\gamma Z\alpha_{K_I}}{1-\gamma(1-\delta_I)}\right]^{\frac{-\alpha_{K_I}}{1-\alpha_{K_T}-\alpha_{K_I}}} \quad (20)$$

$$(1+\tau^c)\frac{c}{n} = \left(1-\alpha_{K_T}-\alpha_{K_I}\right)(1-\tau^w)Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}} + \frac{(1-\beta)\chi}{1-\beta\tau^r}\frac{K_T}{n}, \quad (21)$$

$$n = \left[\frac{(1-\tau^w)(1-\alpha_{K_T}-\alpha_{K_I})\,Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}}}{\varphi\left\{\left(1-\alpha_{K_T}-\alpha_{K_I}\right)(1-\tau^w)Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}} + \frac{(1-\beta)\chi}{1-\beta\tau^r}\frac{K_T}{n}\right\}}\right]^{\frac{1}{1+\theta}}. \quad (22)$$

We obtain the analytical solution of each and aggregate tax revenues at the steady-state value and calibrate the long-run (steady-state) Laffer curves. As entrepreneurs cannot commit to repaying their loans, they can only borrow up to the point where repayment equals a fraction χ of the total value of their tangible capital. We find that the there is positive value of steady-states under $1-\gamma+\gamma(1-\tau^E)\delta_T - \mu\chi > 0 \Rightarrow \chi < \frac{\gamma(1-\tau^E)(1-\tau^r\beta)\delta_T}{\beta(1-\tau^r)-\gamma(1-\tau^E)(1-\tau^r\beta)}$. Therefore, collateral ratio χ cannot be large in this model.

3. Analysis of the Model

In this section, we analytically investigate the effects of tax changes on economic variables and tax revenue at the steady-states. As for each tax base elasticities of their tax rate as follows:

Labor income Tax $\frac{\partial lnwn}{\partial ln\tau^w} = \frac{\partial lnw}{\partial ln\tau^w} + \frac{\partial lnn}{\partial ln\tau^w}$

Capital income Tax $\frac{\partial lnrD}{\partial ln\tau^r} = \frac{\partial lnr}{\partial ln\tau^r} + \frac{\partial lnD}{\partial ln\tau^r} = \frac{\partial lnr}{\partial ln\tau^r} + \frac{\partial lnK_T}{\partial ln\tau^r} = \frac{\partial lnr}{\partial ln\tau^r} + \frac{\partial ln\left(\frac{K_T}{n}\right)}{\partial ln\tau^r} + \frac{\partial lnn}{\partial ln\tau^r}$

Corporate Tax $\frac{\partial ln\pi}{\partial ln\tau^E} = \frac{\partial \ln\left(\left(1-\alpha_{K_T}-\alpha_{K_I}\right)Y-\delta_I K_I-(\delta_T+\chi)K_T\right)}{\partial ln\tau^r}$.

3.1. Effect of Labor Income Tax Change

First of all, the partial derivative of labor supply by the labor income tax rate is expressed as in Eq. (23).

$$\frac{\partial lnn}{\partial ln\tau^w} = -\frac{\tau^w}{(1-\tau^w)(1+\theta)} \frac{\left(1-\alpha_{K_T}-\alpha_{K_I}\right)\tau^w Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}} - \frac{(1-\beta)(1-\tau^r)\chi}{1-\beta\tau^r}\frac{K_T}{n}}{\left[\left(1-\alpha_{K_T}-\alpha_{K_I}\right)(1-\tau^w)Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}} + \frac{(1-\beta)(1-\tau^r)\chi}{1-\beta\tau^r}\frac{K_T}{n}\right]}. \quad (23)$$

Tangible and intangible capital stocks per unit of labor are independent of labor income tax rate. Therefore, Since the labor income tax elasticity of the tax base exceeds 1 in the range $0 < \tau^w < 1$, the Laffer curve for labor income tax is always hump-shaped.

3.2. Effect of Capital Income Tax Change

The partial derivative of labor supply by the capital income tax rate is expressed as in Eq. (24).

$$\frac{\partial lnn}{\partial ln\tau^r} = -\frac{(1-\beta)^2\chi\frac{K_T}{n}\tau^r}{(1+\theta)(1-\beta\tau^r)^2\left[\left(1-\alpha_{K_T}-\alpha_{K_I}\right)(1-\tau^w)Z\left(\frac{K_T}{n}\right)^{\alpha_{K_T}}\left(\frac{K_I}{n}\right)^{\alpha_{K_I}} + \frac{(1-\beta)(1-\tau^r)\chi}{1-\beta\tau^r}\frac{K_T}{n}\right]}. \quad (24)$$

Tangible and intangible capital stocks per unit of labor are independent of labor income tax rate. The tax elasticity of capital income tax is written as:

$$\frac{\partial \ln(\tau^r r D)}{\partial ln\tau^r} = 1 + \frac{\partial \ln r}{\partial ln\tau^r} + \frac{\partial lnn}{\partial ln\tau^r}$$

$$= 1 + \frac{\tau^r}{1-\tau^r}$$

$$- \frac{(1-\beta)^2 \chi \frac{K_T}{n} \tau^r}{(1+\theta)(1-\beta\tau^r)^2 \left[(1-\alpha_{K_T}-\alpha_{K_I})(1-\tau^w) Z \left(\frac{K_T}{n}\right)^{\alpha_{K_T}} \left(\frac{K_I}{n}\right)^{\alpha_{K_I}} + \frac{(1-\beta)(1-\tau^r)\chi}{1-\beta\tau^r} \frac{K_T}{n} \right]}. \quad (25)$$

In Eq.(25), second term shows the tax elasticity of interest rate and goes to infinite as $\tau^r \to 1$. On the other hand, $\frac{\partial lnn}{\partial ln\tau^r}$ converges to finite value as $\tau^r \to 1$. Therefore, the Laffer curve for capital income tax is monotonically increasing when Eq.(4) binds (i.e. μ>0).

3.3. Effect of Corporate Tax Change

The partial derivatives of tangible and intangible capitals and labor supply by the corporate tax rate is expressed as in Eq. (26), (27) and (28).

$$\frac{\partial ln\left(\frac{K_I}{n}\right)}{\partial ln\tau^E} = -\frac{\tau^E}{1-\tau^E} \frac{\alpha_{K_T}(1-\gamma)}{(1-\alpha_{K_T}-\alpha_{K_I})(1-\gamma+\gamma(1-\tau^E)\delta_T - \mu\chi)}, \quad (26)$$

$$\frac{\partial ln\left(\frac{K_T}{n}\right)}{\partial ln\tau^E} = -\frac{\tau^E}{1-\tau^E} \frac{\alpha_{K_T}(1-\alpha_{K_I})(1-\gamma)}{(1-\alpha_{K_T}-\alpha_{K_I})(1-\gamma+\gamma(1-\tau^E)\delta_T - \mu\chi)}, \quad (27)$$

$$\frac{\partial lnn}{\partial ln\tau^E}$$

$$= \frac{\begin{array}{c}\left[1-(1-\alpha_{K_T}-\alpha_{K_I})(1-\tau^w) Z \left(\frac{K_T}{n}\right)^{\alpha_{K_T}} \left(\frac{K_I}{n}\right)^{\alpha_{K_I}}\right] \\ \times \left[\alpha_{K_T} \frac{\partial ln\left(\frac{K_T}{n}\right)}{\partial ln\tau^E} + \alpha_{K_I} \frac{\partial ln\left(\frac{K_I}{n}\right)}{\partial ln\tau^E}\right] - \frac{(1-\beta)(1-\tau^r)\chi}{1-\beta\tau^r} \frac{K_T}{n} \frac{\partial ln\left(\frac{K_T}{n}\right)}{\partial ln\tau^E}\end{array}}{(1+\theta)(1-\beta\tau^r)^2 \left[(1-\alpha_{K_T}-\alpha_{K_I})(1-\tau^w) Z \left(\frac{K_T}{n}\right)^{\alpha_{K_T}} \left(\frac{K_I}{n}\right)^{\alpha_{K_I}} + \frac{(1-\beta)(1-\tau^r)\chi}{1-\beta\tau^r} \frac{K_T}{n} \right]}. \quad (28)$$

The signs of Eq. (26) and (27) depend on the sign of $(1-\gamma+\gamma(1-\tau^E)\delta_T - \mu\chi)$.

4. Numerical Simulation

In this section, we numerically analyze the structural parameters as follows. Table 1 shows some calibrated structural parameters which refer to the annualized parameters in Lopez and Oliveira (2018). As for the parameters of labor supply (

φ *and* θ), θ sets the inverse of Frisch elasticity is one and φ is set so that the labor supply of the benchmark is 0.25. Table 2 shows the benchmark's tax rates in our model. Finally, the fraction of collateralized capital χ is set to 0.05 as a benchmark[4].

We investigate Laffer curve for corporate and income tax not only each tax revenue, but also total (corporate, income and consumption) tax revenue. The aim of this paper is relative comparison of each tax change, we set the benchmark tax revenue to one.

β	0.988
γ	0.885
φ	9.7
θ	1
α^{K_T}	0.25
α^{K_I}	0.015
δ_T	0.028
δ_I	0.064

[4] χ=0.05 is much smaller value than other literatures which calibrated. This is because range of χ which satisfies positive value of steady-states (i.e. $\chi < \frac{\gamma(1-\tau^E)(1-\tau^r\beta)\delta_T}{\beta(1-\tau^r)-\gamma(1-\tau^E)(1-\tau^r\beta)}$) is narrow.

τ^{E*}	0.29
τ^{w*}	0.2
τ^{r*}	0.2
τ^{c*}	0.1

4.1. Laffer Curves in the benchmark

Figure 1 and 2 show the Laffer curve for corporate and labor income taxes in both each tax and total tax revenues. We find that both Laffer curves are hump-shaped.

Figure 1. Laffer Curve for Corporate Tax in the benchmark

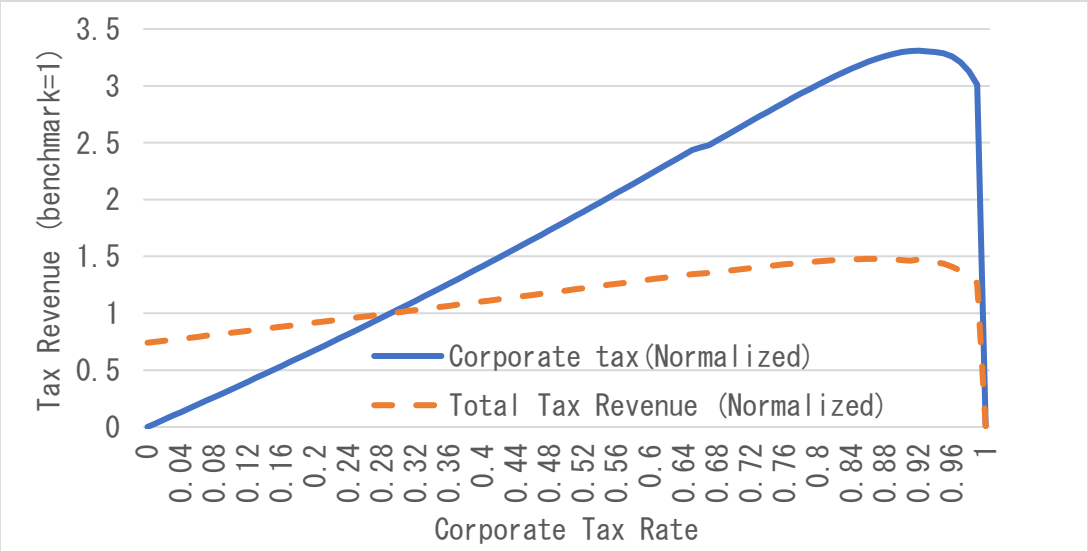


Figure 2. Laffer Curve for Labor Income Tax in the benchmark

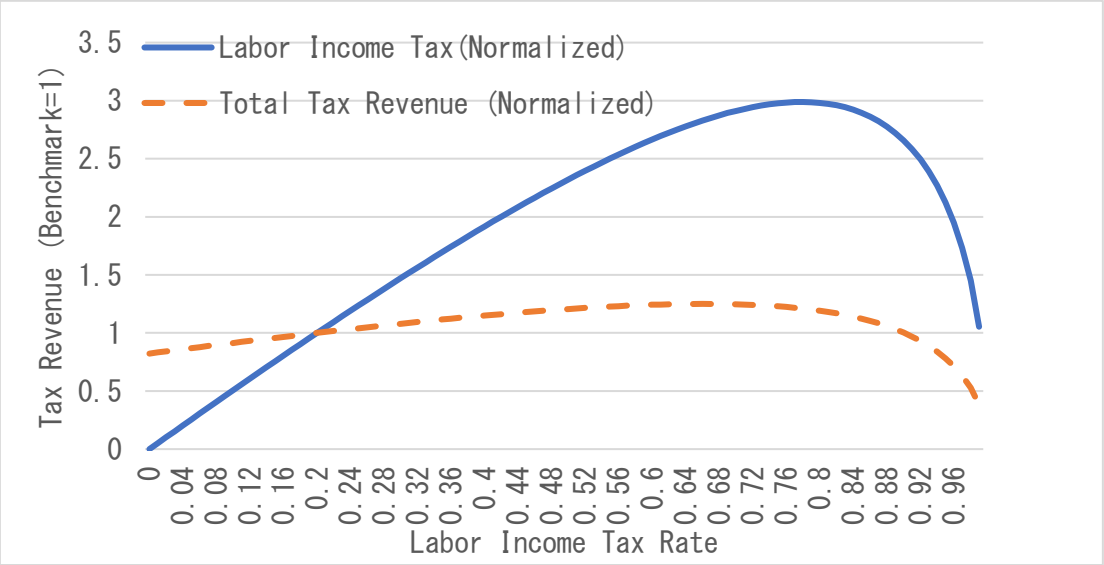
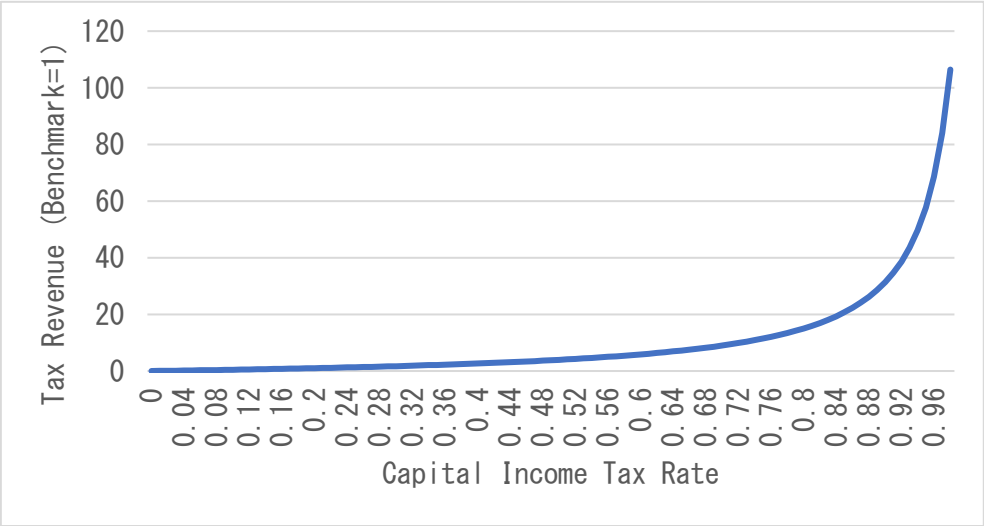


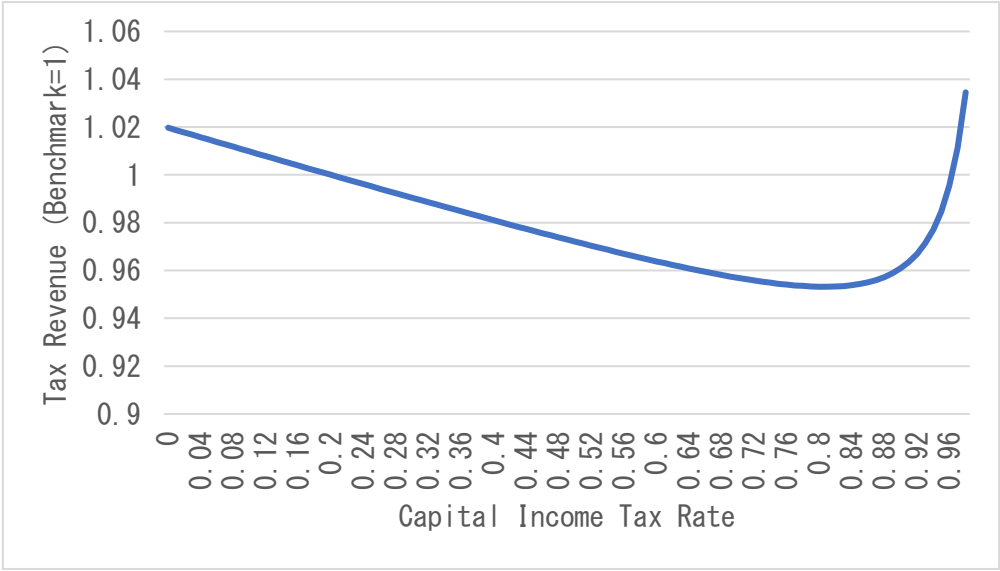
Figure 3 and 4 show the Laffer curve for capital income tax is not hump-shaped. In Figure 3, capital income tax revenue is monotonically increasing, because the elasticity of labor income tax base is less than one. On the other hand, Laffer curve of total tax revenue is U-shaped, because the magnitude of reduction on other tax revenue (corporate, labor income and consumption tax) is relatively large when capital income tax rate is small and the magnitude of increase in capital income tax is dominate to some finite capital income tax rate.

Figure 3. Laffer Curve for Capital Income Tax in the benchmark (Capital Income Tax Revenue)



(Note) This simulation show the case in Eq.(4) is binding.

Figure 4. Laffer Curve for Capital Income Tax in the benchmark (Total Tax Revenue)



(Note) This simulation show the case in Eq.(4) is binding.

4.2. Degree of Financial Friction and Laffer Curve

In this subsection, we compare with two alternative cases; fraction of collateralized tangible capital is higher (χ=0.12) and lower (χ=0.01).

Figure 5 and 6 show the Laffer curves for corporate tax in the case of higher collateralization (Figure 5) and lower (Figure 6). As we can see, the peak tax

rate and its tax revenue is higher when the financial friction is more severe. This result comes from the role of debt repayment as a cost channel. The entrepreneurs have an incentive to borrow as they can do because debt repayment is cost which reduces the corporate tax burden. Therefore, higher χ increases elasticity of tax base and decreases its peak tax rate and maximizing tax revenue. Figure 7 and 8 show the Laffer Curves for labor income tax in the case of higher collateralization (Figure 7) and lower (Figure 8). Figure 9 and 10 show the Laffer Curves for capital income tax on capital income tax revenue (Figure 9) and total tax revenue (Figure 10). The feature of labor income tax is similar to that of corporate tax, while capital income tax seems not to be similar.

Figure 5. Laffer Curve for Corporate Tax (χ=0.12)

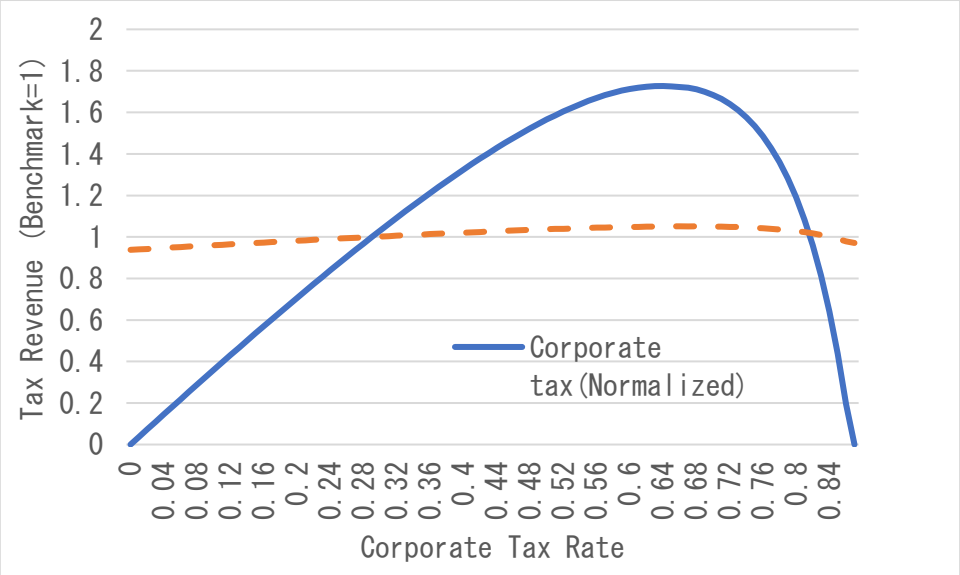


Figure 6. Laffer Curve for Corporate Tax (χ=0.01)

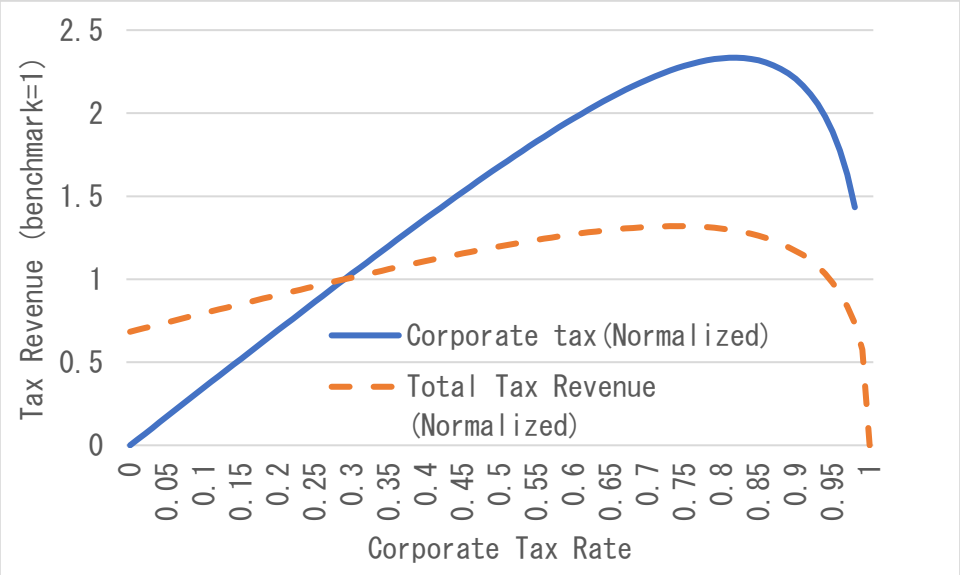


Figure 7. Laffer Curve for Labor Income Tax (χ=0.12)

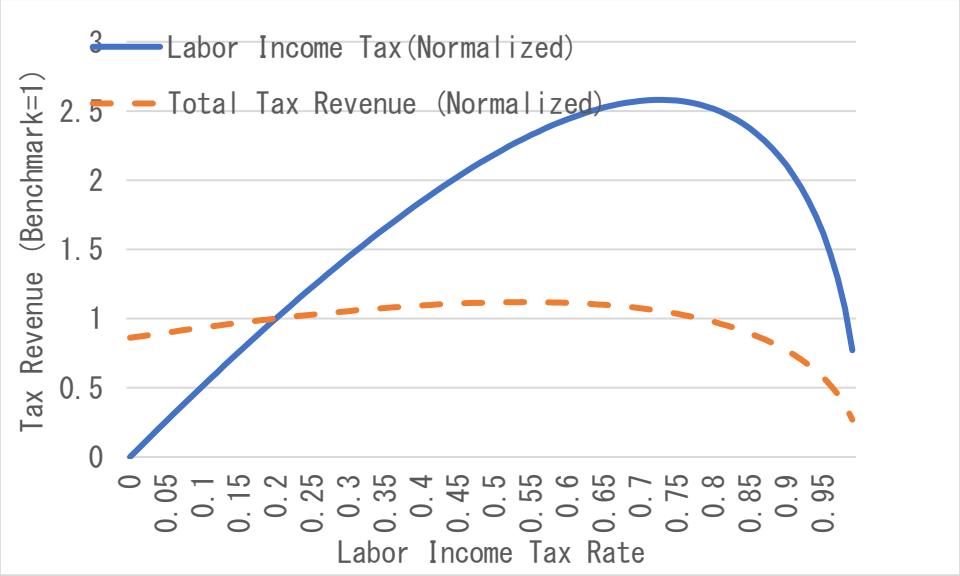


Figure 8. Laffer Curve for Labor Income Tax (χ=0.01)

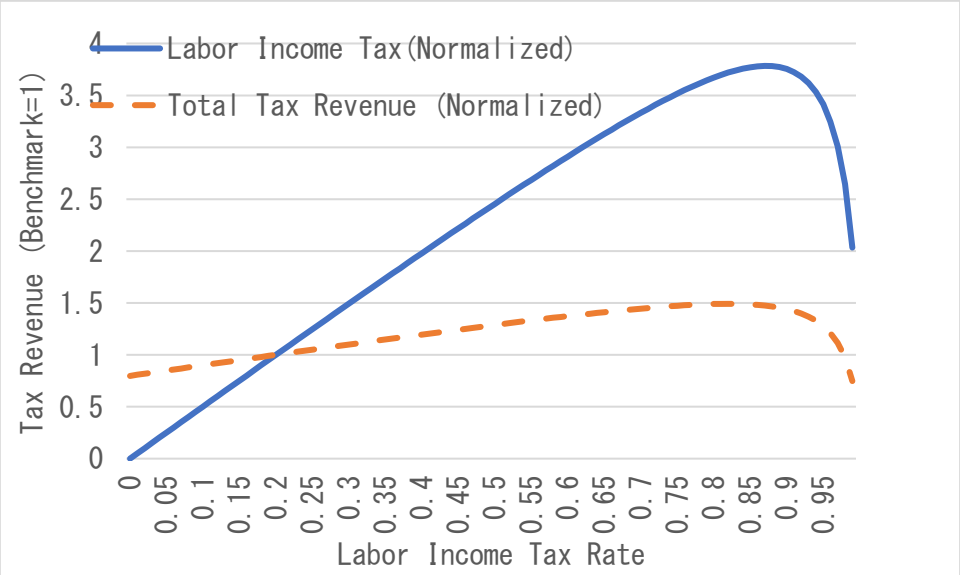


Figure 9. Laffer Curves for Capital Income Tax on Its Revenue

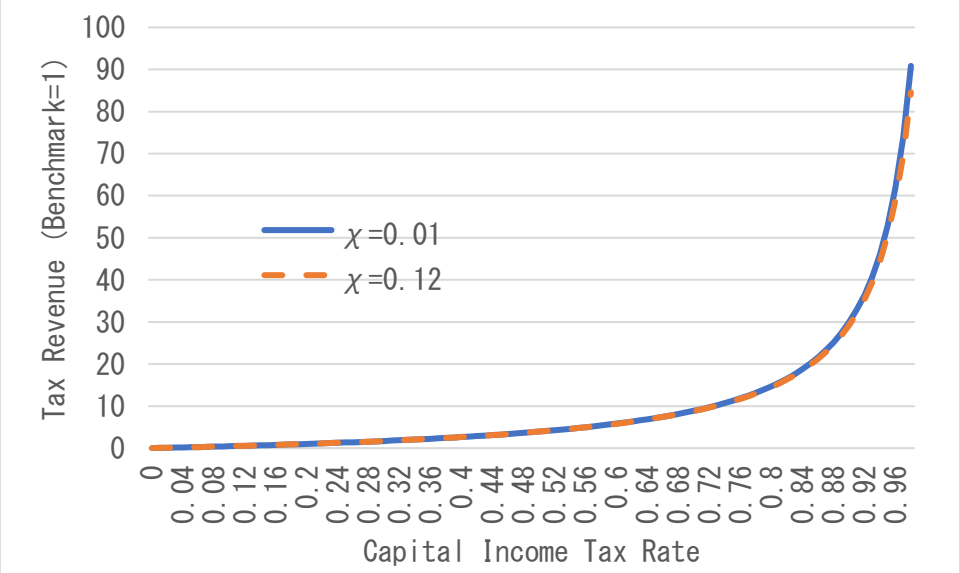
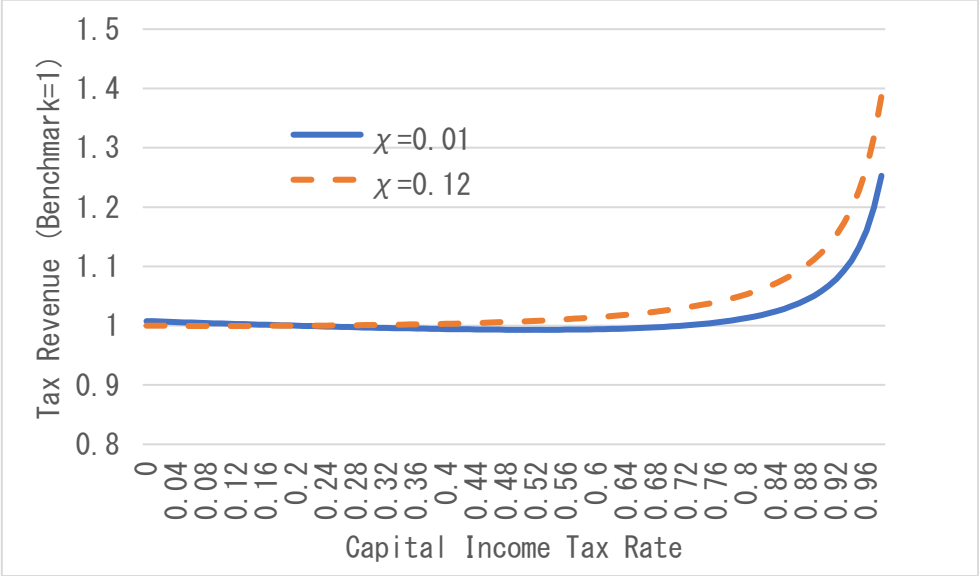


Figure 10. Laffer Curves for Capital Income Tax on Total Tax Revenue



4.3. Policy Implication

There are some policy implications in our numerical simulation, First, corporate tax may not be worse than other tax instruments. This implication comes from the financial friction and heterogeneity of the agent (e.g. lender (households) and borrower (entrepreneurs)). Second, the degree of financial friction affects the shape of Laffer curves. That is, relaxing financial friction decreases the maximizing tax revenue.

5. Conclusion

This study analyzes the shape of the Laffer Curve and its impact on the tax revenue structure in a dynamic general equilibrium model that includes financial market imperfections and non-collateralizable intangible capital. The main results are two-fold. First, Laffer Curves for corporate and labor income taxes are hump-shaped, but that for capital income tax monotonically increasing.

But as always there is plenty of room to extend the basic setup. For example, it would be interesting to induce the externality of intangible capital (e.g. R&D or knowledge spillover) and alternative government expenditure (e.g. transfer or productive public investment). We will deal with future works.

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Exploring the potential of Digital Tourism Innovations for Climate Change Adaptation in Zimbabwean rural communities in Manicaland Province.

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Abstract

The potential of digital tourism innovations as a tool for climate change adaptation in rural Zimbabwe is examined in this study. Zimbabwe's rural areas are especially susceptible to the negative consequences of climate change, such as droughts, floods, and temperature fluctuations, which endanger local businesses and agricultural livelihoods. As a supplementary economic activity, tourism presents chances for resilience development and diversification. Therefore, this study seeks to examine the current use and awareness of digital tourism innovations in rural communities, explore how digital solutions can contribute to climate change adaptation strategies and identify the opportunities and challenges of integrating digital tourism innovations into climate change adaptation efforts in rural communities located in Manicaland Province. This will help in unravelling the ways in which digital technologies, including mobile apps, internet platforms, augmented reality, and virtual reality, might improve tourist experiences, change tourism habits, and generate steady revenue streams for rural communities. In order to evaluate the uptake and effects of digital tourism solutions, the study used a mixed-methods approach that combines quantitative surveys with qualitative interviews with community stakeholders, tourism operators, and policymakers. From a population of 137 tourist attraction centres and tourist service providers, a sample of 102 respondents was selected using online Raosoft sample calculator. Structured questionnaires were used to collect quantitative data and personal interviews were used to collect qualitative data and were analysed using STATA and Nvivo respectively. The results reveal a positive and highly statistically significant influence the adoption of digital tourist innovations climate adaption efficiency. Recommendations suggest incorporating digital tourism into national climate adaption plans, encouraging community involvement, and expanding on successful technologies. This study adds to the conversation about climate resilience, digital transformation, and sustainable development in rural areas.

Key words: Tourism Innovations, Climate change adaptation, Climate change, rural communities

1. Introduction

The travel and tourism industry contributed $10.9 trillion to the global GDP in 2024 covering the sector's direct, indirect, and induced effects (World Travel & Tourism Council, 2025). Travel and tourism accounted for 10% of the world GDP (Dossou, et al., 2024, World Travel & Tourism Council, 2025). The United Nations World Tourism Organisation (UNWTO, 2021) estimates that by 2050, climate change may slow the growth of tourism worldwide by as much as 30%, especially in areas where nature-based travel is popular. The sector's viability is threatened by rising temperatures, intense weather, and biodiversity loss, making it extremely vulnerable to the effects of climate change (Gossling, & Scott, 2024). The tourism industry is under a lot of strain due to climate change, which is changing the socioeconomic and environmental factors that affect traveller behaviour and destination appeal (Tanrisever, et al., 2024). This emphasises how urgently the industry needs creative ways to improve climate resilience.

Digital technologies have become game-changing instruments for the tourism industry, providing chances for sustainability and climate adaption (Kutlu, et al., 2025). For instance, real-time data monitoring and smart tourism applications in Europe have enabled efficient resource usage, lowering carbon footprints by an average of 18% (Abbass, et al., 2022). Similarly, Australia's rural areas have been able to remotely demonstrate their attractions through use of virtual reality (VR) platforms, which has increased visitor interest by 12% while decreasing the requirement for in-person travel (Gu, 2023). These developments reveal how digital technologies may support sustainable tourism practices and generate adaptive methods. In Africa, where the effects of climate change are disproportionately severe, the tourism industry is facing increasing difficulties (Gu, 2023). About 45% of rural communities in Africa that depend on tourism are highly vulnerable to economic disruptions brought on by climate change (Ikol, 2023; African Development Bank AfDB, 2024). However, in countries like South Africa and Kenya, digital solutions are beginning to bridge this divide (Mtapuri, 2024, Ikol, 2023). For instance, in Kenya, rural tourist operators have improved their climate readiness by using mobile-based weather applications, resulting in a 25% reduction in income losses during extreme weather events (Ikol, 2023, Kenya tourist Board, 2022). In a similar vein, South Africa's use of digital marketing platforms has raised ecotourism destinations' profile

and contributed to a 14% rise in sustainable tourist earnings (Chamboko-Mpotaringa, 2024, Mtapuri, 2024, South African tourist, 2021).

Zimbabwe, which is home to well-known tourist destinations including Mutarazi Falls, Great Zimbabwe, Victoria Falls, and Hwange National Park, is also battling the twin issues of climate change and sustainable tourism. According to climate forecasts, average temperatures in Zimbabwe are expected to rise by 2.5°C and rainfall patterns would decrease by 30% by 2050 (Muwani, et al., 2024, Zimbabwe Meteorological Services Department, 2022). Rural communities, home to a large number of the nation's tourist attractions and significantly relying on tourism-related income, are disproportionately impacted by these developments. Despite these obstacles, Zimbabwe's tourism industry has yet to fully integrate digital technology, and rural communities have little access to them (Chirenje & Munyati, 2023, Gossling, & Scott, 2024).

In Manicaland Province, smallholder farmers have seen changes in local weather patterns, including changed rainfall and increased temperature fluctuation (Gohori, & van der Merwe, 2024, Matura, & Mapira, 2018). Droughts have also impacted water-dependent ecosystems in the broader Eastern Highlands (Chirisa, et al., 2021). The biological health and tourist attraction of the area can be impacted by changes in water flow, which can also affect local tourism revenue (Gohori, & van der Merwe, 2024, Chihwai, & Dube, 2023). There is therefore a need for studies to fully understand and mitigate these impacts. Such studies guide policy makers in adaptive actions to preserve the environment and support the lives of those who depend on tourism.

Previous studies on Zimbabwe's tourism have primarily focused on marketing, conservation, and visitor management. However, there is limited research on the potential of digital innovations to support climate adaptation in rural communities. Given that rural areas are home to 63% of the population and are vital for tourism development (Chamboko-Mpotaringa, 2024, Zimbabwe National Statistics Agency, 2023), this gap is particularly concerning. Addressing this gap could enable Zimbabwe’s rural communities to leverage digital tools for climate risk mitigation, tourism product diversification, and improved livelihoods. This study therefore explores the potential of digital tourism innovations in climate change adaptation in rural Manicaland.

2. Literature Review

This section reviews the concepts and theories that underpin digital tourism innovations and climate change adaptation. These theories offer a foundation for comprehending the intricate relationships that exist between digital technologies, tourism, climate change, and rural communities.

2.1 Theoretical Framework

This study in guided by the Adaptive Capacity Framework (ACF). The Adaptive Capacity Framework is a key concept in climate change adaptation and disaster risk reduction. The theory describes the ability of a system to adjust to actual or expected climate changes and their effects. This theory guides response to immediate impacts of climate change as well as anticipating, learning, reorganizing, and taking advantage of new opportunities that may arise from a changing climate. Studies on climate change frequently utilise this framework to assess how well people, communities, and systems can adjust to the dangers posed by the changing climate (Bullock, et al., 2022). Among the components of the adaptive capacity framework is the availability and access to appropriate technologies. The framework can direct the evaluation of how digital innovations improve rural communities' ability to adapt to climate-related difficulties in the tourism industry (DeCaro, et al., 2025, Bullock, et al., 2022). It highlights important elements that are necessary for climate resilience, such as information access, institutional support, and community-level creativity (Thuy Phan, et al., 2023, Chirisa, et al., 2021).

2.2 Tourism and Climate Change

The effects of climate change pose serious threats to the travel and tourism sector (Shashwat, 2024). Travel patterns are disrupted, infrastructure is damaged, and the sustainability of tourist-dependent communities is threatened by extreme weather events (Ndlovu, et al., 2024). It is estimated that, by 2050 climate change may cause a 10%-15% decline in the demand for travel worldwide, particularly in developing nations (Mtapuri, et al., 2024, Chirisa, et al., 2021). Rural communities in Africa that depend on nature-based tourism are especially vulnerable, due to their reliance on biodiversity and ecosystems that are vulnerable to climate change, (UNWTO, 2022).

Climate change effects are evident in Zimbabwe as rainfall patten has become unpredictable rainfall and temperatures are rising negatively impacting the country's agriculture and tourism industries (Chirenje & Munyati, 2023). Climate change expert warn that if adaptation measures are not put in place, Zimbabwe's tourism industry may lose up to 20% of its yearly revenue as

a result of climate-related disruptions (Gohori, & van der Merwe, 2024, Zimbabwe Tourism Authority, 2022). These figures demonstrate how urgent it is to implement measures that improve tourism operations' resilience, particularly in rural areas.

2.3 Adoption and use of digital tourism innovations among tourism stakeholders in rural communities

The term Digital Tourism Innovations (DTI), refers to the use of digital technologies, including social media, Internet of Things (IoT), mobile applications, remote sensing, Geographic Information Systems (GIS), and virtual and augmented reality, to improve tourism operations, experiences, and sustainability (Ndlovu , et al, 2024, Chirisa, et al., 2021). The tourism industry is rapidly changing due to digital innovations, which make it possible for new forms of promotion, interaction, and service delivery (Chihwai, & Dube, 2023). In order to improve tourist experiences and operational efficiency, tourism operators are progressively implementing digital tools, which include mobile applications, social media platforms, virtual reality (VR), augmented reality (AR), geolocation systems, and artificial intelligence (AI) (Chamboko-Mpotaringa, 2024). The use of digital technology in tourism has increased dramatically on a global scale, particularly after the COVID-19 pandemic heightened demand for contactless travel experiences (Abbass, et al., 2022). By 2020, more than 70% of tourism-related enterprises globally had implemented at least one digital solution, such as contactless payments, digital booking platforms, or mobile-based visitor interaction tools (Chihwai, & Dube, 2023, UNWTO, 2021). Rural communities worldwide are progressively embracing digital tourist innovations, albeit at a slower and more uneven rate, whereas metropolitan and developed locations are leading the way in these advances (Ndlovu, et al, 2024).

Digital tourism technology is presently a major factor in the expansion of the tourist industry (Akhtar et al, 2022). However, rural regions continue to face barriers to the uptake of digital tourist advances. For instance, European rural tourist companies are adopting digital transformation more slowly because of skill-based, financial, and infrastructure constraints (Organisation for Economic Co-operation and Development (OECD), 2020). For example, rural agritourism businesses in Spain and Italy still mostly rely on conventional marketing strategies and are unable to sustain internet platforms (Romero & Tejada, 2021). Nordic nations like Finland and Norway, on the other hand, have advanced significantly in incorporating digital technology with nature-based tourism (Fredman, & Margaryan, 2021). To increase safety and customisation, Finland's national parks and isolated lodges employ digital guides,

geotagged visitor logs, and real-time weather updates (Gossling, & Scott, 2024, Tussyadiah et al., 2017).

Due to economic obstacles, gaps in digital literacy, and inadequate infrastructure, adoption is still happening more slowly in Sub-Saharan Africa and is exacerbated by expensive data plans and inconsistent internet access in rural areas (Muwani, et al., 2024). Although mobile phones are widely used, most rural tourist operators only utilise digital tools for informal marketing and rudimentary communication (Mtapuri, et al., 2024). However, nations like Rwanda, Kenya, and South Africa have made great strides in incorporating ICT into their travel plans (Tanrisever, et al., 2024, World Bank, 2020). For example, Rwanda's smart tourism app and Kenya's e-visa platform have greatly improved travel accessibility and tourist happiness (Ikol, 2023, Muwani, et al., 2024).

Stakeholders in rural tourism throughout the world are adopting digital innovations at varying degrees. Many rural areas in the Global South are still overcoming fundamental obstacles, while developed countries are investigating smart tourist ecosystems (Chamboko-Mpotaringa, 2024). The development of inclusive infrastructure, reasonably priced technology, and community-led digital capacity building must be the main priorities in order to close this digital gap (Mtapuri, et al., 2024). It is crucial to comprehend and adapt to these various adoption settings in order to guarantee that developments in digital tourism fairly benefit all parties involved.

2.4 Digital tourism innovation and climate change adaptation among rural communities

Climate change has left most ural communities that mostly depend on natural resources and climate-sensitive sectors like tourism and agriculture are at considerable risk (Ramaano, 2024, DeCaro, et al., 2025). The tourism sector, particularly in rural areas is increasingly viewed as victim, as well as tool for adaptation and resilience as well as a possible victim of climate change (DeCaro, et al., 2025). Innovations in digital tourism provide transformational tools that can assist rural communities in communicating hazards, diversifying their sources of income, monitoring environmental changes, and developing adaptive skills (Muwani, 2024, UNWTO, 2021; Scott et al., 2016). Digital tools can lower the ecological impact of tourism in fragile rural areas, encourage sustainable habits, and offer real-time environmental information (Chamboko-Mpotaringa, 2024, Muwani, 2024). The subsections below persure the potential benefits of digital tourism to climate change adaptation.

2.4.1 Environmental monitoring and early warning

Digital advances have the potential to improve environmental monitoring, helping with climate adaption (Ndlovu, et al., Muwani, et al., 2024). Mobile-based weather alerts, sensor networks, and GPS-enabled applications are some of the tools that give rural tourism operators up-to-date information on climate threats, such as floods, storms, and fire hazards (Muwani, et al., 2024, Ramaano, 2024). To lower the danger of landslides and flooding and to lessen local vulnerability, community-based tourism networks in Nepal have implemented mobile weather alarm systems (Mtapuri, et al., 2024, Byers & Main, 2020). Similar to this, smart tourism platforms in Kenya employ GIS and satellite images to track drought trends and animal movements, enabling local communities to modify tourism services appropriately (Ramaano, 2024).

2.4.2 Promoting low-carbon and climate-resilient tourism models

Digital innovations aid in the shift of rural tourism to low-carbon models. Technologies like online booking platforms can cut down on paper waste, digital storytelling that takes the place of physical signs, and virtual tours that eliminate the need for long-distance travel (Chirisa, et al., 2021, Chiwaridzo, & Masengu, 2023). VR and AR have made it possible for ecotourism destinations in rural areas to provide immersive experiences without compromising delicate ecosystems or necessitating high-carbon travel (Torabi, et al., 2023). These technologies aid in conservation, lessen the influence that visitors have on delicate ecosystems, and promote certification programs for sustainable tourism (Ramaano, 2024, Dumitru, et al., 2021).

2.4.3 Enhancing adaptive capacity

By enabling remote marketing, simplifying reservations, and promoting e-commerce for regional crafts and experiences, digital platforms can increase the size of rural tourist marketplaces (DeCaro, et al., 2025). One important aspect of climate adaption that is improved by this diversity is economic resilience (Hernandez Sanchez,& Oskam, 2025). Despite interruptions from climate-related calamities, indigenous tourism operators in the Andes have utilised Facebook and Instagram to draw eco-aware tourists, enabling communities to make money (Moreno & Seabra, 2022). Similarly, when conventional agriculture fails during droughts in Sub-Saharan Africa, mobile-based tourism markets have helped people find other sources of income (Mapingure, & du Plessis, 2022, World Bank, 2020).

2.4.4 Knowledge sharing and community empowerment

Digital advancements increase knowledge accessibility, which aids in climate adaption (Ndlovu, et al., 2024, Dumitru, et al., 2021). Best practices in climate-smart tourism and sustainable land use are shared via mobile applications and online platforms (DeCaro, et al., 2025). International development organisations sponsor a digital tourist learning hub in rural

India that offers training on biodiversity protection and climate resilience to homestay operators and local guides (UNDP, 2022, Chirisa, et al., 2021). Giving communities access to digital technologies promotes inclusive adaptation techniques, local agency, and creativity (Thuy Phan, et al., 2023, Bullock, et al., 2022).

Developments in digital tourism enable adaptability of rural populations to climate change (Kumar, & Shekhar, 2020). These technologies help increase rural resilience to climate threats by empowering local stakeholders, encouraging sustainable tourist practices, improving environmental monitoring, and diversifying livelihoods (Hernandez Sanchez, & Oskam, 2025). However, investment in inclusive infrastructure, capacity building, and coordinated policy assistance are necessary to achieve this promise (Lalisan et al., 2024, Ndlovu, et al, 2024).

Regarding the extent and variety of digital tourism innovation usage in rural Zimbabwe, there is a glaring information vacuum (Dube, 2024). The data that is available is dispersed, and not many studies have covered how various stakeholder groups such as, neighbourhood businesses, residents, and park officials' use or profit from digital technology. By offering a thorough evaluation of the present levels of acceptance and application of digital tourism technologies in Manicaland province, this research closes that gap.

3.0 Methodology

In order to strengthen the rigour of the findings, the researchers employed a mixed method approach, which allowed them to triangulate across many approaches (Creswell and Clark, 2011). There was a combination of personal interviews, and quantitative surveys (Gössling, et al., 2021). This triangulation guarantees thorough insights into adoption and obstacles and wide coverage of patterns. Data was gathered from representatives of tourist attractions and service providers using questionnaire (See Appendix 1) administered with Kobo Collect digital tools. Management was interviewed in person. In order to collect contextual information, the researchers also consulted secondary data sources and interviewed local stakeholders (Dawadi, Shrestha, and Giri, 2021). Using an online RaoSoft sample calculator, a sample of 102 respondents was determined from a population 137 tourist attraction centres and tourist service providers from Manicaland Province (See fig 1). This was calculated using a 5% error margin and a 95% level of significance. Purposive sampling was employed in the study to choose key informants from the two clusters. Purposive sampling, according to Nikolopoulou (2023), is a category of non-probability sampling procedures in which units are chosen based on the possession of attributes that are required in your sample. Quantitative data was analysed using STATA Software version 2. In this study, the main independent variable is digital tourism

innovations. The other variables, Role in the tourism sector and Experience in Tourism sector are control variables that help isolate the effect of the main independent variable thus reducing potential bias in the estimated coefficients (Newey, & Stouli, 2021). Different roles in the tourism sector might have varying levels of exposure to climate impacts or different resources for adaptation, or even different access to digital tools. By controlling for "Role," the researchers are ensuring that the observed effect of digital tourism adoption on climate change adaptation effectiveness is not simply because, for example, National Parks have a higher digital adoption and are more inherently geared towards adaptation than, say, Shuttle Services. The study isolates the effect of digital innovation regardless of the specific role. Similarly, by including the years of experience as control variable, these researchers are statistically holding their effects constant so that they can more confidently interpret the unique contribution of digital tourism innovation (Memona, Thurasamya, Ting, Cheahi and Chuahj, 2024). Organizations with more years of experience might have developed more robust adaptation strategies over time, or they might have had more time to adopt digital innovations. Qualitative data was processed using NVivo software and thematic analysis was used to determine themes ad patterns. For ethical reasons, the participants were made fully aware of the survey's objectives, their roles, and the necessary but voluntary nature of their participation. They were also told that they were not required to participate in the evaluation and that they could leave the survey at any moment without providing a reason, and that their answers would be kept as anonymous as possible.

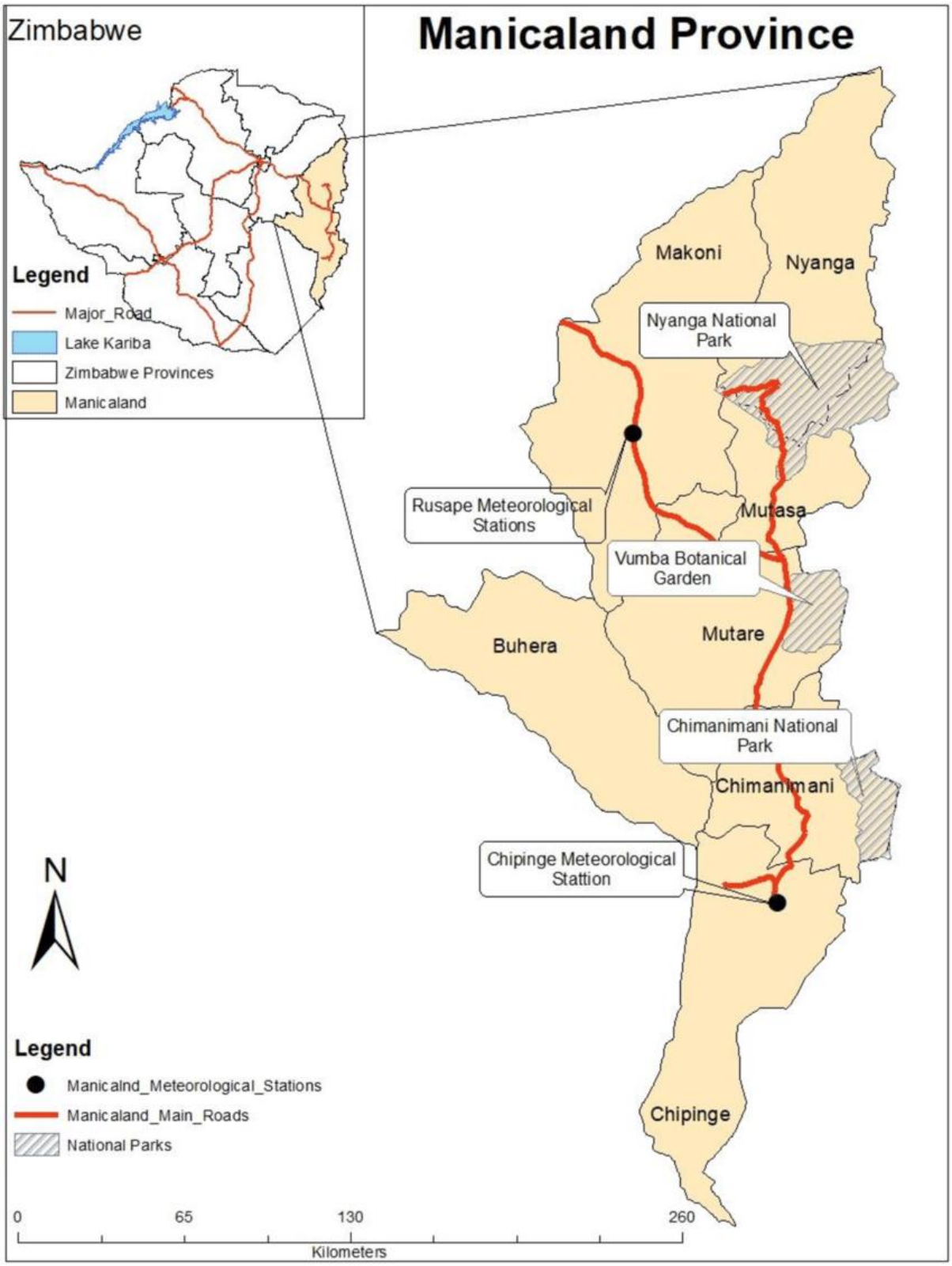

Figure1: Map of Manicaland Province, Zimbabwe. Source: Mushawemhuka, 2021

4.0 Results and Discussion

This section will present quantitative and qualitative results followed by a discussion section

4.1 Current Use of Digital Tourism Innovations

Table 1: The current level of adoption and use of digital tourism innovations among tourism stakeholders in Manicaland Province

Statement	Mean	Std. Dev.
We use digital platforms to share information about local attractions with potential visitors.	3.82	0.961
We provide digital information about local attraction to visitors.	4.01	0.985
Visitors can easily book accommodation or tourism activities in our area through online platforms	4.16	.960
Our organization uses digital payment methods for tourism-related services.	3.37	0.998
We use digital systems to manage reservations and bookings for tourism services.	3.91	0.925
We offer digital tools to enhance the visitor experience at Mutarazi Falls.	3.59	1.006
Digital tourism innovations are a central part of our overall strategy for tourism development	4.00	0.903
Internet speed is sufficient to support digital tourism activities	3.25	1.183
Public Wifi or community internet centres are available in my locality	3.16	1.226
Most people in this community use smart phones	4,45	0.789
Local government and NGOs support digital access and ICT development in this community	3.95	0.93

The descriptive results in Table 1 show a largely positive picture of digital tourism innovation adoption in Manicaland Province. Stakeholders actively use digital platforms for information sharing and online bookings, and the local population are knowledgeable and proficient in using digital technologies. The highest mean (4.45) for smartphone usage clearly indicates a high level of digital readiness among the community population, which is a significant asset for digital tourism. Furthermore, the strong perceived support from local government and

NGOs (3.95) for digital access and ICT development is highly encouraging. However, the lower scores for internet speed sufficiency (3.25) and public Wi-Fi availability (3.16) their high standard deviations**,** suggest variability and persistent challenges in core digital infrastructure. This indicates that while demand and support for digital are high, the fundamental connectivity needed to fully leverage digital innovations remains an area for improvement.

Qualitative results concur with quantitative results indicating an increase in the uptake of digital innovations in tourism promotions. Facebook, Instagram, and WhatsApp were often mentioned by participants as the main platforms for advertising nearby attractions. One respondent said,
"*We post pictures, hold giveaways, and inform visitors about trail conditions and weather on Facebook and WhatsApp every day*."
For rural areas with little infrastructure, digital advances were viewed as cost-effective and efficient marketing tools. In order to increase their digital reach, several operators mentioned working with influencers.
Further to that, one guest house manager alluded to the use of online booking and digital payments. EcoCash, ZIPIT, and mobile banking are now accepted for bookings by an increasing number of providers. He is quoted saying;
"*Bank transfers and EcoCash made it simpler for domestic travellers to pay in advance, particularly those travelling from Mutare or Harare*."
Some tourist companies reported using innovative technologies including digital feedback kiosks, app-based guided tours, and QR-coded trail maps, especially in the vicinity of Mutarazi Falls.

"*When guests arrive, they may download an interactive map that we introduced. It provides information about the local climate and leads them along the trekking track*."

These results corroborate with Chamboko-Mpotaringa, (2024) who noted that tourism operators are progressively implementing digital tools including mobile applications, social media platforms, virtual reality (VR), augmented reality (AR), geolocation systems, and artificial intelligence (AI). This is further supported by Abbass, et al., (2022) who noticed a dramatic increase in use of digital technology in tourism on a global scale, particularly after the COVID-19 pandemic heightened demand for contactless travel experiences.

4.2 Regression analysis

The purpose of this study was to investigate how digital tourism innovations (DTIs), can improve rural tourist communities' ability to adapt to climate change in Zimbabwe's Manicaland Province. Regression analysis was conducted and results are presented in Table 2.

Table 2: OLS, OLOGIT and OPROBIT estimates: Digital Tourism Innovations in achieving Climate Change Adaptation in Zimbabwean Rural Communities in Manicaland Province, Zimbabwe

	OLS	OLOGIT	OPROBIT
VARIABLES	(1)	(2)	(3)
Digital Tourism Innovation	0.418***	4.661***	2.493***
	(0.142)	(0.583)	(0.446)
Lodge	0.241***	1.135***	0.813***
	(0.0856)	(0.319)	(0.342)
Tour Guide	-0.0378	0.0239	-0.0196
	(0.171)	(0.986)	(0.532)
Shuttle Services	-0.0678	-0.210	-0.176
	(0.184)	(0.845)	(0.577)
Airbnb	0.206	0.537	0.344
	(0.156)	(0.467)	(0.687)
Experience years	0.239***	1.439***	1.018***
	(0.164)	(0.922)	(0.616)
Constant cut1		15.75***	12.26***
		(3.414)	(2.361)
Constant cut2		18.38***	17.50***
		(4.480)	(2.112)
Constant	0.312		
	(0.600)		
Observations	102	102	102
R-squared	0.332	0.2589	0.2602

Robust standard errors in parentheses

This study primarily focused on the coefficient and significance of DTI score, while acknowledging that role and experience in tourism were important factors to account for to strengthen the validity of your core findings. A series of regression analyses, employing Ordinary Least Squares (OLS), Ordered Probit (OPROBIT), and Ordered Logit (OLOGIT) models was conducted to establish the robustness of the results, all of which yielded remarkably consistent and corroborating results. The OLS model produced a positive and highly statistically significant coefficient ($\beta = 0.418$, $p < 0.01$), indicating that the perceived adaption efficiency score increases by 0.418 for every unit rise in the adoption of digital tourist innovations. With coefficients of 2.493 and 4.661, respectively, the OPROBIT and OLOGIT models supported this trend and were also significant at 1% level.

Interviews participants support quantitative results, digital technologies assisted in controlling tourist flows and warning travellers about weather-related hazards such as, landslides or fog at destinations such as Mutarazi Falls and Mount Inyangani.

“By using WhatsApp groups and facebook pages to give out early weather alerts, we have prevented a number of incidents. Visitors come more prepared.”

More so, through online pre-order systems, digital platforms have enabled young people and women in rural areas to sell food and crafts to visitors, assisting in maintaining revenue during off-peak seasons.

"Our community members now use social media to promote their organic honey and beaded crafts. Orders continue to pour in even during the months with the fewest tourists.”

The embracing of digital platforms in tourism related activities has allowed local residents to learn climate-smart tourism techniques through community seminars that were conducted via Zoom or WhatsApp. Increased water collection, sustainable waste disposal, and reforestation activities were attributed by several responders to these sessions.

"*We began implementing water-saving measures at our lodges and teaching villagers how to recycle plastic for crafts after attending a webinar last year."*

However, high data prices, frequent power outages, and restricted internet coverage were identified as the main obstacles to a more thorough digital transition.

"*We frequently lose contact with clients when the power goes out if we don't have a generator or solar backup."*

The majority of operators pointed out that community residents and employees lacked digital literacy. They demanded specialised instruction on cyber security, SEO, and digital content production.

"Our employees are proficient in taking photos, but few are proficient in editing or running sponsored advertisements. Workshops specifically designed for rural entrepreneurs are needed."

The quantitative and qualitative results concur with previous studies that developments in digital tourism enable adaptability of rural populations to climate change (Kumar, & Shekhar, 2020). Furthermore, these technologies help increase rural resilience to climate threats by empowering local stakeholders, encouraging sustainable tourist practices, improving environmental monitoring, and diversifying livelihoods (Hernandez Sanchez, & Oskam, 2025).

5. Conclusion and Recommendation

This section provides conclusions for the study followed by recommendations and areas for future research.

5.1 Conclusion

This study offers contextual and empirical proof that innovations in digital tourism greatly improve the results of climate change adaption in rural areas. The robustness and coherence of both quantitative and qualitative results demonstrate how digital technologies have the capacity to revolutionise livelihoods, safety, communication, and environmental management. Therefore, it is prudent to note that, the efficacy of digital innovation varies depending on the function in tourism and has to be interpreted in light of organisational capability, experience, and resource availability. In developing rural areas like Manicaland Province, digital tourism offers a scalable and sustainable alternative for climate adaptation, despite skill-based and infrastructure-related obstacles. Digital tourism innovations are becoming more and more important for boosting rural tourism, maintaining livelihoods, and aiding in climate change adaption. Even while there have been encouraging advancements, particularly in the areas of digital marketing and community resilience, there are still many obstacles to overcome in terms of digital infrastructure, cost, and skills. By filling up these gaps, digital tourism in rural Manicaland Province, Zimbabwe may reach its full potential as a tool for climate resilience and sustainable development.

5.2 Recommendations

Following the above findings this study gives the following recommendations:

- There is need for the government agencies and other relevant digital service providers to expand rural digital infrastructure through investments in dependable Wi-Fi zones, solar-powered charging stations, and broadband access in underserved rural tourism corridors.
- The government and tourism boards should provide incentives for innovation, such as tax breaks, recognition programs, or grants, for operators who digitise their services sustainably.
- The government should encourage community-led digital initiatives including smartphone applications for ecotourism, visitor information centres, and weather alert networks.

5.3 Areas for future Research

While the study findings provide focus to the Zimbabwean rural Communities in Manicaland Province, the findings may not be directly generalizable to other provinces or different types of rural communities in Zimbabwe, which may have distinct socio-economic contexts, infrastructure, or climate vulnerabilities. Therefore, this study recommends future studies on digital tourism extending to other provinces of Zimbabwe as well as comparative studies in various nations.

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Appendix 1

Questionnaire

Section A: Organisational Characteristics

1. Role in the Tourism Sector

Hotel	02
Lodge	03
Tour Guide	04
Shuttle Services	05
National Park	06
Airnb	07

2. Experience in the tourism sector

0≤ years ≤ 5	01
6 ≤ years ≤ 10	02
11 ≤ years ≤ 15	03
Years ≥ 16	04

Section B: The current level of adoption and use of digital tourism innovations among tourism stakeholders in Manicaland Province.

Please indicate the extent to which your organization has adopted the following digital tourism innovations

. 1. Not at all; 2. Very Limited Extent; 3. Moderate Extent; 4. Significant Extent; 5. Extensive Extent

Statement	**Please tick against relevant response**				
	1	**2**	**3**	**4**	**5**
We use digital platforms to share information about local attractions with potential visitors.					
We provide digital information about local attraction to visitors.					
Visitors can easily book accommodation or tourism activities in our area through online platforms					

Our organization uses digital payment methods for tourism-related services.					
We use digital systems to manage reservations and bookings for tourism services.					
We offer digital tools (e.g., mobile apps, QR codes for information, interactive online maps) to enhance the visitor experience at Mutarazi Falls.					
Digital tourism innovations are a central part of our overall strategy for tourism development					
Internet speed is sufficient to support digital tourism activities (e.g uploading photos, video calls, online bookings e.t.c)					
Public Wifi or community internet centres are available in my locality					
Most people in this community use smart phones					
Local government and NGOs support digital access and ICT development in this community					

Section C: Climate change adaptation among rural communities dependent on tourism in the Manicaland Province.

For the following question use the below scale to respond to the questions, tick against the chosen number:

(**1**=Not at all **2**= Slightly **3**=Average **4**=Significant **5**=A great deal)

Statement	**Please tick against relevant response**				
	1	**2**	**3**	**4**	**5**
In the recent past we have witnessed a reduction in the negative impacts of climate change on our community					
Our community is becoming more resilient to the impacts of climate change					
We have witnessed an improvement in the viability of tourism livelihoods in our area in the recent past.					

Our community is becoming more resilient to the impacts of climate change.					
There is a noticeable improvement in our community's well-being					
We have effectively overcome major challenges in climate change adaptation					

Thank you

Appendix 2: Interview Guide

Section A. Background Characteristics

A1. What is your role in the tourism sector?

A2. For how long have you been involved in tourism activities?

Section B: Current Use of Digital Tourism Innovations

B1. Can you describe the digital tourism innovations your organization is currently using to promote tourism surrounding areas?

B2. Describe your organization's online presence how did you go about establishing it.

B3. How has your organization integrated online booking or digital payment methods into its tourism services?

B4. In what ways does your organization utilize digital marketing and promotion to reach potential tourists? Probe: social media campaigns, online ads, engaging with review platforms)

B4. Beyond marketing and bookings, what other digital tools or technologies has your organization adopted to enhance the visitor experience at Mutarazi Falls? Probe: mobile apps, QR codes, interactive maps, Wi-Fi access

Section C: Digital Tourism and Climate Change Adaptation

C1. From your perspective, has there been a reduction in the negative impacts of climate change that you have experienced? Could you provide specific examples?

C2. Is there an improvement in the viability of tourism livelihoods in the tourism area? Are there any specific activities or initiatives that stand out?

C3. Do you feel that our community is more resilient to the impacts of climate change now compared to recent year? Please explain why or why not.

The End

Transit for All: Evaluating the Mental Health Impact of Fare Reduction Initiatives on Low-Income Communities

Jana Abou Hjaily*

February 21, 2025

Abstract

Public transportation is vital for equitable urban living, particularly for low-income individuals who depend on it for daily travel. Many U.S. cities have implemented fare reduction programs to enhance equity, yet the specific impacts of these programs remain understudied. This paper examines the effects of fare reduction programs on mental health outcomes in low-income neighborhoods, with healthcare utilization and unemployment explored as mechanisms driving these effects. Using a triple difference-in-difference model and event-study framework, the analysis employs data from the American Public Transportation Association, the American Community Survey, and the CDC's 500 Cities and PLACES datasets. The findings reveal that treated census tracts experience a 2.65% reduction in the proportion of individuals reporting poor mental health, driven by a 1.39% increase in healthcare utilization and a 12% decrease in unemployment rates in low-income areas. This study shifts the focus from general public transit accessibility to the specific benefits of fare reduction programs, providing evidence of their potential to improve mental health and promote equity in urban communities.

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1 Introduction

Public transportation is a public good essential for equitable urban living. Low-income individuals rely heavily on public transit for daily travel (Giuliano, 2005), which is particularly true in the U.S. context, where wealthier people are more likely to drive their cars. Public transit agencies operating in multiple cities across the U.S. have been implementing fare reduction programs for low-income individuals in an attempt to enhance the equity of public transportation.

Public transit users spend around $900 annually on fares, which, for the lowest income quintile, represents nearly 6% of their income. While advocates support further subsidies for public transportation to promote equity, opponents highlight concerns about financial sustainability. In Pennsylvania, for example, debates have arisen about increasing mass transit funding to address fiscal shortfalls, with some lawmakers questioning the long-term viability of expanded subsidies without stable funding sources (Levy, 2024). Understanding the impact of relaxing this financial burden on the well-being of low-income individuals is crucial, as overall health, including mental health, is a key aspect of well-being and is often influenced by economic stressors.

In the United States, low-income individuals often experience poorer mental health outcomes and limited access to healthcare. For instance, 8.7% of people with incomes below the poverty level report severe psychological distress (Anxiety and Depression Association of America, 2022). Furthermore, 12.4% of low-income adults delay or forgo medical care due to cost, resulting in unmet medical needs (Martinez and Ward, 2016). While the impact of access to reliable transportation is well-studied in the literature, there is limited understanding of how reducing public transit fares directly affects the individuals who need it most. This paper examines the mental health outcomes of fare reduction programs in low-income neighborhoods, exploring healthcare utilization and unemployment as potential mechanisms driving the effect.

Fare reduction programs across the U.S. aim to alleviate financial burdens for low-income individuals through discounted or free public transportation. These programs vary in their eligibility criteria across different cities. Some programs offer benefits to individuals enrolled in Medicare, Medicaid, or the Supplemental Nutrition Assistance Program (SNAP), while others impose specific income requirements. For example, New York City's Fair Fares program, introduced in 2019, provides a 50% discount on eligible subway and bus fares to income-eligible residents aged 18 to 64. Prior to this program, the Metropolitan Transportation Authority (MTA) offered reduced fares to seniors, individuals with disabilities, and Medicare recipients through its Reduced-Fare MetroCard program. Another notable program is Kansas City's Zero Fare Transit, which eliminates fares for all riders. As shown in Figure 1, by 2022, more than 80 cities across the U.S. had implemented some form of fare reduction for low-income individuals. The growing adoption of these programs highlights the importance of studying their potential impacts on low-income communities.

Existing research primarily focuses on the role of public transit accessibility in shaping various aspects of life for low-income communities. Reliable transportation is a critical factor in labor outcomes among these communities (Blumenberg et al., 2015; Gautier and Zenou, 2010; Garasky et al., 2006). Consequently, access to public transit influences the spatial distribution of poverty in metropolitan areas (Barton and Gibbons, 2017; Akbar, 2022). Additionally, studies have examined the impact of public transport accessibility on public health (Brown et al., 2019; Bauernschuster et al., 2017; Stevenson et al., 2016), healthcare utilization (Aggarwal, 2018; Smith et al., 2021; Wolfe et al., 2020), food consumption (Baek, 2016; Arnold, 2023), and social connection (Bailey et al., 2019). While this body of research provides substantial evidence on the effects of public transport accessibility, it largely overlooks the impact of reducing public transport costs.

Emerging research on public transportation subsidies, much of which is derived from experimental studies, offers initial insights into how fare reduction programs affect labor outcomes and other aspects of well-being. Field experiments conducted in Chile, Copenhagen, Ethiopia, and the U.S. suggest that reduced-fare public transportation increases ridership (Bull et al., 2020; Thøgersen, 2009) and enhances job search intensity (Franklin, 2018; Phillips, 2014). According to a randomized controlled trial by Brough et al. (2024), providing free public transportation to low-income individuals does not significantly affect paid hours worked or earnings. However, the authors find that treated individuals appear to use less healthcare, which they suggest may indicate a positive impact on well-being. Lastly, a study examining the impact of an age-friendly transportation policy on mental health reports positive effects driven by improved social engagement among senior citizens in England (Reinhard et al., 2018).

The primary empirical strategy employed in this paper is a triple difference-in-difference model, complemented by an event-study framework. To examine the effects on mental health and healthcare utilization, I utilize the 500 Cities and PLACES datasets provided by the Centers for Disease Control and Prevention (CDC). These datasets offer detailed information on the percentage of individuals reporting poor mental health at the census tract level, along with various indicators of healthcare utilization. Additionally, the analysis employs data from the American Public Transportation Association and the American Community Survey to assess the impact of reduced fare programs on unemployment rates in low-income neighborhoods. As a robustness check, I also apply matching techniques to ensure that the results are not driven by differences in baseline characteristics between treated and control groups.

The results suggest that reducing public transportation costs indeed benefits low-income communities. Relative to their counterfactual, treated low-income census tracts experience a reduction of 0.404 percentage points in the percentage of individuals reporting poor mental health within census tracts in the 1st quartile of the city income distribution, compared to other tracts.

This reduction represents a 2.65% decrease relative to the full sample average of individuals reporting poor mental health. To put this number in perspective, if fare reduction programs were implemented nationwide in all census tracts within the 1st quartile of the income distribution, an estimated 1.93 million individuals would report improved mental health. The result appears to be driven by an increase in healthcare utilization and a reduction in the unemployment rate. Specifically, the treatment raises the healthcare utilization index in low-income neighborhoods by 1.39% and increases the percentage of individuals receiving a health checkup by 0.915%, both relative to the outcome mean. Additionally, reduced fares appear to decrease unemployment rates by 1.15 percentage points within census tracts in the 1st quartile of the city income distribution, relative to all other tracts. The magnitude of this effect corresponds to 8.51% of the mean unemployment rate in low-income tracts and 12% of the total mean unemployment rate.

While previous studies have examined the impact of reducing transportation costs on labor outcomes and general well-being, this paper contributes to the existing literature by focusing specifically on the direct benefits of fare reduction programs on mental health, particularly within low-income neighborhoods, and exploring potential mechanisms. Additionally, this study provides empirical evidence on the broader impacts of fare reduction by employing a causal framework supplemented with matching techniques and utilizing nationally representative data, offering new insights into how public policy can enhance equity in urban living.

The paper is organized as follows: Section 2 introduces the datasets, Section 3 outlines the empirical framework, Section 4 presents the results, followed by an exploration of potential mechanisms in Section 5, robustness checks in Section 6, and conclusions in Section 7.

2 Data

American Public Transportation Association provides data on fares for low-income individuals from 2010 to 2022. Public transportation agencies across various U.S. cities report annually to the association. When data from a particular agency is missing for one or more years, I fill in the gaps by carrying forward information from the first available report following the missing observations. An agency is considered treated if the fare for low-income individuals is strictly less than the regular fare, and a city is considered treated if one or more agencies within the city implement this fare reduction.

500 Cities and PLACE dataset, published by the Centers for Disease Control and Prevention (CDC), utilizes individual-level data from the Behavioral Risk Factor Surveillance System (BRFSS) to provide small-area geographical estimates. This dataset includes the percentage of respondents who reported 14 or more days during the past 30 days in which their mental health was not good, estimated at the census tract level and available annually, which I will use as the outcome variable for mental health. Additionally, I calculated an equally weighted index for healthcare utilization using the available indicators. These include the percentage of adults who

had routine checkups within the past year, cholesterol screening, colorectal cancer screening, dental care visits, and the percentage of older men and women who are up to date on a core set of clinical preventive services. It is important to note that some healthcare utilization variables are available in even years, while others are available in odd years, except the percentage of adults who had routine checkups within the past year which is available annually (Table **??** provides more details on the healthcare utilization variables). Therefore, I used both linear interpolation and extrapolation techniques to fill in the missing healthcare utilization data. In its final version, the dataset covers the years 2014 to 2022. When analyzing the effect of fare reduction on mental health and healthcare utilization, cities that were treated in 2014 or earlier are excluded from the study due to the lack of pre-treatment observations.

American Community Survey (ACS) providing both the unemployment rate as an outcome variable and a range of control variables. The ACS offers information on census tract aggregates, including the unemployment rate, the percentage of workers using public transportation, household mean and median income, the percentage of educated individuals, and industry composition. The ACS 5-year data provides annual estimates from 2010 to 2022 at the census tract level. Finally, any city treated in 2010 is excluded from the sample when studying the impact of fare reduction on the unemployment rate, as no pre-treatment observations exist.

Data Linking: The 500 Cities/PLACES dataset provides a direct crosswalk between cities and census tracts, enabling data merging with the APTA data using city and state names and with control variables from the ACS data using tract FIPS codes (census tract codes). Since the 500 Cities/PLACES dataset consistently uses the 2010 census tract definitions across all years, I apply the 2010–2020 census tract crosswalk from the United States Census Bureau to remap ACS data from 2020 onward to the 2010 definitions. When analyzing the effect of public transit fare reductions on unemployment rates, I also use this crosswalk to ensure consistency in census tract definitions. However, instead of solely relying on the 500 Cities/PLACES crosswalk for matching cities and tracts in the unemployment analysis, I utilize the Geocorr application provided by the Missouri Census Data Center. This approach generates a city-to-census tract crosswalk based on the 2010 Census definitions, helping to retain observations for cities included in the APTA dataset but not in the 500 Cities/PLACES dataset when studying the impact of fare reductions on unemployment rates.

3 Research Design

3.1 Difference-in-Difference

The basic estimated equation is as follows:

$$Y_{ict} = \alpha + \beta Treated_{ict} + \beta_2 X_{ict} + \delta_i + \theta_t + \epsilon_{ict} \tag{1}$$

such that Y_{ict} is the outcome variable of interest, and $Treated_{ict}$ is a dummy variable equal 1 if census tract i is within city c that implemented any reduced fare program. X_{ict} is a vector of control variables, δ_i represents census tract fixed effects, θ_t represents time fixed effects, and ϵ_{ict} is the error term. It is important to note that while this equation provides a foundational estimation framework, it is not the primary focus of the analysis.

To estimate the corresponding dynamic treatment effect over time, I utilize the following event-study framework:

$$Y_{ict} = \left(\sum_{j=-m,..,0,..n} \gamma_j \cdot D_{ic,t-j} \right) + \delta_i + \theta_t + \beta \cdot X_{ict} + \epsilon_{ict} \tag{2}$$

such that $D_{ic,t-j}$ is an indicator variable for event time j, I also include census tract fixed effects δ_i, and time fixed effects θ_t. Under this approach, the treatment effect is estimated relative to the omitted period before the event.

3.2 Triple Difference-in-Difference

Since transportation barriers and financial limitations are significant concerns among underprivileged communities, I do not expect the treatment to affect low-income and wealthy individuals in the same way. Additionally, most reduced fare programs specifically target low-income individuals, with only a few eliminating fares for everyone. Therefore, the primary model for estimating the effect of transit fare reductions is the following triple difference-in-differences equation:

$$\begin{aligned} Y_{ict} = \alpha &+ \beta\, Treated_{ict} + \beta_2\, Lowincome_{ic} \\ &+ \beta_3\, (Lowincome_{ic} \times Treated_{ict}) + \beta_4\, X_{ict} \\ &+ \delta_i + \theta_{ct} + \epsilon_{ict} \end{aligned} \tag{3}$$

Such that Y_{ict} is the outcome variable of interest, $Treated_{ict}$ is the treatment dummy, and $Lowincome_{ic}$ is a dummy variable equal to 1 if the census tract i is low-income and 0 otherwise. Low-income census tracts are defined in two ways: census tracts within the 1st quartile of each city's income distribution or census tracts with income below the city-median income. Additionally, $(Lowincome_{ic} \times Treated_{ict})$ is an interaction term between the treatment dummy and the low-income dummy. X_{ict} is a vector of control variables, δ_i represents census tract fixed effects, θ_{ct} represents city-by-year fixed effects, and ϵ_{ict} is the error term. The coefficient β_3 is the primary focus of interest in this analysis. Furthermore, to estimate the corresponding dynamic treatment effects over time, I utilize the following event-study framework:

$$\begin{aligned} Y_{ict} = &\left(\sum_{j=-m,..,0,..n} \gamma_j \cdot D_{i,t-j} \cdot Lowincome_{ic} \right) \\ &+ \beta \cdot Treated_{ict} + \beta_2 \cdot Lowincome_{ic} \\ &+ \beta_3 \cdot X_{it} + \delta_i + \theta_t + \epsilon_{it} \end{aligned} \tag{4}$$

Such that $D_{i,t-j} \cdot Lowincome_{ic}$ represents the interaction of event time with the low-income tract indicator, and $Treated_{ict}$ and $Lowincome_{ic}$ are additional control terms for the treatment and the low-income indicator. I also include census tract fixed effects δ_i and time fixed effects θ_t. Under this approach, the treatment effect is estimated relative to the omitted period before the event.

4 Main Results

Before delving into the main empirical results, Figures 2 and 3 present descriptive evidence on the raw relationship between fare reduction programs and key outcomes related to mental health and public transit usage. The left panel of Figure 2 shows that while the percentage of individuals reporting poor mental health has generally increased across all cities, the rise is notably smaller in treated cities compared to control cities. Similarly, the right panel of Figure 2 indicates a general decline in public transit use among workers, but this trend is less pronounced in cities implementing fare reduction initiatives. Figure 3 further illustrates these patterns through the distribution of changes between pre- and post-treatment periods. The density plots reveal that treated cities tend to cluster around smaller increases in poor mental health and exhibit a softer decline in public transit use. These raw trends suggest that fare reduction programs may play a role in mitigating negative outcomes, providing a strong motivation for the causal analysis presented in the subsequent sections.

Tables 1 and 2 present the effects of fare reduction initiatives on mental health, measured as the percentage of individuals reporting poor mental health. Columns (4) through (6) report the triple-difference-in-differences coefficient β_3 from Equation (3). Among these, column (6) provides the most robust result, as the regression includes both census tract and city-by-year fixed effects.

Table 1 demonstrates that the treatment reduces the percentage of individuals reporting poor mental health by 0.404 percentage points in census tracts within the 1st quartile of the city income distribution, compared to other tracts. This reduction represents a 2.19% decrease relative to the mean percentage of individuals reporting poor mental health in 1st-quartile census tracts and a 2.65% decrease relative to the full sample average.

Column (6) of Table 2 reports similar findings, though with a slightly smaller treatment effect. Specifically, the coefficient reflects a 0.363 percentage point reduction in the percentage of individuals reporting poor mental health in census tracts where the median income is below the city median income. This reduction corresponds to a 2.09% decrease relative to the mean percentage of individuals reporting poor mental health in below-median-income census tracts and a 2.38% decrease relative to the full sample average. Additionally, the significance level of the coefficient in column (6) differs between the two tables, being significant at the 1% level in Table 2 and at the 5% level in Table 1. These results suggest that the positive impact of fare

reduction initiatives on mental health is more pronounced in poorer neighborhoods.

Columns (1) through (3) report the difference-in-differences coefficient β from Equation (1). Columns (1) and (2) present results using the full sample, while column (3) of Tables 1 and 2 restricts the sample to census tracts within the 1st quartile of the city income distribution and to census tracts with median income below the city median income, respectively. The results of Equation (1) are statistically insignificant, and the coefficients are not different from zero.

Figure 4 reports the event-study coefficients γ_j from Equation (4), corresponding to the triple-difference-in-differences framework. Panel A shows the interaction of the treatment variable with a dummy variable equal to 1 if the census tracts belong to the cities' 1st quartile income distribution. Panel B shows the interaction of the treatment variable with a dummy variable equal to 1 for census tracts with a median income below the cities' median income. The coefficients in both panels are very similar and cannot be interpreted differently.

In both panels, there are no significant pre-trends within the four years preceding the treatment, supporting the parallel trends assumption. After the treatment implementation, the coefficients are significantly negative, indicating a reduction in the percentage of individuals reporting poor mental health in low-income tracts due to the treatment.

Appendix Figure A.1 presents the same event study but uses year-fixed effects instead of city-by-year fixed effects. The results are consistent across both specifications; however, controlling for city-by-year fixed effects appears to strengthen the parallel trends assumption by accounting for city-wide shocks or trends that may have influenced mental health outcomes across tracts. Appendix Figure A.3 reports the coefficients of the event study from Equation (2). The results demonstrate that the treatment reduces the percentage of individuals reporting poor mental health across all panels, with stronger effects observed in the matched samples of low-income census tracts (Panels B and C). Nevertheless, these findings should be interpreted with caution, as the confidence intervals are relatively large and often include zero.

5 Mechanisms

The findings from the main results highlight the significant impact of fare reduction initiatives on improving mental health outcomes in low-income neighborhoods. However, to better understand the channels through which these benefits are realized, it is essential to examine potential mechanisms. Improved healthcare access and reduced unemployment rates are two plausible pathways that may explain the observed improvements in mental health. The subsequent sections explore these mechanisms in detail, starting with the role of healthcare utilization.

5.1 Healthcare Utilization

Tables 3 and 4 report the treatment effects on healthcare utilization, measured using the constructed healthcare utilization index. The triple-difference-in-differences estimates presented in column (6) of Table 3 indicate that reducing public transit fares increases healthcare utilization by 0.818 percentage points in census tracts within the 1st quartile of the city income distribution, compared to other tracts. This effect represents a 1.53% increase relative to the mean healthcare utilization index in 1st-quartile census tracts and a 1.39% increase relative to the full sample average.

Similarly, Column (6) of Table 4 shows that the treatment is associated with a 0.783 percentage point increase in healthcare utilization in below-median-income census tracts. This represents a 1.42% increase relative to the outcome mean in below-median-income tracts and a 1.33% increase relative to the mean in the full sample.

Since only the percentage of individuals getting a checkup is available at an annual level, I estimate the treatment effect separately for this outcome variable. The results are described in Tables 5 and 6. Column (6) of Table 5 indicates that fare reduction raises the health checkup rate within 1st-quartile census tracts by 0.650 percentage points, which represents 0.915% of the total mean outcome. Similarly, the treatment increases the percentage of individuals getting a checkup in below-median-income tracts by 0.964% of the total mean outcome.

Figure 5 reports the event-study coefficients corresponding to the triple-difference-in-differences estimation, where Panel A and Panel B show the dynamic effects on healthcare utilization, and Panel C and Panel D present the event-study for the checkup rate. In all four panels, the post-treatment coefficients are significantly positive and increase over time, indicating a rise in healthcare utilization among individuals in low-income neighborhoods (both within the 1st quartile of the city income distribution and in census tracts below the median income) as a result of fare reductions in public transportation. In Panels A and B, the coefficient at $t = -4$ is statistically negative, raising some concerns about the existence of a pre-trend, whereas in Panels C and D, the parallel trends appear to hold, reassuring the robustness of the results. Additionally, Figure A.4 reports the same estimation using census tract and year fixed effects; the results remain consistent.

5.2 Unemployment

Tables 7 and 8 report the treatment effects on the unemployment rate. Column (6) of Table 7 shows that reducing the cost of public transportation decreases unemployment by 1.15 percentage points within census tracts in the 1st quartile of the city income distribution, relative to all other tracts. The magnitude of this coefficient corresponds to 8.51% of the mean unemployment rate in low-income tracts and 12% of the total mean unemployment rate. Similarly, Column

(6) of Table 8 indicates that the treatment reduces the unemployment rate by 0.892 percentage points in census tracts below the city median income. This effect represents 7.43% of the mean unemployment rate in below-median-income neighborhoods and 9.35% of the total mean unemployment rate.

Appendix Tables A.9 and A.10 examine the effects of fare reductions on female and male unemployment rates, respectively. The results suggest that the observed treatment effect is primarily driven by a reduction in male unemployment.

Figure 6 presents the event-study coefficients γ_j from Equation (4), corresponding to the triple-difference-in-differences framework. In both Panels A and B, no significant pre-trends are observed in the four years preceding the treatment. However, the coefficients are significantly negative after the treatment is implemented, indicating a reduction in unemployment rates in low-income tracts due to the intervention. Furthermore, the results remain robust when using census tract and year fixed effects, as shown in Figure A.7.

6 Robustness Checks

6.1 Matching Technique

The matching process employs Nearest Neighbor Propensity Score (PS) Matching with Replacement to create a balanced comparison between treated and control units. Propensity scores are estimated using a generalized linear model (GLM) with a probit link, based on the percentage of individuals with a Bachelor's degree and the population density. These two covariates were selected because they have the highest predictive power for selection into the treatment, as shown in Table A.11. Each treated unit is matched to five control units with the closest propensity scores, allowing for replacement, meaning that control units can be reused across multiple treated units. This approach increases the pool of matched controls for each treated unit, enhancing covariate balance while potentially increasing variance in subsequent analyses. To evaluate the success of the matching, balance is assessed using standardized mean differences (SMD) across various covariates. The balance before and after matching is reported in Appendix Figure A.10. The weights derived from the matching process will be applied in subsequent analyses to account for the matching design and ensure accurate estimation of treatment effects.

The analysis using the matched sample aligns with the main results, showing no substantial shift in the magnitude of the effect. Appendix Tables A.1 through A.8 present the results using the matched sample. Similarly, the event-study analysis indicates that the dynamic effects and parallel trends remain consistent when using the matched sample, as illustrated in Appendix Figures A.2, A.5, and A.8.

7 Conclusion

Despite growing policy interest in equitable access to public transportation within U.S. cities, the specific impacts of reduced-fare programs on mental health in low-income communities have received limited empirical attention. This paper addresses this gap by estimating the impact of reducing public transit costs on mental health in low-income census tracts within treated cities, and it explores healthcare utilization and unemployment rates as potential mechanisms. The analysis employs a triple-difference-in-differences model and an event-study framework to establish causal evidence, supplemented by matching techniques for a more robust analysis.

The results demonstrate that low-income neighborhoods benefit significantly from reduced-fare programs. Compared to their counterfactual, treated census tracts in the 1st quartile of the city income distribution experience a 2.65% reduction in the percentage of individuals reporting poor mental health, relative to the mean. This improvement appears to be driven by an increase in healthcare utilization and a decline in unemployment. Specifically, the treatment raises the healthcare utilization index in low-income neighborhoods by 1.39% and the percentage of individuals receiving a health checkup by 0.915%, both relative to the outcome mean. Additionally, reduced fares seem to reduce unemployment rates by 1.15 percentage points within census tracts in the 1st quartile of the city income distribution, where the magnitude of the effect corresponds to 8.51% of the mean unemployment rate in low-income tracts and 12% of the total mean unemployment rate. These findings contribute to the literature by offering empirical evidence on how financial relief in transportation costs can enhance well-being in economically disadvantaged areas, complementing existing experimental evidence and research on public transit accessibility.

While this paper provides evidence on the mental health benefits of reduced-fare programs, including insights into healthcare utilization and unemployment as potential mechanisms, several additional questions remain for future research. For instance, future studies could examine how reduced public transit costs influence travel behavior among low-income individuals, exploring whether these programs lead to increased access to essential services, or if they also encourage additional trips for leisure and social activities. It would also be valuable to understand whether improved mental health outcomes arise primarily from increased disposable income or directly from easing an additional financial burden. Additionally, examining whether reduced-fare programs lower job search costs or expand job opportunities for low-income residents could deepen our understanding of the broader economic impacts of these initiatives.

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8 Figures and Tables

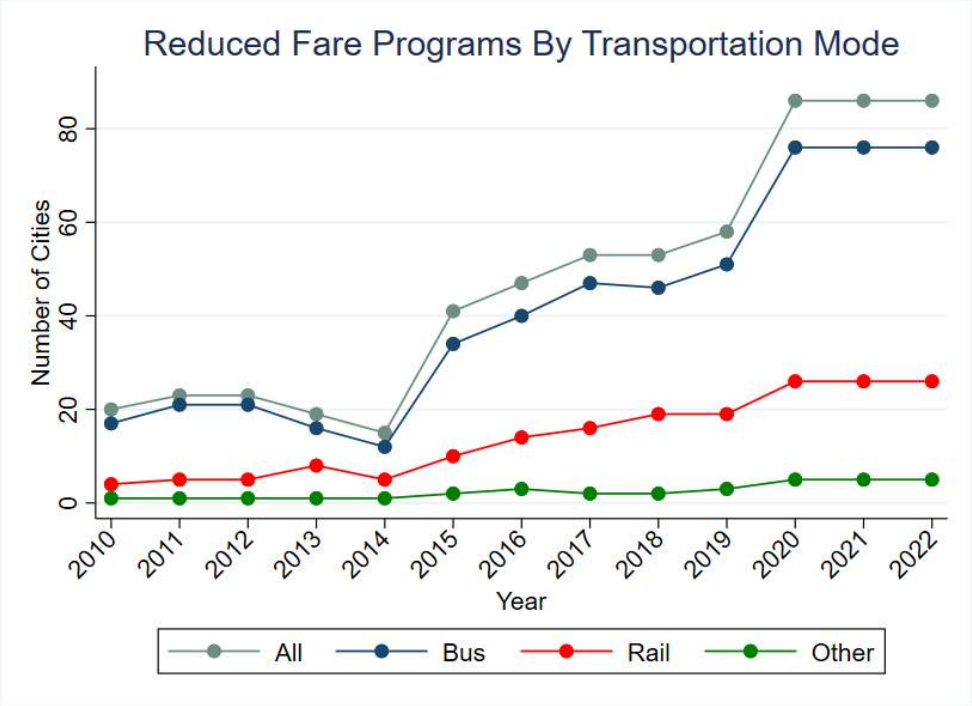


Figure 1: This figure reports the total number of cities adopting any type of reduced-fare programs between the years 2010 and 2022. The dark blue plot represents the total number of cities having fare reduction in their bus transit agencies. Whereas, the red plot shows the number of cities having fare reduction within their rail agencies

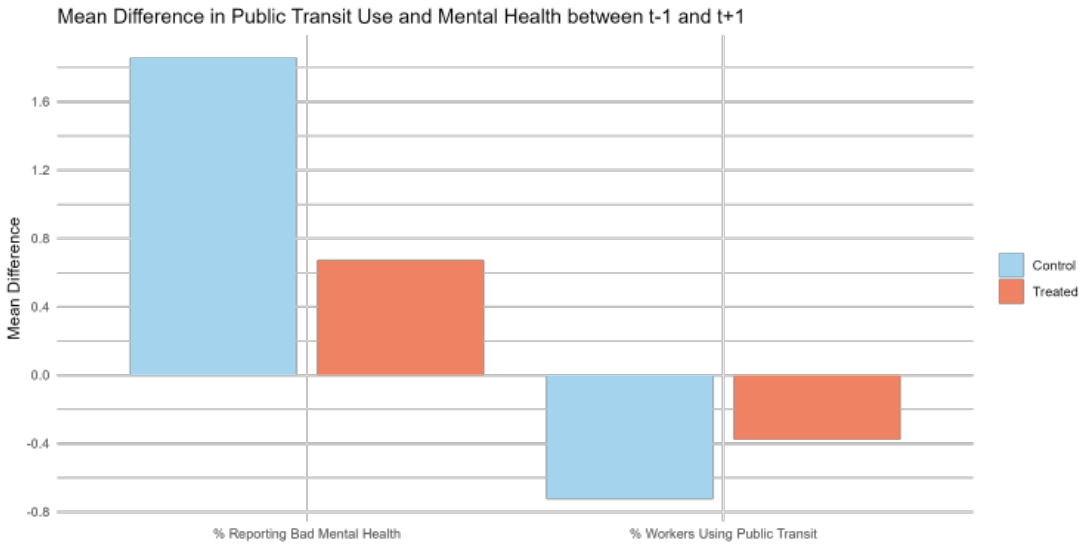


Figure 2: Mean Difference in Public Transit Use and Mental Health between $t-1$ and $t+1$. The figure compares the mean difference in the percentage of individuals reporting poor mental health and the percentage of workers using public transit between treated and control cities. While mental health outcomes have generally worsened, the increase is less pronounced in treated cities. Similarly, the decline in public transit use is less severe in treated cities.

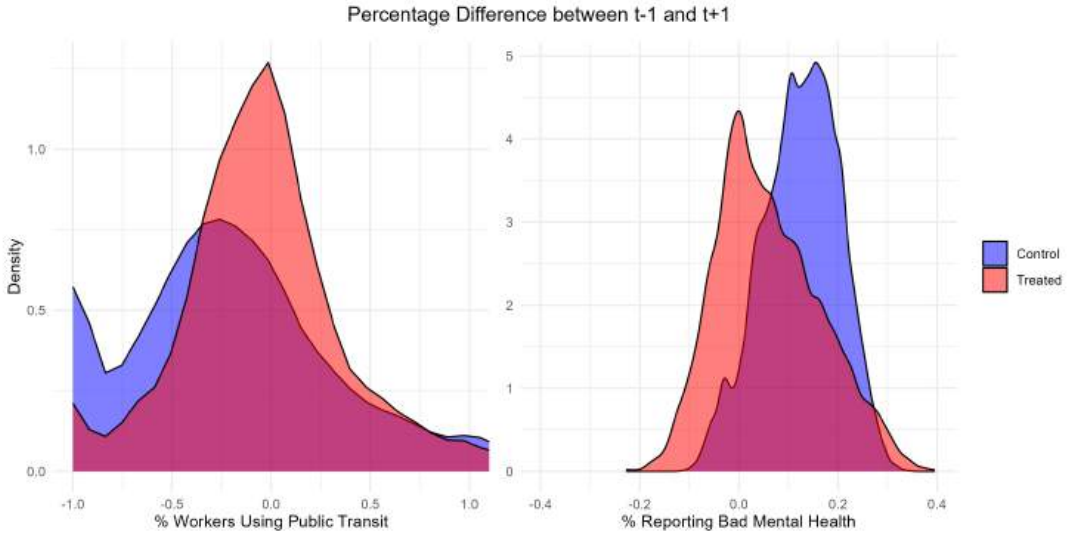
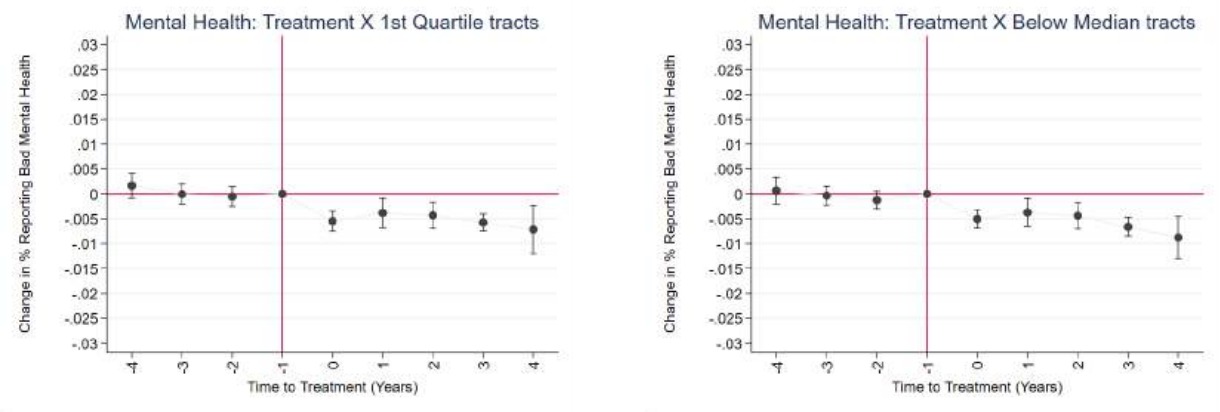
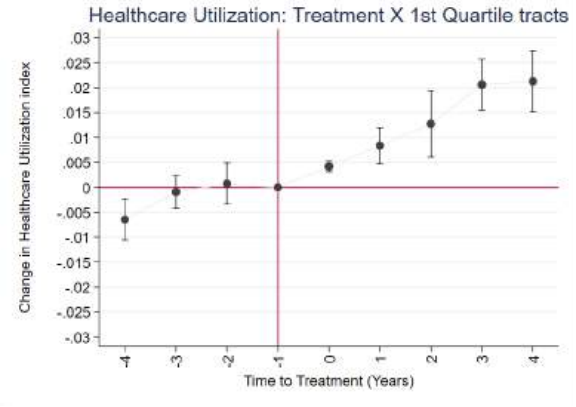


Figure 3: Distribution of Percentage Differences in Public Transit Use and Mental Health between $t-1$ and $t+1$. The density plots illustrate the distribution of changes in mental health outcomes and public transit use for treated and control cities. Treated cities show smaller increases in poor mental health and a softer decline in public transit usage, suggesting a mitigating effect of fare reduction programs.

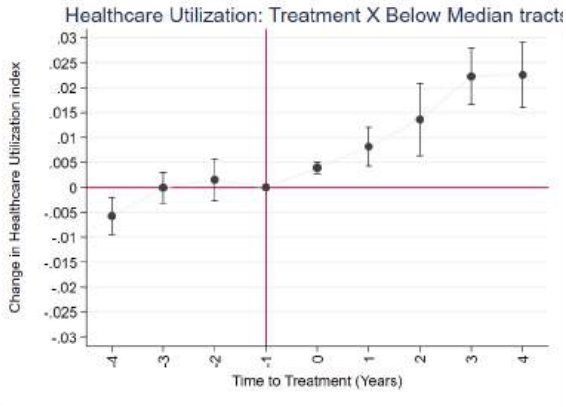


Panel A Panel B

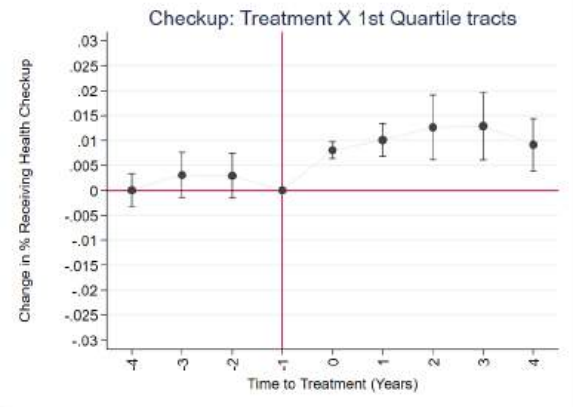
Figure 4: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the % of individuals reporting bad mental health relative to the period before the treatment. In Panel A the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in Panel B the low-income tracts are defined as the tracts below city median income. This event study includes both census tracts and city-by-year fixed effects. The coefficient at $t = -1$ is normalized to zero.



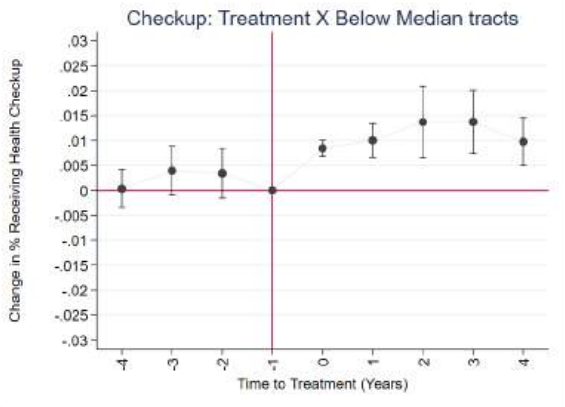
Panel A



Panel B

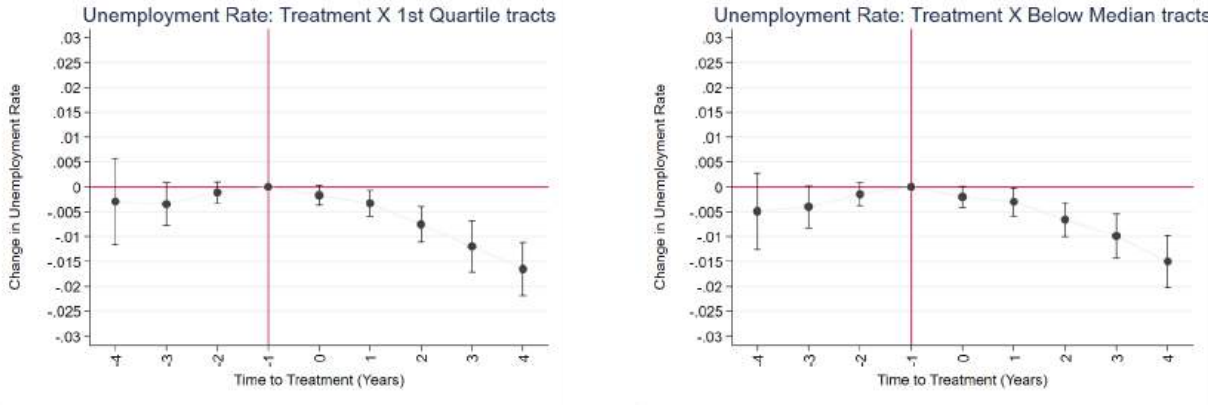


Panel C



Panel D

Figure 5: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the healthcare utilization index relative to the period before the treatment. Panels C and D report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the % of individuals getting a health checkup relative to the period before the treatment. In panels A and C the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in panels B and D the low-income tracts are defined as the tracts below city median income. These event studies include both census tracts and city-by-year fixed effects. The coefficient at $t = -1$ is normalized to zero.



Panel A Panel B

Figure 6: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the unemployment rate relative to the period before the treatment. In Panel A the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in Panel B the low-income tracts are defined as the tracts below city median income. This event study includes both census tracts and city-by-year fixed effects. The coefficient at $t = -1$ is normalized to zero.

Table 1: Impact of Reduced Fare programs on Mental Health (1st Quartile)

	Outcome: % Individuals reporting bad mental health					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000168	-0.000144	0.0000341			
	(0.0021)	(0.0021)	(0.0028)			
Treatment X 1st Quartile Tracts				-0.00376**	-0.00396**	-0.00404**
				(0.0016)	(0.0017)	(0.0017)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	132107	131652	33549	132105	131980	131980
Clusters	180	180	180	180	180	180
Adj. R^2	0.928	0.930	0.869	0.928	0.929	0.953
Outcome mean	0.152	0.152	0.184	0.152	0.152	0.152
Outcome Mean for 1st Quartile	0.184	0.184	0.184	0.184	0.184	0.184

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on self-reported mental health in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Impact of Reduced Fare programs on Mental Health (Below Median)

	Outcome: % Individuals reporting bad mental health					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000168	-0.000144	0.0000382			
	(0.0021)	(0.0021)	(0.0026)			
Treatment X Below Median Tracts				-0.00363*	-0.00382*	-0.00363*
				(0.0021)	(0.0021)	(0.0019)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	132107	131652	69877	132105	131980	131980
Clusters	180	180	180	180	180	180
Adj. R^2	0.928	0.930	0.891	0.928	0.929	0.953
Outcome mean	0.152	0.152	0.173	0.152	0.152	0.152
Outcome Mean for below Income	0.173	0.173	0.173	0.173	0.173	0.173

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on self-reported mental health in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Impact of Reduced Fare programs on healthcare utilization (1st Quartile)

	Outcome: healthcare utilization Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000699	-0.000620	-0.00177			
	(0.0030)	(0.0028)	(0.0025)			
Treatment X 1st Quartile Tracts				0.00790*	0.00822*	0.00818*
				(0.0041)	(0.0042)	(0.0042)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	128350	128350	32632	128292	128292	128292
Clusters	180	180	180	180	180	180
Adj. R^2	0.939	0.941	0.922	0.939	0.940	0.975
Outcome mean	0.587	0.587	0.534	0.587	0.587	0.587
Outcome Mean for 1st Quartile	0.534	0.534	0.534	0.534	0.534	0.534

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on healthcare utilization in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Impact of Reduced Fare programs on healthcare utilization (Below Median)

	Outcome: healthcare utilization Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000699	-0.000620	-0.00156			
	(0.0030)	(0.0028)	(0.0026)			
Treatment X Below Median Tracts				0.00827*	0.00841*	0.00783*
				(0.0047)	(0.0047)	(0.0046)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	128350	128350	68154	128292	128292	128292
Clusters	180	180	180	180	180	180
Adj. R^2	0.939	0.941	0.924	0.939	0.940	0.975
Outcome mean	0.587	0.587	0.551	0.587	0.587	0.587
Outcome Mean for Below Median Income	0.551	0.551	0.551	0.551	0.551	0.551

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on healthcare utilization in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Impact of Reduced Fare programs on health checkups (1st Quartile)

	Outcome: % Individuals Getting a Health Checkup					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00331	-0.00300	-0.00449			
	(0.0049)	(0.0046)	(0.0045)			
Treatment X 1st Quartile Tracts				0.00647***	0.00659***	0.00650***
				(0.0024)	(0.0024)	(0.0024)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	131652	131652	33477	131490	131490	131490
Clusters	180	180	180	180	180	180
Adj. R^2	0.891	0.893	0.920	0.892	0.892	0.982
Outcome mean	0.710	0.710	0.707	0.710	0.710	0.710
Outcome Mean for 1st Quartile	0.707	0.707	0.707	0.707	0.707	0.707

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on the % of individuals getting an annual health checkup. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Impact of Reduced Fare programs on health checkups (Below Median)

	Outcome: % Individuals Getting a Health Checkup					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00331	-0.00300	-0.00375			
	(0.0049)	(0.0046)	(0.0045)			
Treatment X Below Median Tracts				0.00732***	0.00737***	0.00685***
				(0.0027)	(0.0027)	(0.0026)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	131652	131652	69772	131490	131490	131490
Clusters	180	180	180	180	180	180
Adj. R^2	0.891	0.893	0.913	0.892	0.892	0.982
Outcome mean	0.710	0.710	0.708	0.710	0.710	0.710
Outcome Mean for Below Median Income	0.708	0.708	0.708	0.708	0.708	0.708

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on % of individuals getting an annual health checkup. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Impact of Reduced Fare programs on Labor Outcomes (1st Quartile)

	Outcome: Unemployment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000367	-0.000329	0.00168			
	(0.0039)	(0.0032)	(0.0044)			
Treatment X 1st Quartile Tracts				-0.0154***	-0.0123***	-0.0115***
				(0.0036)	(0.0034)	(0.0032)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Low-Income	Full	Full	Full
Observations	210689	210403	53806	210214	209960	209907
Clusters	285	285	285	285	285	281
Adj. R^2	0.685	0.709	0.673	0.685	0.709	0.729
Outcome mean	0.0953	0.0952	0.135	0.0954	0.0953	0.0953
Outcome Mean for 1st Quartile	0.135	0.135	0.135	0.136	0.135	0.135

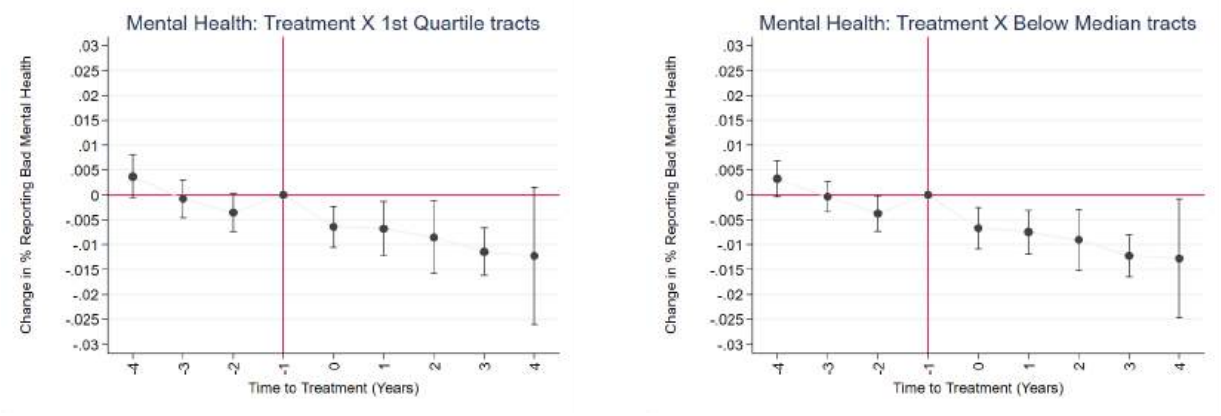
Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on the unemployment rate in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Impact of Reduced Fare programs on Labor Outcomes (Below Median)

	Outcome: Unemployment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000367	-0.000329	0.00145			
	(0.0039)	(0.0032)	(0.0041)			
Treatment X Below Median Tracts				-0.0150***	-0.0114***	-0.00892***
				(0.0036)	(0.0033)	(0.0028)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Low-Income	Full	Full	Full
Observations	210689	210403	109796	210214	209960	209907
Clusters	285	285	277	285	285	281
Adj. R^2	0.685	0.709	0.683	0.685	0.709	0.729
Outcome mean	0.0953	0.0952	0.120	0.0954	0.0953	0.0953
Outcome Mean for Below Median Income	0.120	0.119	0.120	0.120	0.120	0.120

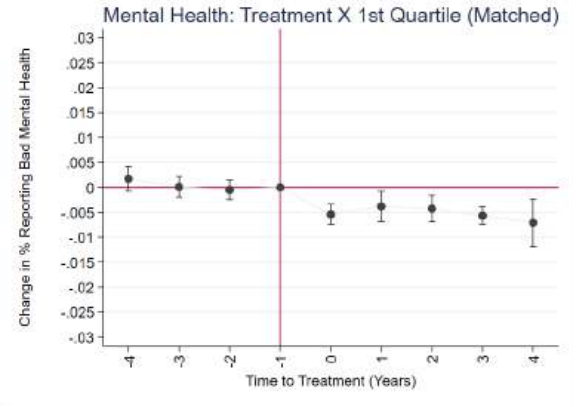
Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on the unemployment rate in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

9 Appendix Tables and Figures

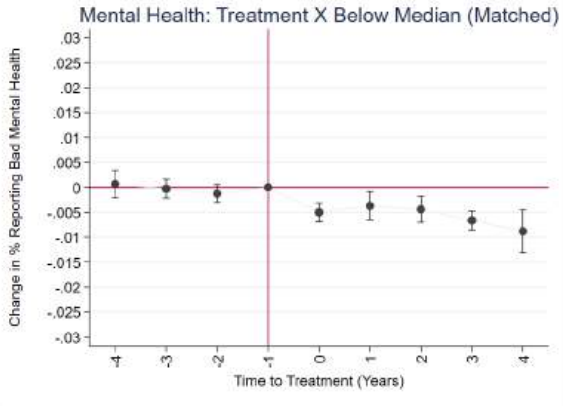


Panel A Panel B

Figure A.1: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the % of individuals reporting bad mental health relative to the period before the treatment. In Panel A the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in Panel B the low-income tracts are defined as the tracts below city median income. This event study includes both census tracts and year fixed effects. The coefficient at $t = -1$ is normalized to zero.



Panel A



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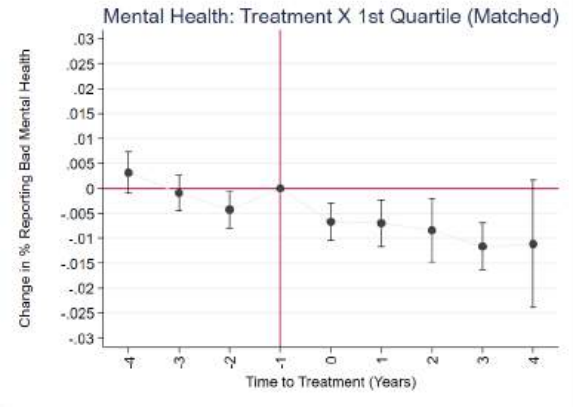
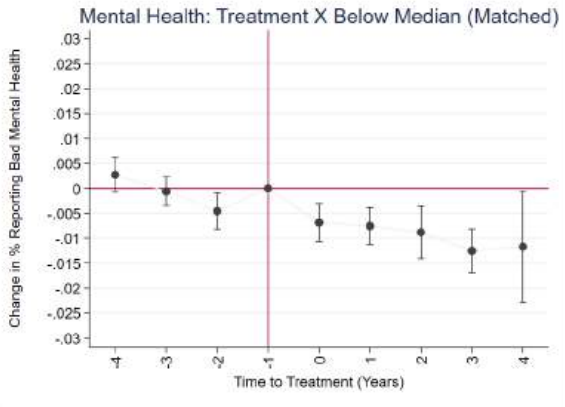
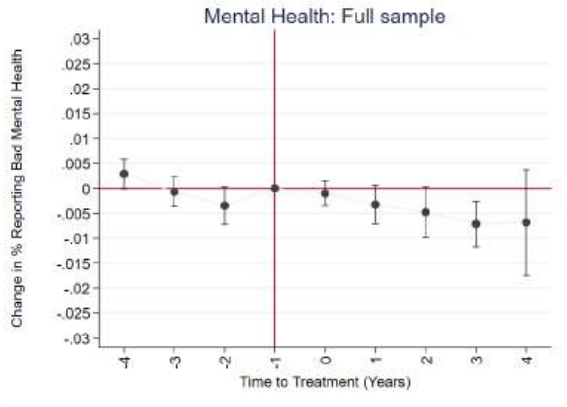


Panel C

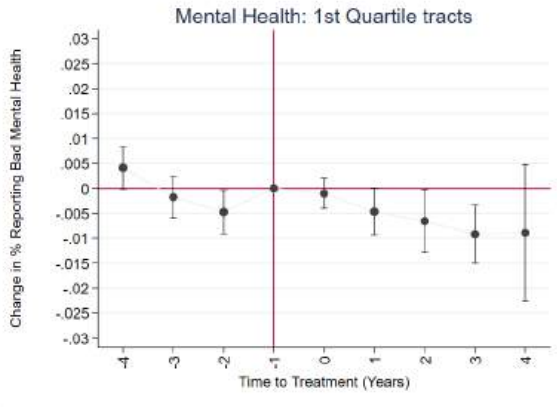


Panel D

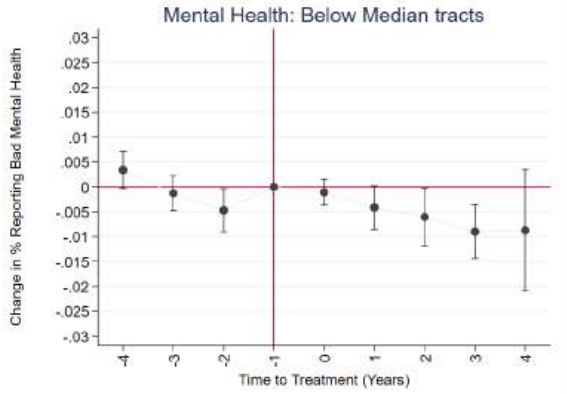
Figure A.2: These figures report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the % of individuals reporting bad mental health relative to the period before the treatment. The figures utilize the propensity score matched sample. In Panel A and C the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, panel A includes census tracts and city-by-year fixed while panel C includes census tracts and year fixed effects. In panel B and D the low-income tracts are defined as the tracts below city median income, panel B includes census tracts and city-by-year fixed while panel D includes census tracts and year fixed effects. The coefficient at $t = -1$ is normalized to zero.



Panel A

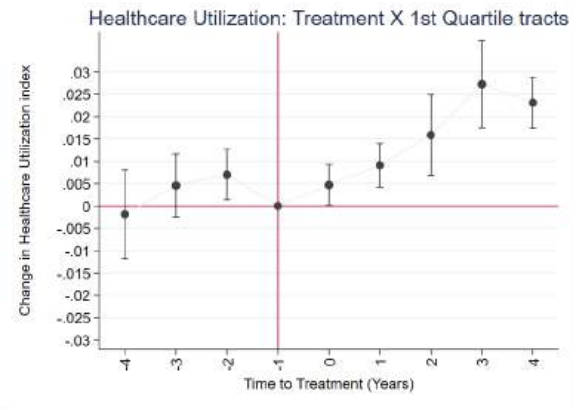


Panel B

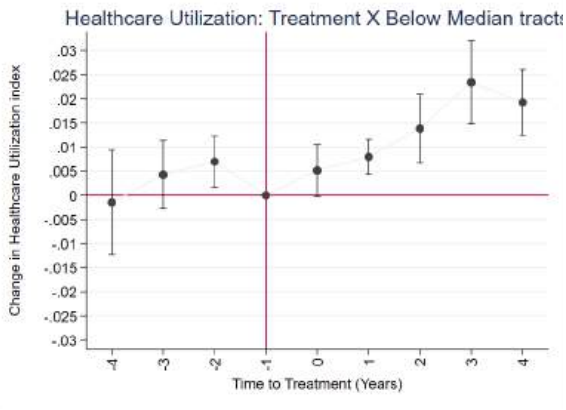


Panel C

Figure A.3: Panels A, B, and C report the regression coefficients and the associated 95% confidence intervals for the difference in the % of individuals reporting bad mental health between the treated and control census tracts relative to the period before the treatment. This figure utilizes the propensity score sample. Panel A reports the effect on the full sample of census tracts. In panel B the sample is restricted to the census tracts in the 1st quartile of the income distribution in a city, while in panel C the sample is restricted to the census tracts that are below the city median income. This event study includes both census tracts and year-fixed effects. The coefficient at $t = -1$ is normalized to zero.



Panel A



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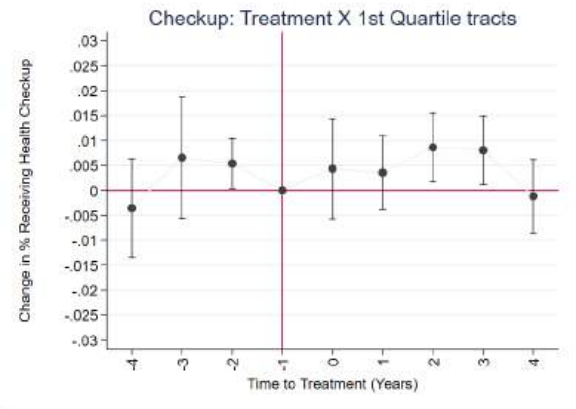
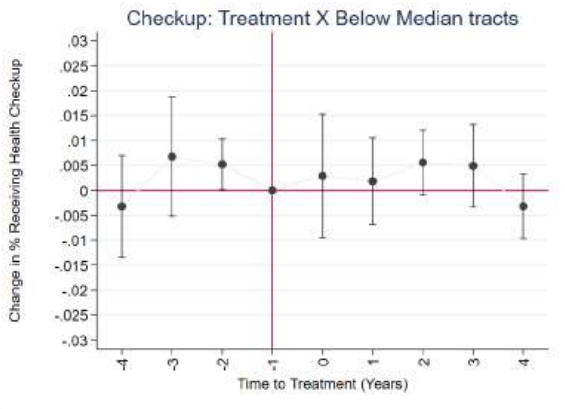
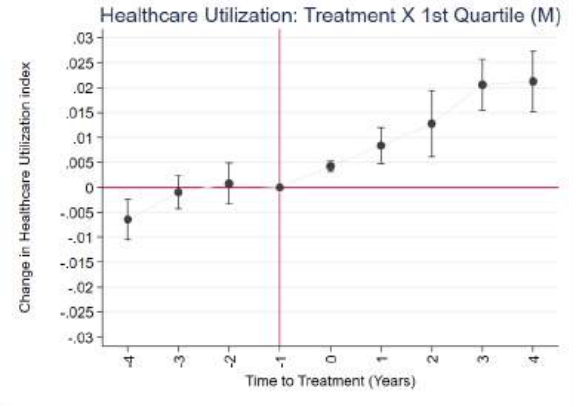


Panel C

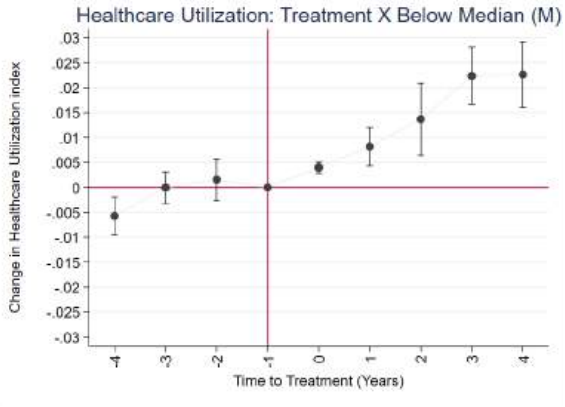


Panel D

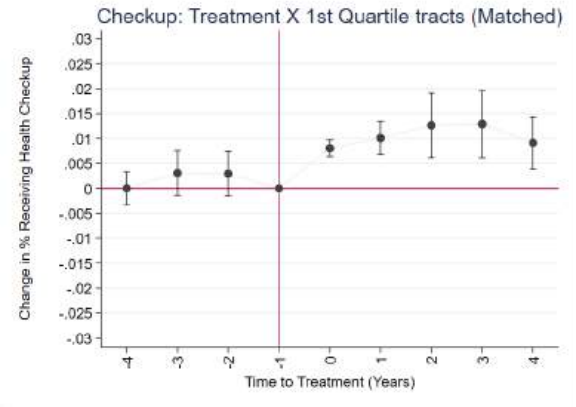
Figure A.4: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the healthcare utilization index relative to the period before the treatment. Panels C and D report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the % of individuals getting a health checkup relative to the period before the treatment. In panels A and C the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in panels B and D the low-income tracts are defined as the tracts below city median income. The event studies include both census tracts and year fixed effects. The coefficient at $t = -1$ is normalized to zero.



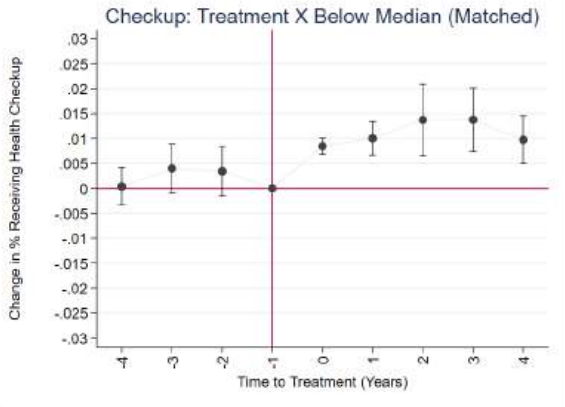
Panel A



Panel B



Panel C



Panel D

Figure A.5: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the healthcare utilization index relative to the period before the treatment. Panels C and D report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the % of individuals getting a health checkup relative to the period before the treatment. In panels A and C the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in panels B and D the low-income tracts are defined as the tracts below city median income. The event studies utilize the propensity score matched sample and include both census tracts and city-by-year fixed effects. The coefficient at $t = -1$ is normalized to zero.

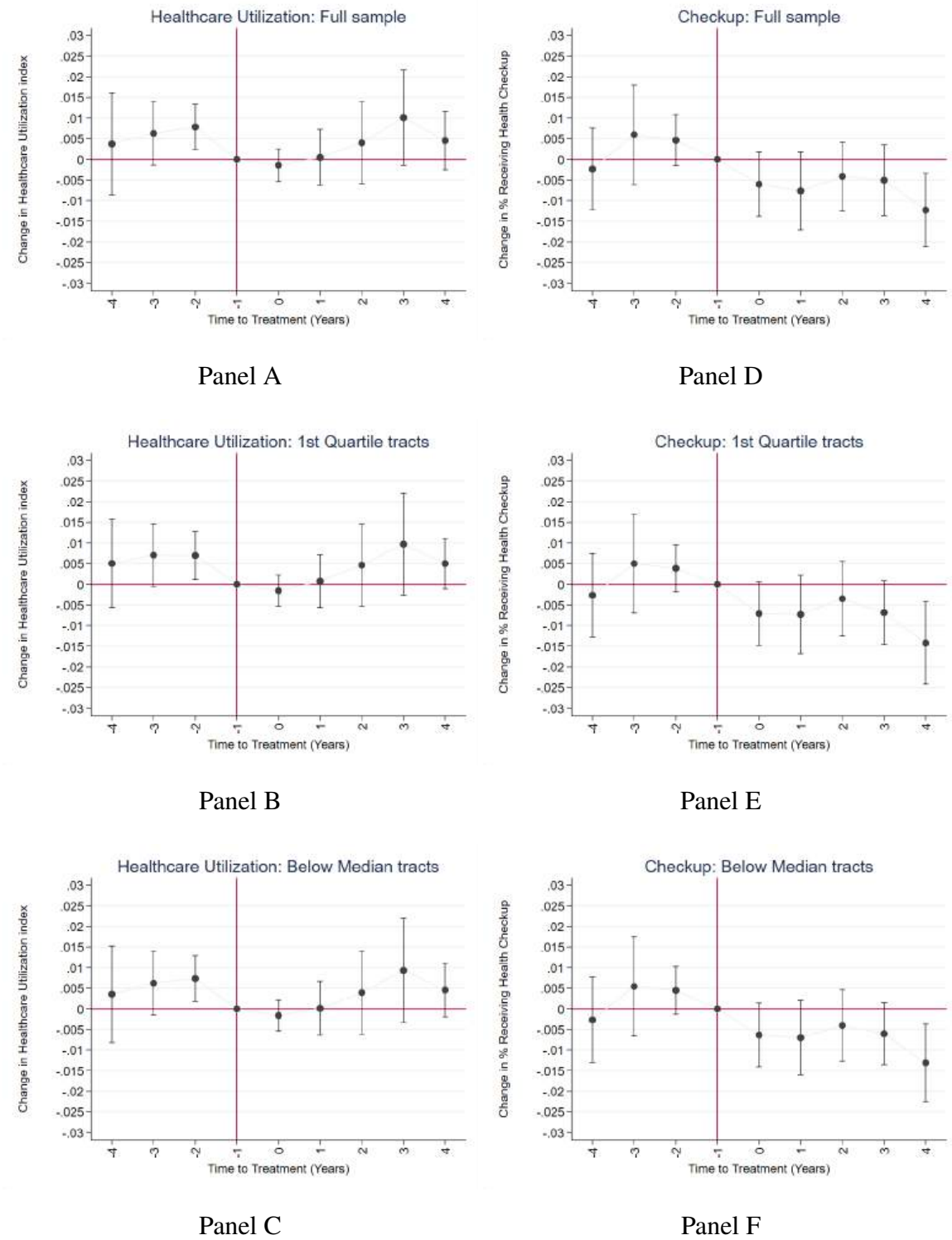
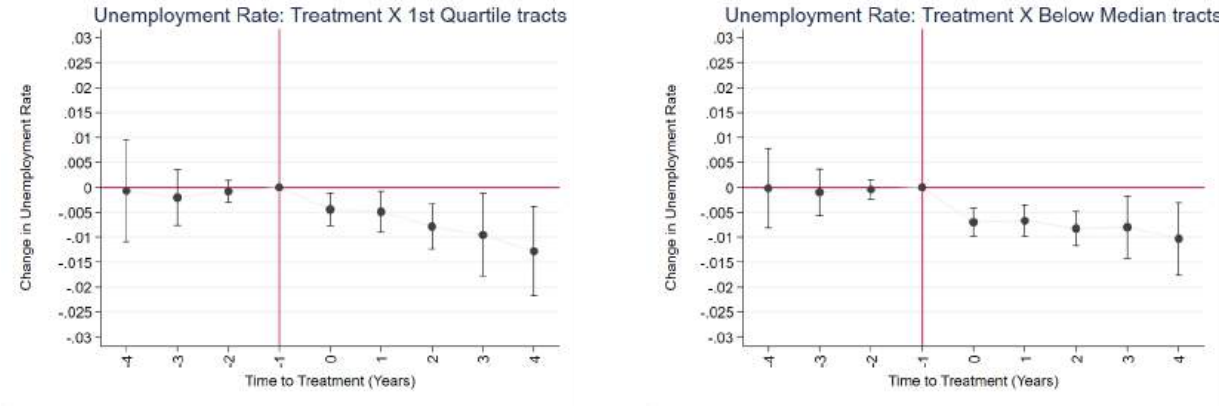
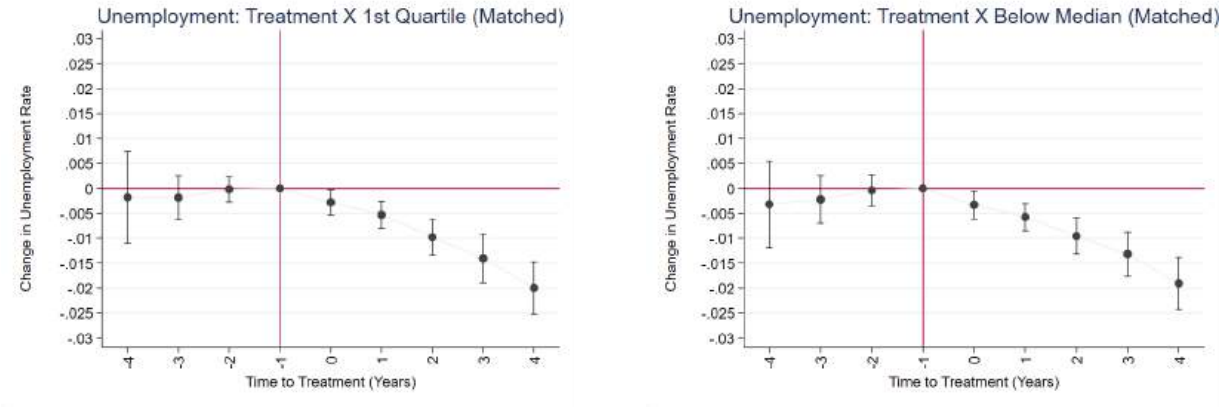


Figure A.6: Panels A, B, and C report the regression coefficients and the associated 95% confidence intervals for the difference in the healthcare utilization index between the treated and control census tracts relative to the period before the treatment. Panel A reports the effect on the full sample of census tracts. In panel B the sample is restricted to the census tracts in the 1st quartile of the income distribution in a city, while in panel C the sample is restricted to the census tracts that are below the city median income. Panels D, E, and F report the regression coefficients and the associated 95% confidence intervals for the difference in the healthcare utilization index between the treated and control census tracts relative to the period before the treatment. Panel A reports the effect on the full sample of census tracts. In panel B the sample is restricted to the census tracts in the 1st quartile of the income distribution in a city, while in panel C the sample is restricted to the census tracts that are below the city median income. The event studies include both census tracts and year-fixed effects. The coefficient at $t = -1$ is normalized to zero.



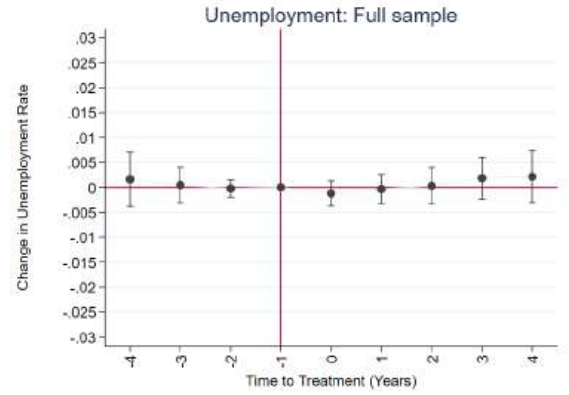
Panel A Panel B

Figure A.7: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the unemployment rate relative to the period before the treatment. In Panel A the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in Panel B the low-income tracts are defined as the tracts below city median income. This event study includes both census tracts and year fixed effects. The coefficient at $t = -1$ is normalized to zero.

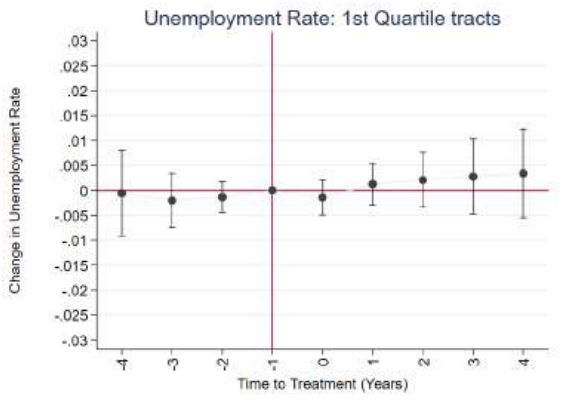


Panel A Panel B

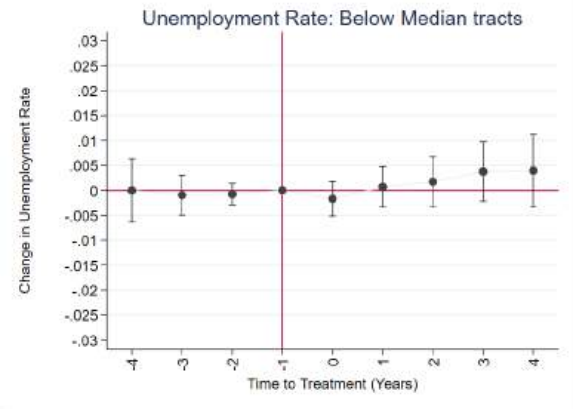
Figure A.8: Panels A and B report the regression coefficients and the associated 95% confidence intervals for the interaction between treatment and low-income tracts on the unemployment rate relative to the period before the treatment. In Panel A the low-income tracts are defined as the tracts in the 1st quartile of the income distribution in a city, while in Panel B the low-income tracts are defined as the tracts below city median income. The event studied utilize the propensity score matched sample and include both census tracts and city-by-year fixed effects. The coefficient at $t = -1$ is normalized to zero.



Panel A



Panel B



Panel C

Figure A.9: Panels A, B, and C report the regression coefficients and the associated 95% confidence intervals for the difference in the unemployment rate between the treated and control census tracts relative to the period before the treatment. Panel A reports the effect on the full sample of census tracts. In panel B the sample is restricted to the census tracts in the 1st quartile of the income distribution in a city, while in panel C the sample is restricted to the census tracts that are below the city median income. The event studies include both census tracts and year-fixed effects. The coefficient at $t = -1$ is normalized to zero.

Table A.1: Impact of Reduced Fare programs on Mental Health (Matched Sample)

	Outcome: % Individuals reporting bad mental health					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.000741	0.000763	0.0000494			
	(0.0020)	(0.0020)	(0.0028)			
Treatment X 1st Quartile Tracts				-0.00376**	-0.00393**	-0.00403**
				(0.0016)	(0.0017)	(0.0017)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	107703	107586	27781	107703	107697	107697
Clusters	180	180	180	180	180	180
Adj. R^2	0.924	0.925	0.863	0.924	0.925	0.952
Outcome mean	0.151	0.151	0.183	0.151	0.151	0.151
Outcome Mean for 1st Quartile	0.183	0.183	0.183	0.183	0.183	0.183

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on self-reported mental health in U.S. cities, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Impact of Reduced Fare programs on Mental Health (Matched Sample)

	Outcome: % Individuals reporting bad mental health					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.000741	0.000763	0.000839			
	(0.0020)	(0.0020)	(0.0025)			
Treatment X Below Median Tracts				-0.00360*	-0.00378*	-0.00359*
				(0.0021)	(0.0021)	(0.0019)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	107703	107586	57807	107703	107697	107697
Clusters	180	180	180	180	180	180
Adj. R^2	0.924	0.925	0.886	0.924	0.925	0.952
Outcome mean	0.151	0.151	0.172	0.151	0.151	0.151
Outcome Mean for Below Median Income	0.172	0.172	0.172	0.172	0.172	0.172

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on self-reported mental health in U.S. cities, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3: Impact of Reduced Fare programs on healthcare utilization (Matched Sample)

	Outcome: healthcare utilization Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00115	-0.00108	-0.00102			
	(0.0034)	(0.0032)	(0.0025)			
Treatment X 1st Quartile Tracts				0.00787*	0.00818*	0.00819*
				(0.0041)	(0.0042)	(0.0042)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	105119	105023	27066	105119	105113	105113
Clusters	180	180	180	180	180	180
Adj. R^2	0.941	0.943	0.931	0.942	0.943	0.976
Outcome mean	0.585	0.585	0.534	0.585	0.585	0.585
Outcome Mean for 1st Quartile	0.534	0.534	0.534	0.534	0.534	0.534

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on healthcare utilization in U.S. cities, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Table A.4: Impact of Reduced Fare programs on healthcare utilization (Matched Sample)

	Outcome: healthcare utilization Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00115	-0.00108	-0.00143			
	(0.0034)	(0.0032)	(0.0027)			
Treatment X Below Median Tracts				0.00805*	0.00819*	0.00785*
				(0.0046)	(0.0047)	(0.0046)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	105119	105023	56466	105119	105113	105113
Clusters	180	180	180	180	180	180
Adj. R^2	0.941	0.943	0.929	0.942	0.943	0.976
Outcome mean	0.585	0.585	0.550	0.585	0.585	0.585
Outcome Mean for Below Median Income	0.550	0.550	0.550	0.550	0.550	0.550

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on healthcare utilization in U.S. cities, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5: Impact of Reduced Fare programs on health checkups (Matched Sample)

	Outcome: % Individuals Getting a Health Checkup					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00121	-0.00102	-0.00164			
	(0.0045)	(0.0043)	(0.0042)			
Treatment X 1st Quartile Tracts				0.00650***	0.00660***	0.00648***
				(0.0024)	(0.0024)	(0.0024)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	107703	107586	27781	107703	107697	107697
Clusters	180	180	180	180	180	180
Adj. R^2	0.901	0.902	0.925	0.901	0.902	0.984
Outcome mean	0.709	0.709	0.705	0.709	0.709	0.709
Outcome Mean for 1st Quartile	0.706	0.706	0.705	0.706	0.705	0.705

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on the % of individuals getting an annual health checkup, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Impact of Reduced Fare programs on health checkups (Matched Sample)

	Outcome: % Individuals Getting a Health Checkup					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00121	-0.00102	-0.00124			
	(0.0045)	(0.0043)	(0.0041)			
Treatment X Below Median Tracts				0.00717***	0.00719***	0.00684***
				(0.0027)	(0.0026)	(0.0026)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	107703	107586	57807	107703	107697	107697
Clusters	180	180	180	180	180	180
Adj. R^2	0.901	0.902	0.920	0.901	0.902	0.984
Outcome mean	0.709	0.709	0.706	0.709	0.709	0.709
Outcome Mean for Below Median Income	0.706	0.706	0.706	0.706	0.706	0.706

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on % of individuals getting an annual health checkup, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: Impact of Reduced Fare programs on Labor Outcomes (Matched Sample)

	Outcome: Unemployment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000220	-0.000391	-0.000892			
	(0.0037)	(0.0034)	(0.0051)			
Treatment X 1st Quartile Tracts				-0.0154***	-0.0151***	-0.0152***
				(0.0037)	(0.0034)	(0.0035)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	1st Quartile	Full	Full	Full
Observations	182837	182837	46851	182774	182774	182708
Clusters	283	283	280	283	283	278
Adj. R^2	0.697	0.707	0.694	0.698	0.706	0.727
Outcome mean	0.0955	0.0955	0.136	0.0955	0.0955	0.0955
Outcome Mean for 1st Quartile	0.136	0.136	0.136	0.136	0.136	0.136

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on the unemployment rate in U.S. cities, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8: Impact of Reduced Fare programs on Labor Outcomes (Matched Sample)

	Outcome: Unemployment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.000220	-0.000391	-0.0000393			
	(0.0037)	(0.0034)	(0.0043)			
Treatment X Below Median Tracts				-0.0148***	-0.0147***	-0.0136***
				(0.0036)	(0.0034)	(0.0033)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Below Median	Full	Full	Full
Observations	182837	182837	95792	182774	182774	182708
Clusters	283	283	275	283	283	278
Adj. R^2	0.697	0.707	0.690	0.698	0.706	0.728
Outcome mean	0.0955	0.0955	0.120	0.0955	0.0955	0.0955
Outcome Mean for Below Median Income	0.120	0.120	0.120	0.120	0.120	0.120

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on the unemployment rate in U.S. cities, using the matched sample. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "Below Median" only includes census tract with household median income below the city median income in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Impact of Reduced Fare programs on Female Labor Outcomes

	Outcome: Female Unemployment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.00794	-0.00699	-0.0112			
	(0.0075)	(0.0069)	(0.0108)			
Treatment X 1st Quartile Tracts				-0.00698	-0.0105	-0.0103
				(0.0073)	(0.0075)	(0.0076)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Low-Income	Full	Full	Full
Observations	177725	177623	45546	177285	177192	177147
Clusters	285	285	285	285	285	281
Adj. R^2	0.595	0.603	0.670	0.595	0.602	0.619
Outcome mean	0.139	0.139	0.169	0.139	0.139	0.139
Outcome Mean for 1st Quartile	0.193	0.192	0.192	0.193	0.192	0.192

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on female unemployment rate in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.10: Impact of Reduced Fare programs on Male Labor Outcomes

	Outcome: Male Unemployment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.00347	0.00269	0.00332			
	(0.0050)	(0.0036)	(0.0066)			
Treatment X 1st Quartile Tracts				-0.0297***	-0.0237***	-0.0231***
				(0.0060)	(0.0057)	(0.0056)
Controls	No	C1	C2	No	C2	C2
Tract Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
City by Year Fixed Effects	No	No	No	No	No	Yes
Sample	Full	Full	Low-Income	Full	Full	Full
Observations	208929	208816	53107	208493	208389	208336
Clusters	285	285	285	285	285	281
Adj. R^2	0.384	0.393	0.394	0.384	0.393	0.400
Outcome mean	0.0992	0.0991	0.144	0.0993	0.0992	0.0992
Outcome Mean for 1st Quartile	0.177	0.177	0.177	0.177	0.177	0.177

Note: This table presents difference-in-differences regression results examining the influence of reduced fare public transportation on male unemployment rate in U.S. cities. The unit of observation is the census tract while the treatment level is a city. The set of control variables "C1" includes % of individuals above 25 years who hold a bachelor's degree, % of workers in finance, % of workers in retail and trade, % of workers in information, household median income, population density. Whereas "C2" excludes household median income. In column (3), the sample "1st Quartile" only includes census tract with household median income in the 1st quartile of city income distribution in 2010. Columns (1) to (3) present the results from the basic difference-in-difference model, while columns (4) to (6) present the results from the main Triple difference-in-difference framework. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.11: Impact of Reduced Fare Programs on Mental Health (1st Quartile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
% Workers using Public Transit	0.0596**										-0.0107
	(0.0251)										(0.0514)
% Uninsured		0.0142									-0.0110
		(0.0254)									(0.0337)
Mean Time To Work			0.00514								0.00154
			(0.0254)								(0.0404)
% With BA or Higher				0.0783***							0.112***
				(0.0250)							(0.0426)
Median Income					0.0255						-0.0527
					(0.0253)						(0.0497)
Population Density						0.0578**					0.0681
						(0.0251)					(0.0477)
% In Construction							-0.0190				0.0240
							(0.0254)				(0.0340)
% In Retail Trade								-0.0441*			-0.0135
								(0.0252)			(0.0285)
% In Information									0.0434*		0.00576
									(0.0252)		(0.0298)
% In Finance										0.0274	0.00655
										(0.0253)	(0.0330)
Observations	285	285	285	285	285	285	285	285	285	285	285
Adj. R^2	0.0161	-0.00243	-0.00339	0.0302	0.0000374	0.0148	-0.00155	0.00718	0.00685	0.000584	0.0267

Note: This table is generated by regressing the treatment dummy on various baseline covariates to assess potential selection into treatment using the full sample. Each baseline covariate is individually regressed on the treatment dummy, adjusting for census tract fixed effects and year fixed effects, while clustering standard errors at the city level. The F-test for joint significance of the baseline variables shows that they are jointly significant predictors of treatment assignment (F(10, 274) = 1.78 Prob > F =0.0642

Table A.12: Healthcare Utilization Index

Service	**Description**
CHECKUP	Visits to doctor for routine checkup within the past year among adults aged $\geq$ 18 years
CHOLSCREEN	Cholesterol screening among adults aged $\geq$ 18 years
COLON_SCREEN	Colorectal cancer screening among adults aged 50-75 years
COREM	Older adult men aged $\geq$ 65 years who are up to date on a core set of clinical preventive services
COREW	Older adult women aged $\geq$ 65 years who are up to date on a core set of clinical preventive services
DENTAL	Visits to dentist or dental clinic among adults aged $\geq$ 18 years
MAMMOUSE	Mammography use among women aged 50-74 years

Note: An equally weighted healthcare utilization index is created using the 7 variables listed in this table. The variables are in the form of percentages within census tracts. The variable CHECKUP is available annually from year 2014 through 2022, CHOLSCREEN is available only in odd years, while the rest of the variables are available only in even years.

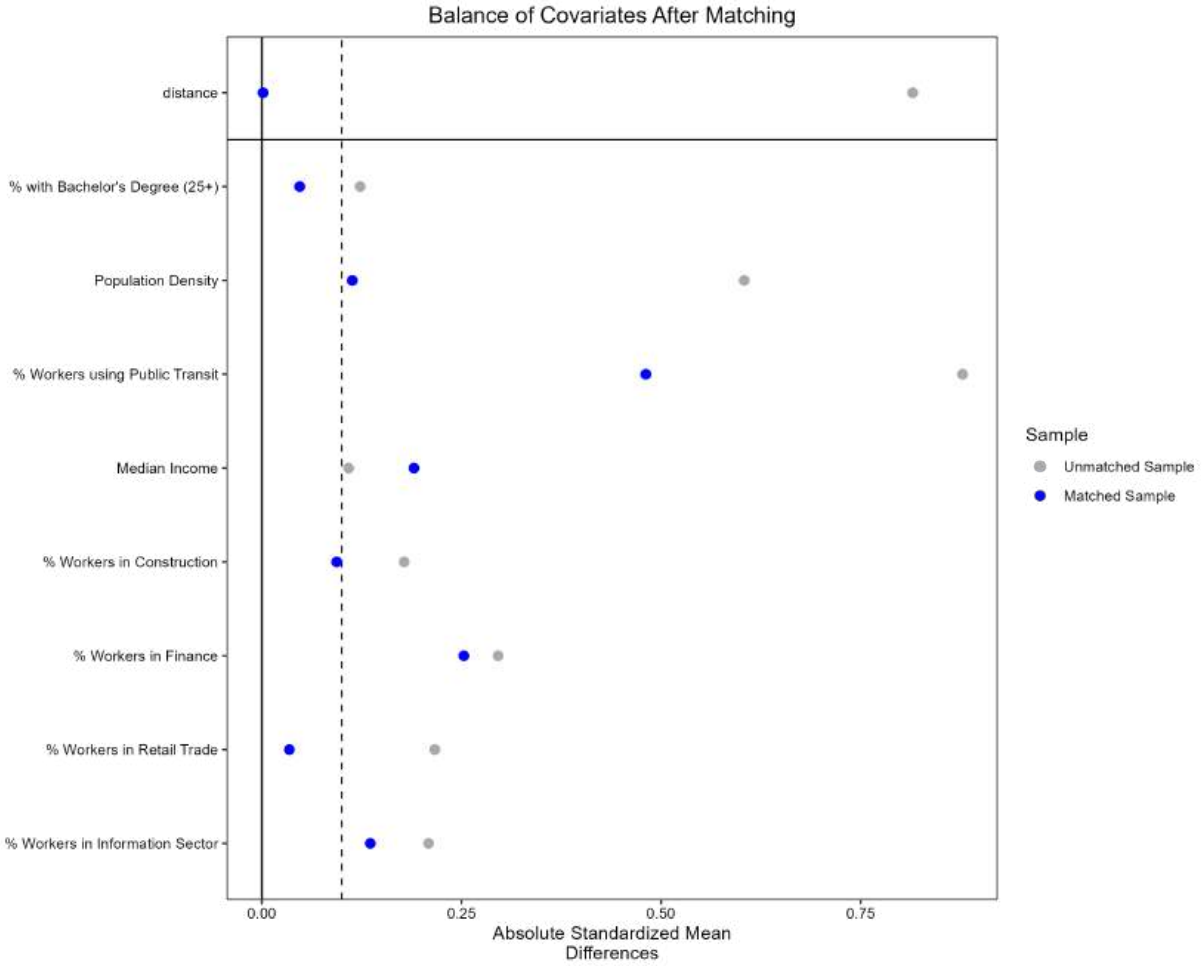


Figure A.10: Balance of covariates before and after 5:1 nearest neighbor propensity score matching. The plot shows the absolute standardized mean differences for each covariate before (gray points) and after (blue points) matching. The vertical dashed line represents the threshold of 0.1, indicating acceptable balance. Covariates include demographic, economic, and workforce characteristics, with improved balance observed for most variables after matching.

Digital Content Analysis of Tourism on Social Media

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Abstract

This research investigates the content characteristics employed in tourism-oriented social media pages. The findings indicate that content predominantly manifests in Entertainment and Inspiration categories, typically conveyed through Emotional and Awareness-oriented formats. The most prevalent narrative structures identified are Before-After-Bridge and Three-Act Structure, with content frequently depicting travel experiences characterized by challenges, cultural immersion, and self-discovery processes. Furthermore, the analysis reveals that Educational content provides pragmatic travel information, including itineraries, reservation procedures, routes, and destination-specific data. Persuasive content appears with less frequency and is generally integrated subtly in the form of endorsements for community enterprises or tourism services. The research also demonstrates platform-specific content differentiation, with abbreviated content on Instagram (Reels) and TikTok prioritizing engagement metrics, while extended content on Facebook and YouTube emphasizes comprehensive narratives featuring high-resolution visual media to showcase scenic landscapes, culinary offerings, and cultural activities that promote community-based tourism initiatives.

Keywords: Digital Content, Content Marketing, Storytelling, Social Media, Tourism

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Background

In an era where digital technology plays a crucial role in all aspects of daily life, communication and information sharing through social media have significantly transformed consumer behavior, particularly in the tourism sector which relies on information dissemination and experiential sharing to attract tourists. Social media has become an essential tool for tourism businesses and agencies to create awareness about destinations and generate interest in various attractions. These platforms enable rapid and widespread dissemination of information and imagery to target audiences, propelling tourism into a rapidly growing industry with intensified competition. Tourism represents one of the consistently expanding industries globally. With advancements in information and communication technologies, social media has emerged as a vital instrument for publicity, promotion, and stimulation of interest in various tourist destinations. Both domestic and international tourists frequently rely on social media to research travel destinations, reviews, and recommendations from actual users, making digital content created and distributed on social media platforms instrumental in tourists' decision-making processes. According to data from We Are Social and Hootsuite in 2023, global social media users numbered approximately 4.76 billion, a figure that continues to increase annually. Among the most popular content categories is tourism-related material. Consequently, marketing communications in the tourism industry have evolved in accordance with consumer behavior trends that utilize digital media for information gathering and decision-making. (We Are Social and Hootsuite, 2023) The importance of creating high-quality digital content has thus become a critical factor in promoting tourism. Furthermore, tourism-related content on social media platforms influences users' perceptions, destination image formation, and the construction of travel experiences. (Amaro, S., Duarte, P., and Henriques, C., 2016) The creation of digital content for tourism promotion has become an indispensable element in contemporary marketing strategies. Internet accessibility has significantly facilitated tourists' decision-making processes. Content presentation through digital media including social media platforms, travel websites, blogs, and travel applications has evolved into an essential instrument for promoting tourist destinations globally. This is particularly effective when such content is strategically designed to align with target demographics. Effective communication through digital content enhances the impact of tourism marketing and substantially expands reach to potential tourists. (Xiang, Z., and Gretzel, U., 2010) Contemporary tourists exhibit information-seeking and travel planning behaviors that

markedly differ from historical patterns. They have shifted from relying predominantly on tour operators or traditional media advertisements to increasingly utilizing online channels for information acquisition, such as reading reviews from fellow travelers, viewing destination review videos, or following tourism-focused influencers. The accessibility of such information not only facilitates tourists' selection of appropriate destinations but also generates inspiration and stimulates interest in locations they might not have previously considered. (Buhalis, D., and Law, R., 2008) Moreover, this transformation necessitates adaptation by tourism industry entrepreneurs to align with technological advancements and evolving consumer behaviors. The creation of content that effectively addresses tourists' needs has gained heightened significance, particularly content capable of facilitating communication and interaction. Examples include experiential delivery through virtual reality technology that enables tourists to engage with destinations prior to physical visitation, the utilization of high-resolution photography and videography, the narration of compelling stories about local cultures and communities, and the provision of insightful, beneficial information derived from tourists' direct experiences. (Hays, S. et al., 2013)

One of the primary significances of digital content creation for tourism promotion lies in generating motivation and leaving a favorable impression on tourists, particularly when presented through social media channels. Content delivered in photographic or video formats effectively evokes emotional responses from viewers. The utilization of aesthetically pleasing imagery and creatively produced videos can rapidly instill excitement and desire in tourists to visit specific destinations. The strategic deployment of digital media capable of creating impactful first impressions constitutes a crucial competitive advantage for tourist destinations in the global marketplace. Effective digital content not only motivates travel but also stimulates tourist interest in local cultural practices and community lifestyles, thereby promoting cultural and experiential tourism. The presentation of narratives concerning community livelihoods, indigenous cultures, and lesser-known attractions can engender in tourists a sense that their journey represents a unique and valuable experience. Content that authentically portrays destinations from intimate and realistic perspectives tends to attract tourists more effectively than conventional commercial advertisements. Social media platforms are fundamentally important in digital content creation for tourism promotion, as they provide channels through which tourists can easily access and interact with content. Communication via social media platforms such as Facebook, Instagram, or YouTube enables

tourists to share their travel experiences, generate comments, and distribute engaging content to their connections and followers. Content strategically designed for social media can rapidly generate interest and engagement from target demographics. The application of appropriate hashtags or the presentation of narratives in concise and distinct formats facilitates wider content discovery and dissemination. (Kaplan, A. M., and Haenlein, M., 2010) Furthermore, entrepreneurs can utilize data from social media platforms to analyze tourist behaviors and interests, subsequently employing this information to enhance service provision or develop marketing strategies more precisely aligned with tourist requirements. For instance, the application of artificial intelligence (AI) technology to analyze data derived from tourist comments on social media platforms enables entrepreneurs to adapt to trending preferences and generate content that addresses target demographic needs in a timely manner.

Quality digital content not only promotes tourism at the individual level but also plays a crucial role in strengthening local economies. The presentation of content related to local communities helps tourists develop understanding and interest in indigenous cultures and products. Communities can utilize digital content to promote distinctive goods or services, such as handicrafts, local cuisine, or cultural activities capable of attracting tourists to specific areas. The establishment of networks between local communities and tourists through digital media also facilitates valuable knowledge and cultural exchange, supporting sustainable development in these regions. (Hays, S. et al., 2013) The creation of digital content that aligns with the distinctive identity of local communities also generates opportunities for novel economic development in rural areas or regions that attract minimal tourist visitation. The utilization of technology to communicate community identity such as livestreaming cultural activities, developing tourism applications emphasizing community participation, or employing virtual reality technology to showcase difficult-to-access attractions, constitutes effective methodologies for enhancing local economic development opportunities. This is particularly significant during periods when conventional tourism operations may be disrupted, such as during disease outbreaks or events impacting travel. Digital content can additionally function as an instrument for maintaining interest and establishing connections with tourists during periods when physical travel is not feasible. (Buhalis, D., and Law, R., 2008) The use of digital media to communicate tourism information, particularly in the context of sustainable tourism, has become an increasingly popular

approach. Modern travelers are placing greater emphasis on environmentally responsible tourism and on activities that contribute to the well-being of local communities. Digital content that highlights adherence to environmental conservation principles and the support of local communities can effectively attract tourists who are interested in these values. Moreover, such content can serve as a tool for raising community awareness about the importance of natural resource conservation and can foster collaboration in the sustainable development of tourist destinations. At the same time, the creation of digital content to promote tourism should not be limited to merely producing and disseminating information. It is also essential to measure and evaluate the effectiveness of such content. Evaluation can be conducted through the analysis of various data sources, such as website traffic, social media metrics, and user engagement indicators such as likes, shares, and comments. Additionally, there are tools available to facilitate in-depth analysis of audience responses to digital content, including Google Analytics and social media analytics platforms. These tools enable tourism operators to refine and tailor their content more precisely to the needs and preferences of their target audience. (Xiang, Z., and Gretzel, U., 2010) Furthermore, evaluating the effectiveness of content enables a deeper understanding of tourism marketing trends. This includes insights into selecting appropriate media channels, creating content that aligns with the needs and preferences of tourists, and leveraging emerging technologies to enhance the promotion of tourist destinations. Such information allows tourism operators to plan their marketing strategies with greater precision and increases the likelihood of achieving long-term success.

For these reasons, the research titled "Digital Content Analysis of Tourism on Social Media" is crucial for understanding effective content creation strategies that resonate with the needs of tourists. The objective of this study is to analyze tourism-related digital content disseminated through social media and to examine the characteristics of content that effectively communicates with audiences.

Objectives

To analyze the characteristics of tourism digital content that is disseminated through social media platforms.

Literature Review

The Concept of Content Marketing

The characteristics of content marketing refer to the nature and format of marketing content used to communicate with customers across various contexts, with the aim of generating audience interest and fostering ongoing engagement from target groups. Content marketing plays a critical role in creating a competitive advantage, as it must align with the marketing strategies established by the organization. (Holliman, G. and Rowley, J., 2014, p. 273) The structure of content must adhere to a systematic creative framework, such as the Content Marketing Matrix, which serves as a guideline for categorizing content into diverse dimensions. This model facilitates organized content management and ensures that the message is effectively delivered to the target audience. Content marketing can be classified into four main types: 1.Educational Content (Educate): This type of content primarily aims to inform and raise awareness among readers. Examples include infographics, press releases, reports, and seminar courses. Educational content often emphasizes credibility and professionalism, thereby enhancing the brand's image. 2.Persuasive Content (Convince): This content focuses on influencing consumer decisions through logical reasoning. It may highlight the benefits of products or services, present case studies, promote special offers, or clarify customer value. The goal is to enable consumers to compare brands within the same industry, thus assisting in the decision-making process. Such content should be creatively distinct to stand out from competitors and attract attention. 3.Entertainment Content (Entertain): This content type centers around enjoyment and emotional appeal. It is particularly effective in enhancing brand awareness and often takes the form of viral marketing. Common examples include contests, quizzes, and interactive games designed to maximize user engagement and potentially increase the customer base. 4.Inspirational Content (Inspire): This type of content combines emotional storytelling with subtle product promotion. It may involve reviews or influencer marketing, where emotional narratives are embedded in product or service presentations to encourage purchasing decisions. On websites, examples of such content can be found on platforms like Pantip. In content creation, the strategy should align with the different stages of the marketing funnel: Top of Funnel (Awareness Stage) At this stage, businesses should focus on providing informative content that helps potential customers recognize available solutions or become aware of the brand's products or services. This can be achieved through formats such as blog posts,

how-to videos, or infographics. The primary objective is to increase brand or product awareness. Middle of Funnel (Consideration Stage) During this stage, content should deliver knowledge, insights, and detailed information that assist potential customers in evaluating their options and making informed decisions. Examples include testimonials, case studies, demo videos, and FAQ pages. The aim is to enhance the credibility of the brand's offerings and stimulate interest, preference, and intent to purchase. Bottom of Funnel (Decision Stage) At this point, content should provide specific information or calls-to-action that directly influence purchase decisions. This may include pricing details, a pricing page, free trials, or discount coupons. The goal is to facilitate or prompt conversions, turning prospects into customers. (ForeToday, 2564)

The Concept of Storytelling

Storytelling has gained widespread popularity and is considered one of the most accessible methods for conveying a brand's narrative. It can serve as a framework for writing content, advertisements, and can be effectively applied across various platforms including social media, marketing campaigns, and landing pages. In the digital age, the volume of online content far exceeds the capacity of consumers to absorb it all. Therefore, communication that highlights a brand's unique identity through distinctive and authentic storytelling helps enhance content appeal and facilitates memorability. According to a survey by The Brand Shop, brand storytelling is a highly effective strategy for fostering strong engagement between target audiences and the brand. (Chawaltawat, F., 2019) According to storytelling statistics in 2023 (Bogwasi, 2023), a survey revealed that 92% of consumers prefer brands that incorporate storytelling into their advertisements. Furthermore, 68% of customers stated that brand storytelling enhances their decision-making when purchasing products and services. Additionally, 64% of customers are likely to make a purchase after watching a video on social media, and 55% of customers are more likely to remember the narrative of an advertisement compared to standard content.

The Concept of Social Media

Social media refers to electronic-based media in various formats that allow senders to share content with receivers through online networks. It facilitates interaction between the sender and the receiver, as well as among receivers themselves. Social media can be categorized into three main characteristics: 1.Media disseminated through social interaction. It involves conversations that may evolve into public discourse or a "talk of the town" when

interesting topics are raised and widely shared. The content can be in the form of text, images, audio, or video. 2.Media transformed from traditional one-way communication. Unlike conventional media that transmits information from one source to many receivers, social media enables multi-user conversations. These dialogues allow groups to engage in discussions on shared interests without content control even by the original content creator. Recipients of the information can participate through comments or even edit the content, reflecting a shift in power dynamics. 3.Media that transforms consumers into content creators. When individuals produce content that resonates with a broad audience, they may become influential figures, or influencers, capable of persuading followers to make purchasing decisions for products or services.

The purposes of using social media include: 1.Consumer Generated Media (CGM). Media created by consumers themselves, actively engaging with products or services whether as buyers, users, or individuals with direct or indirect experiences. CGM also serves as a medium through which consumers can communicate with other consumers. 2.Social Media Marketing (SMM). The use of social media as a marketing tool to reach target audiences rapidly. It supports publicity efforts and allows for wide dissemination of messages to a broad audience. 3.Word of Mouth (WOM). Viral Marketing and Buzz Marketing. Consumer opinions based on personal experiences with products, services, or companies positive or negative shared widely via social media. WOM is also employed to generate public interest and stimulate discussions about products or services, thereby extending reach to potential consumers. 4.Communication with friends and acquaintances. Social media facilitates reconnection with old friends, the formation of new relationships, and the exchange of experiences and stories among users. 5.Sharing images, videos, links, or personal interests. Users can distribute content that reflects their preferences or interests with others. 6.Serving as a social network for communication and knowledge exchange. Social media acts as a platform for sharing information, beliefs, events, and advice among users.

Methodology

The research titled “Digital Content Analysis of Tourism on Social Media” employed a qualitative research approach. The research methodology was conducted as follows: The sample group for analyzing the characteristics of digital content related to tourism consisted of the top 10 social media accounts that present tourism-related content and have more than 1,000,000 followers on social media platforms, including Facebook, YouTube,

Instagram, and TikTok. The selection of content for analysis was based on a conceptual framework, with the criteria that the content must have been published between 2021 and 2023 and must not be direct advertisements of products or services. Based on the survey and data collection from social media conducted on November 23, 2023, the identified social media accounts relevant to tourism consisted of:

Table 1 Table of Rankings by Number of Followers of Tourism-Related Social Media Accounts

No.	Account	Followers (Unit: Million)
1	I Roam Alone	10.8
2	Pigkaploy (พลอยเรียนจบแล้วทำไรต่อ)	4.8
3	Sneak out หนีเที่ยว	4.4
4	อาสา พาไปหลง	3.8
5	Go Went Go	3.6
6	บอลพาเที่ยว Backpacker Ball	3.2
7	The Gaijin Trips แบกเป้เที่ยวคนเดียว	1.95
8	Rayron : เร่ร่อน	1.5
9	ไปคนเดียว+	1.2
10	Walker Talker : เดินทางเล่าเรื่อง	1.1

Result

The Characteristics of Tourism Digital Content on Social Media. The content presented on social media pages primarily falls into two main categories: entertainment and inspiration. Many pages and channels feature content that stimulates a desire among followers to travel, explore, and experience new things. This is often achieved through storytelling, such as sharing solo travel experiences or portraying the search for life's meaning through journeys. For instance, the I Roam Alone page tells stories of travel that are filled with challenges and cultural discoveries. Similarly, the Pigkaploy page documents a train journey to Sapa, Vietnam, where despite encountering obstacles and disappointments such as being unable to reach the summit of Mount Fansipan. the creator continues the journey, finds new perspectives, and shares local community life. The narrative emphasizes the value of embracing new experiences. Although the trip did not go according to the original plan, it

led to meaningful insights and broadened understanding of the local way of life in Sapa. In terms of entertainment content, it is commonly presented through engaging language and storytelling styles that incorporate humor. For example, Go Went Go and Asa Pa Pai Long are pages that use dynamic narration in video formats. These videos feature varying tones and rhythmic storytelling interspersed with jokes, making the content enjoyable and entertaining for viewers. Regarding educational content, some pages focus on delivering practical travel information such as itinerary planning, instructions for booking tickets or accommodations, travel routes, and details about tourist destinations. This type of content enables audiences to learn about different cultures while watching or obtain useful information for planning their own trips. As for persuasive content, it is used less frequently and often subtly integrated into the main narrative, typically as a form of product or service tie-in. Such content may involve promoting community-based tourism services or supporting local businesses, including car rentals, tent rentals, activity equipment, local food, or cafés.

The types of content featured on tourism-related social media pages predominantly fall under two main formats: emotional content and awareness-oriented content. Pages such as I Roam Alone, Go Went Go, The Gaijin Trips, Rayron, and Ball Pa Tiew often utilize storytelling that conveys personal emotions and experiences during travel, ranging from joy and excitement to challenges encountered along the way. These pages contribute to raising awareness of lesser-known destinations and provide fresh perspectives on travel, including recommendations of remote locations and the experience of traveling solo, which often evokes a sense of novelty. The content also introduces both domestic and international tourist spots, showcases community-based tourism, and presents local cuisines, offering in-depth insights into local cultures and places. Additionally, they often include practical travel information, highlight interesting activities, and provide essential tips for travelers. Moreover, during the COVID-19 pandemic, many pages emphasized health and safety awareness, encouraging followers to wear masks and wash their hands regularly while traveling. In terms of emotional content, these pages often share fun and thrilling travel experiences using an informal and relatable tone, which helps create a sense of intimacy and enjoyment for followers. For instance, the page The Gaijin Trips presents a variety of emotional experiences related to solo travel, such as loneliness, challenges, and the joy of self-discovery. This style of storytelling creates an immersive atmosphere, allowing followers to better understand and emotionally connect with the travel experiences being shared.

Furthermore, many creators include personal stories about overcoming obstacles and adapting to unexpected situations during their journeys. These narratives foster a strong sense of empathy and connection among followers, making the content more engaging and relatable.

The storytelling approach commonly used on social media pages primarily follows the Before–After–Bridge structure. This format emphasizes connecting events or experiences from an initial point by introducing the context such as presenting a travel destination or recounting an experience that followers can relate to. These introductions may involve descriptions of travel plans during the COVID-19 pandemic or the challenges faced while reaching specific destinations (Before). The narrative then moves to describe the outcomes or experiences that occurred, such as the beauty of the destination, engaging in new and exciting activities, or memorable moments gained through the journey (After). Finally, the story links to practical suggestions or inspirational messages, inviting followers to try similar experiences, recommending related destinations and activities, or promoting relevant travel-related products or services for instance, suggesting followers watch a travel video or take care of their health while traveling (Bridge). An example is a post about rock climbing in Lamphun, which begins with a mention of waking up early to see the sunrise (Before), followed by a description of the difficult journey and the rewarding view at the top (After), and concludes with advice on preparing for the trip and suggesting to wait until the COVID-19 situation improves before traveling (Bridge). Another commonly used storytelling approach is the Three-Act Structure, although it is used less frequently than the Before–After–Bridge model. This format is often found in documentary-style narratives and travel stories that begin with an introduction of the creator’s channel/page, the travel destination, or the goals of the trip. This opening stage may also include trip preparations or anticipated challenges designed to capture interest and build narrative tension (Act 1). The second act (Act 2) typically involves encountering obstacles or challenges along the way such as steep climbs, difficult trails, natural impediments, or fatigue which are described with emotional and personal reflections to enhance excitement and suspense for the audience. The final act (Act 3) presents the outcome or success of the journey. These conclusions often highlight the beauty of the place visited, the lessons learned, or the sense of peace and fulfillment achieved after an arduous journey, leaving the audience with a sense of reward. In some cases, however, the story ends on a note of disappointment or failure to achieve the original

plan such as unexpected weather changes or being unable to visit specific locations. These endings often include a reflection on the mistakes made, turning them into lessons for future travel planning. Other narrative structures appear occasionally but are less prevalent. These include the Problem–Agitate–Solve and Features–Advantages–Benefits models, particularly in content related to product promotion. These structures involve identifying a problem experienced by users, introducing a product that resolves the issue, or highlighting product features, advantages, and benefits within the context of travel.

Based on the analysis of tourism digital content on social media platforms, promotional and awareness-raising content about tourism is typically conveyed through emotionally driven storytelling and the distinct identity of each social media page. Such content becomes more impactful when integrated with visually appealing photographs or videos. Short-form content such as animated images or video clips, on platforms like Instagram (Reels) and TikTok tends to focus on encouraging user engagement, including views, likes, shares, and saves. In contrast, long-form content (videos longer than one minute) on platforms such as Facebook and YouTube emphasizes a more in-depth narrative approach. These formats showcase high-quality visuals and compelling storytelling to highlight scenic landscapes, local cuisine, and culturally significant activities. The integration of text, still images, and video footage serves to enhance audience engagement and contributes significantly to the promotion of tourism.

Discussion

The characteristics of tourism digital content used on social media primarily appear in the form of entertainment content and inspirational content. Many pages or channels present content that motivates followers to feel the desire to travel, explore, and experience new things through storytelling. Examples include narratives about solo travel experiences or searching for life's meaning through tourism. For instance, the "I Roam Alone" page relates journeys filled with challenges and learning about various cultures, or even the "Pigkaploy" page, which describes a train journey to Sapa, Vietnam. Despite encountering obstacles and disappointments, such as being unable to ascend Fansipan Peak, the content continues to move forward and presents other interesting perspectives through the journey, including changes in travel plans and experiences with local villagers. The content demonstrates the value of embracing new experiences; even when plans aren't followed exactly, it leads to learning and opens new perspectives about the lives of Sapa's local residents. Regarding

entertainment content, it typically employs language and storytelling that incorporates elements of fun, occasionally interjecting humor at various points in the narrative. Examples include the "Go Went Go" page and the "Asa Pa Pai Long" page, which feature descriptions in video content that utilize varying vocal pitch, rhythmic narration with periodic humorous elements, making followers feel entertained by the commentary. This aligns with Thungsuwan, N.'s (2018) study, which found that content that can present both entertainment and information elevates the experience of accessing the intended message. Using digital content to create engagement in information searching, dissemination, or content sharing is another strength of digital communication, beyond its marketing or promotional benefits, which can inspire consumers and stimulate travel. Entertainment content is the most popular type for tourism communication, as it responds to digital-era media consumption behaviors that seek relaxation and rapid information reception. Meanwhile, inspirational and educational content serve complementary functions, building credibility and depth for the tourism experience. A balanced combination of various content types produces maximum effectiveness in tourism marketing communications. Persuasive content is used less frequently, with such content subtly embedded or tied in with specific situations. The created content typically features community tourism service bookings or invitations/support for local businesses, such as vehicle rentals, tent rentals, activity equipment services, food establishments, and cafés.

Emotional content is a type that utilizes storytelling through personal experiences, beautiful images and videos, and emotionally stimulating language to attract viewers, making them empathize and desire to experience these moments themselves. Awareness content, which is the second most frequently used after emotional content, introduces new tourist destinations or locale-specific activities that viewers may not have previously encountered. Emotional and awareness content are often used in conjunction to create recognition and leave lasting impressions. Meanwhile, rational content and purchase stimulation content are employed in certain circumstances for promoting specific products or services, and are used together to build confidence and encourage decision-making.

Storytelling formats in tourism content employ various approaches, but the Before-After-Bridge format stands as the most prominent primary structure due to its problem-solving nature and decision-stimulating capacity. This format helps viewers clearly visualize how specific services or products can resolve issues, aligning with marketing objectives and

consumer behavior patterns. The Before-After-Bridge storytelling structure is particularly well-suited for social media platforms, as the content is concise, compact, and explicit, capable of rapidly capturing the target audience's attention. Meanwhile, the Three-Act Structure is predominantly found on YouTube, as this storytelling format is appropriate for presenting content through motion pictures lasting eight minutes or longer, which requires explaining historical context, providing location details, and generating excitement and memorable impressions for viewers. This format follows a clear storytelling structure: 1) The journey's commencement, 2) Points of interest in various areas, and 3) The conclusion or outcomes of the journey.

Content used for tourism promotion or creating tourism awareness consists of stories conveyed through emotions and reflections of page identity. These become more distinctive when combined with beautiful photographs or videos. The use of short-form content (motion pictures) on Instagram (Reels) and TikTok platforms focuses on generating engagement, such as views, likes, shares, and saves. Meanwhile, long-form content (videos exceeding one minute) on Facebook and YouTube platforms emphasizes more profound storytelling techniques, as they present beautiful imagery and high-quality videos showcasing landscapes, cuisine, and cultural activities that are essential for tourism promotion through a combination of text, still images, and motion pictures (videos). This aligns with the research of Piewruangnon, C. (2023, pp. 31-34), which found that still image presentations are used to show details of community lifestyles and tourism activities, such as houses along canals, local ways of life, and activities in which tourists can participate. Additionally, graphics and animation are employed to enhance realism and increase viewer engagement through interactions available on Facebook platform tools, such as emotional reactions, reviews, check-ins, and hashtag applications to increase viewer participation, enabling content distribution and expanding awareness to broader target audiences. The use of social media as a channel for creating engagement allows content creators to reach target audiences extensively and effectively, which corresponds to the study by S. Novita et al. (2023, p.218) that highlights the effectiveness of digital content marketing in increasing accessibility and promoting tourist visits. Furthermore, content must focus on responding to follower needs, communicating in alignment with their interests to foster continuous following and viewership (Sukhonpanya, P., 2021, pp. 66-67).

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Exploring Key Drivers of Work-Life Balance Initiatives within the UAE

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Abstract:

This study aims to explore the status of work-life balance (WLB) initiatives within HR departments and their impact on organizational sustainability and workforce development across various business organizations in the United Arab Emirates (UAE). The study adopts a qualitative approach. Data was collected through six semi-structured interviews with Human Resource directors, managers and assistants. The analysis reveals four main themes that highlight the importance of leadership and learning organizational culture in advancing work-life balance initiatives. Several recommendations are presented to HR personnel and senior decision makers regarding policies that facilitate job flexibility for employees as well as training that equip line managers with the necessary skills to effectively implement and manage WLB initiatives within their teams. This study contributes to existing literature by highlighting major drivers of WLB initiations, providing insights into the status of these initiatives in the UAE. It also offers practical recommendations for management.

Keywords: Work-Life Balance, Gender Equality, Work Practices, Flexible Work, UAE.

Introduction:

In today's organizational environments, employees are frequently balancing their work with family responsibilities. The challenging work atmosphere is marked by the demands of meeting deadlines or attaining specific performance goals. A lack of equilibrium between job responsibilities and social life often leads to adverse effects on employees, such as burnout, high turnover rates, and decreased productivity (Sirgy & Lee, 2018). Consequently, organizations experience low productivity, poor performance, and diminished competitiveness (Roopavathi & Kishore, 2021). To counter the adverse impacts of workplace pressures on employees and their subsequent influence on organizations, workers are increasingly valuing work-life balance (WLB) initiatives. Koon (2022) defines WLB as the HR activities created by organizations to attract and retain skilled employees by acknowledging their work contributions while offering support for their personal lives. HR professionals play a crucial role in developing a competent workforce that aligns with strategic objectives (Sirgy & Lee, 2018). Establishing WLB is one method they employ to reach this aim, crafting practices and programs to ensure employees have the necessary social and psychological backing to fulfill their roles.

Work-life balance is a key determinant of employee welfare as well as corporate efficaciousness. HR departments are unquestionably important when it comes to the designing, implementing, and management of work-life balance initiatives. Some of the initiatives include flexible working hours, paid time off, and psychosocial support in the workplace through fitness centers or stress management programs. Investment in such initiatives creates promise for higher job satisfaction and employee retention (Rodríguez-Sánchez et al., 2020).

The study attempts to answer the following research questions:

1. What are the key drivers of successful work-life balance initiatives within HR departments.
2. What is the impact of WLB initiatives on organizational sustainability and workforce development?

The study adds to the limited literature on WLB initiatives in organizations within the Middle East region. It also extends knowledge by linking WLB with sustainability and workforce development. This study holds important implications for both theory and practice by presenting best practices,

challenges, and outcomes associated with work-life balance initiatives. The results are intended to assist HR practitioners and organizational leaders in making evidence-based decisions. It endorses workplace strategies that enhance employee well-being and satisfaction while also ensuring organizations thrive and remain competitive in the UAE business landscape.

Literature Review:

Context of the UAE

The UAE is at the forefront of attracting skilled professionals to its workforce. The federal government's objective is to draw the top talent to support economic growth. Additionally, the individual flexibility of each Emirate fosters internal competition among the eight Emirates to attract expatriates (Ewers, 2017). For instance, the Government of Al Sharjah introduced a 4-day work week in 2022, with other Emirates offering a half-day on Fridays (Shafique & Al Haddi, 2022). According to Parakandi and Behery (2016), a large portion of the UAE's workforce consists of expatriates who relocated for improved living conditions and are attracted by the tax-free salaries, with around 80% being expatriates. These demographic underscores a strong focus on monetary benefits, which may tend to overshadow work-life balance considerations. Businesses in the UAE are adopting a range of work-life balance strategies, such as flexible hours and compressed work weeks (Glover, 2023). Although many organizations in the UAE engage in informal work-life balance practices, scholars call for additional research on WLB adoption (Ferreira et a., 2021).

Theoretical Framework

This study employs Social Exchange Theory (SET) as the primary theoretical lens to examine work-life balance initiatives within HR departments in the UAE. SET, rooted in organizational behavior, posits that relationships are built upon reciprocal exchange of resources between the parties (Cropanzano & Mitchell, 2005). WLB initiatives may include flexible work plans, wellness programs, and career development. Such exchanges constitute a form of social and economic support offered by the organization, while in response, the employee is likely to reciprocate through increased commitment, productivity, and performance. The reciprocity further denotes mutual benefit in establishing WLB, with emphasis placed on cultures like that of the UAE where work-related demands frequently

compete with familial obligations. Examining the role of SET in this regard, this study attempts to analyze these different initiatives, populating into the worldview of enhancing employee well-behavior, trust, loyalty, and strategic benefit to the business.

SET thus functionally identifies the key factors contributing to successful work-life balance initiatives by accentuating the exchange's perceived value. For these schemes to elicit a positive reaction from employees, they must address such concerns as stress levels, justice, and career advancement. In the UAE, where a remarkable composition of the labor force encompasses a vast array of social and cultural classes, fairness and inclusion in the initiatives are signs on which much depends.

Work-Life Balance

WLB-related initiatives are a subject of ongoing research, as various scholars explore the different initiatives, their impact, and the role of HR professionals or departments in their implementation. Flexible work arrangements, work leaves, and employee assistance programs are some of the most common initiatives of WLB practices. HR managers have an important responsibility to implement and assess the effectiveness of the practice. The role of HR managers in advancing employee wellbeing within an organization is central to the devising of the policies and programs that regulate the implementation of these programs. (Koon, 2022).

It is the duty of organizational leaders to cultivate a culture that values balance, allowing for the resolution of complex issues among employees and the management of challenges that may arise in the workplace.

Organizations guided by their HR departments are adopting various measures aimed at assisting employees in managing both their professional and personal lives without impacting the other. Some of these measures include effective talent management strategies that will enhance the quality of human capital and boost employee retention. Talent management strategies acknowledge the importance of striking a balance between employees' work and social lives. When HR professionals display concern for employees' work-life balance, organizations experience higher retention rates driven by increased employee motivation. Other outcomes may include decreased work-family conflict, increased job satisfaction, and greater organizational commitment (Chaudhuri, Arora & Roy, 2020).

Social support in achieving a WLB within organizations is a crucial element for employees. When employees are supported by their colleagues and supervisors in developing their careers and achieving their goals, they experience increased job satisfaction and commitment, which enhances organizational performance (Roopavathi & Kishore, 2021).

Methodology

Data Collection

This study adopts a qualitative approach. Data was collected through semi-structured interviews with directors, managers and specialists within HR departments to offer more in depth understanding about the phenomenon under investigation (Brinkmann and Kvale, 2005). The interview protocol was designed based on the research questions presented in the introduction section of this study and the existing literature (Yin et al., 2018).

Participants

The interviewees for this study were chosen from various sectors including consulting, real estate and government entities across different roles and levels within the organization. Details on the participants are presented in Appendix A.

HR departments play a significant role in implementing various work-life balance initiatives because they must design, promote, and manage such programs, thus the focus on HR employees for this study. Since this study is still in progress, so far six interviews were conducted by asking the participants several questions regarding their views on WLB. The questions included how they think the HR department can improve and foster organizational development to have a better quality of life while still delivering quality work. Consent was requested and granted by all participants. The data was transcribed and analyzed thematically. The data analysis and interpretation followed a process of initial, focused and theoretical coding (Charmaz, 2014; Glaser and Strauss, 1967). The initial findings are presented in the next section.

Preliminary Results and Findings

Fifty codes were identified from the data. These codes revolved around the concepts of flexible work arrangements and employee training among others. Twelve focused codes were derived from the initial codes and these included Dynamic Work Flexibility, Leadership-Driven Trust Culture and Barriers to Effective Implementation. Subsequently four core categories were identified based on the focused codes. Details are presented in Appendix B. These categories are Flexibility as a Foundation for Work-Life Balance, Leadership and Trust, Well-being and Inclusivity, Innovation and Feedback.

The first category, Flexibility in work arrangements explains that hybrid models, telecommuting, or customized schedules are central to achieving work-life balance. This flexibility allows employees to manage personal and professional responsibilities effectively, fostering satisfaction and productivity.

In the second core category, Leadership and Trust: Catalysts for Successful Initiatives, participants talk about the importance of leadership support for the success of work-life balance programs. Leaders play a pivotal role in fostering environments where employees feel safe utilizing benefits without judgment.

Under core category three, Well-being and Inclusivity as Pillars of Engagement participants discuss the concepts of comprehensive well-being initiatives and inclusive practices, such as wellness programs and support for gender-specific needs, strengthen employee engagement and retention.

The last core category, Innovation and Feedback: Driving Continuous Improvement presents how work-life balance initiatives are tied to technological innovation and employee feedback loops. This creates adaptable, forward-looking organizational processes. Organizations leveraging technology for remote work and employee input are better positioned to remain adaptive and innovative while meeting organizational goals.

Discussion:

The results of the study highlight the need of employees for WLB practices as well as the important role of leadership in endorsing these practices. In addition to the need for clear

policies on WLB practices, organizations should also prioritize technological investments to facilitate work flexibility. Employees are expected to reciprocate with increased commitment, engagement, and productivity.

Practical Recommendations

It is important for organizations to incorporate WLB initiatives in their policies to provide clarity on the implementation and enforcement of such policies. The direct communication of flexibility in work schedules and other WLB initiatives needs to be clearly documented and stated to eliminate employee confusion and should apply equitable access to benefits across the organization.

Next, the resistance brought about by top management needs to be met by demonstrating that WLB initiatives also do provide tangible benefits. Ensuring the use of data that would show improvements in employee satisfaction, productivity, and retention is a supporting mechanism for substantiating decision-making at a high management level.

Limitations of the Study:

Although this study presents insight into work-life balance initiatives in the HR departments within the UAE, it is important to note certain limitations. Since this is still work in progress study, the analysis and results were based on six interviews so far. Naturally, the small sample size is a limitation to the depth of perspectives, as the experiences of so many industries and organizational sizes in the UAE cannot be fully captured.

Conclusion:

The research explores the implementation and impact of work-life balance initiatives within human resource departments across organizations in the United Arab Emirates.

Interviews were conducted with human resource managers from different organizations across the UAE. The results revealed four main core categories indicating that flexibility is a major advantage of WLB practices while leaders play a significant role in the success of these practices. in making such initiatives successful among other things. However, as stated in the previous sections, key areas in need of engagement include policy formalization and commitment towards its common active participation.

The findings underscore the pivotal role of HR in driving WLB initiatives that contribute to a balanced and prosperous future of work.

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Appendix A

Table 1: Participants Information

Participant (P)	**Job Position**	**Industry**
P 1	Senior Consultant Human Capital	Professional Services and Consultancy
P2	HR Specialist	Trading Firm
P3	HR Specialist	Real Estate Firm
P4	Talent Acquisition Manager	Real Estate Firm
P5	HR Representative	Government Entity
P6	HR Consultant	Recruitment and Consultancy Firm

Appendix B

Data Analysis- Core Categories

1. Flexibility as a Foundation for Work-Life Balance

- **Linked Codes**:
    - Dynamic Work Flexibility
    - Barriers to Effective Implementation
    - Feedback-Driven Adaptation

2. Leadership and Trust: Catalysts for Successful Initiatives

- **Linked Codes**:
    - Leadership-Driven Trust Culture
    - Strategic Alignment with Goals
    - Barriers to Effective Implementation

3. Well-being and Inclusivity as Pillars of Engagement

- **Linked Codes**:
    - Comprehensive Employee Well-being Programs
    - Inclusive Gender Practices
    - Sustained Decent Work Practices

4. Innovation and Feedback: Driving Continuous Improvement

- **Linked Codes**:
    - Technology-Enabled Innovation
    - Feedback-Driven Adaptation
    - Evolving Policy Improvements

Appendix C

Examples of Participants' Quotes

Theme	Quote
Flexibility as a Foundation for Work-Life Balance	P1: "We offer flexible working hours, especially for our agents. We also have multiple training programs and are known for our open-minded culture. Our initiatives are designed to ensure that employees have the flexibility they need to balance their professional and personal lives. We do not have work from home options, however we do not ask our agents where they are working from as long as they are closing deals."
Leadership and Trust	P6: "Manager trust: this is by far the most crucial factor as the manager known as the leader, has to provide trust in their employee. They cannot follow up on every issue. There has to be trust from both ends as this trust allows the employee to work in a positive environment which will eventually reflect the performance in a favorable stand."
Well-being and Inclusivity	P1: "In our HR department, we've rolled out a few work-life balance initiatives. We offer

	flexible working hours and the option to work from home, which a lot of people appreciate. There are also wellness programs, like yoga sessions and mental health resources. Plus, we have paid parental leave and employee assistance programs (EAPs) to help with personal and work-related issues. We try to make sure everyone has the tools to work remotely, cutting down on commute times and giving folks more time at home."
Innovation and Feedback	P2: "The retention of employees was, for a large part, a result of our work-life balance initiatives. We are aware of employees who received significantly higher offers but refused to leave [the company] because of the flexibility we offer. The result of such is we have optimized systems and processes in place that keeps [the company] ahead of its competition."

CEO Gender, Boardroom participation with endogenous decisions and Firm Productivity*

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Abstract

We analyze the effect of a female CEO and female boardroom participation on Ecuadorian firms' productivity from 2007 to 2018. We estimate a production function using the Gandhi et al. (2020) estimator. It allows us to endogenize the law of motion for productivity, which permits past decisions of these gender measures to affect future productivity. Furthermore, we do a robustness check using matching techniques to attenuate a possible reverse causality effect. We find that female CEOs increase firm productivity. This effect is larger in the services sector. In terms of size, we find that small, medium and large firms benefit from having a female CEO, except in the natural resources sector. In all cases, we find similar results when we analyze female boardroom participation. Also, we show that the effect of an increase in the number of years as CEO in the firm is larger for women than for men.

Keywords: Board of directors; Gender; Productivity; Ecuador
JEL Codes: D22, D24, L11, L25, J16

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1 Introduction

The gender wage gap and underrepresentation of females in the labor force are problems faced worldwide even though female participation in the labor market has increased in most countries (Cortes and Pan, 2018). Specifically, in the case of managerial positions, there is an evident leadership gap between men and women. Stereotyping, gender bias and discrimination contribute to this gap (Garcia-Retamero and López-Zafra, 2006). However, research also highlights the possibility of a lack of qualified women for this type of position (Eagly et al., 2007; Bertrand et al., 2019).

Consequently, the role of women as leaders is an important and controversial focus of firms' performance and productivity studies. Hunt et al. (2015) mention that it is important to note the role of women as managers because of their capacity to motivate employees, and also they promote strength and trust over the consumers, hence improving the image of firms. Moreover, female leaders could foster strategic change (Triana et al., 2019); they tend to minimize the gender gap of the company's labor force and the differences between managers and subordinates, which in turn might develop workers' productivity and firm performance. Most research has focused on analyzing general gender diversity in firms and not diversity in managerial positions, specifically, the relevance of the gender of CEOs. Also, they analyze the effect on financial performance, but there is still scarce evidence on the relationship to productivity measures. Therefore, the aim of this paper is to analyze the effect of having a female CEO and more females in the boardroom on firm productivity, taking into consideration firms from all economic sectors.

To explore whether firms that are managed by women have higher productivity levels than other firms, we use a panel data set from 2007 to 2018 obtained from the balance sheets and financial statements reported by formal firms to the Superintendencia de Companias, Valores y Seguros (SCVS) in Ecuador. We use an augmented Cobb-Douglas production function to capture and analyze total factor productivity (TFP) between firms with a female CEO and those with a male CEO. Our identification strategy relies in the use of the Gandhi et al. (2020) parametric method to estimate the TFP, which attenuates the problems of endogeneity and reverse causality bias in the selection of inputs and state variables. We also divide all firms into four economic sectors and four firm sizes[1] to find evidence of the heterogeneous effect of female CEOs and female boardroom participation on firm productivity. Our central hypothesis is that female CEOs enhance firms' productivity and that more female participation on executive boards could increase productivity.

This paper makes various contributions to the existing empirical literature. First, there is scarce empirical evidence of the effect of female managers on firm performance in developing countries. Specifically, in Latin America there are few studies that look at this causal relationship.[2]

[1]Firm size is defined in the Organic Code of Production, Trade and Investment of Ecuador. Microenterprises: between 1 to 9 workers or gross revenue less than $100,000; small firms: between 10 to 49 workers or gross revenue between $100,001 and $1,000,000; medium firms: between 50 to 199 workers or gross revenue between $1,000,001; and $5,000.000; large firms: more than 200 workers or revenue above $5,000,001. Gross revenue always prevails over the number of workers.

[2]See, for example, the work done by Moreno-Gómez et al. (2018) or Arráiz (2018).

Hence, this study provides new empirical evidence to the literature on developing countries, where gender parity research is needed. Concretely this study done in Ecuador is motivated by the fact that the gender pay gap is still big and the employment rate of women is lower than men. These gaps imply that the women who are able to be in corporate leadership positions are even more selected than in most developed countries, and they face more discrimination on their way up. Second, the analysis of gender in firms has always been focused on economic or financial performance. In this study, we focus on productivity because boards have more leverage on this outcome variable than on the more commonly used financial performance measures.

Third, our matching strategy mitigates concerns of omitted variable bias and reverse causality because it matches firms with similar observable characteristics that may have a woman as CEO, but do not, with other firms that have a woman as CEO, and in this way creates a treatment group and a control group to capture the differences between these groups. In this vein, our matching emulates some features of randomized experiments by aligning the distribution of the observables in the matched comparison group to be the same as the distribution of those observables in the treatment group (Glewwe and Todd, 2022). Also, we estimate an augmented Cobb-Douglas production function using gender as an additional state variable, which allows us to endogenize the law of motion for productivity. Moreover, using the gender variable as an additional state variable allows past decisions of having a female CEO to affect future productivity, which is relevant because the decision of who is the CEO or the part of the board is not reversible in the short run.[3] This approach has not been used in the literature of gender studies before and is useful for finding robust results.

Fourth, we use a large firm-level longitudinal data set that contains information about the gender of the presidents, CEOs and board members of all the firms in the economy. By focusing on firm-level data, we are able to avoid possible aggregation biases and hence capture the effects of female leaders more precisely. Finally, we consider the years of experience of the CEO to analyze how the results change when we add specific CEO characteristics. For this aim, we interact the variable of tenure (measure of the number of years the CEO has held this position) with the gender variable.

The structure of this paper is as follows. Section 2 provides a brief review of the literature. Then, in Section 3, we present an overview of gender diversity in Ecuador. In Section 4, we describe the empirical strategy used. Section 5 presents the data, variables and preliminary results. Section 6 shows the results of our empirical model. Finally, Section 8 describes the conclusions and policy implications of the results.

2 Literature Review

The impact of female CEOs and gender diversity on boards of directors on firms' performance has been studied by many authors (see, for a review, Christiansen et al., 2017; Post and Byron, 2015)

[3]The Ecuadorian labor market is in general rigid; some characteristics of hiring and firing procedures are not rapidly reversible.

because it has become relevant for researchers and policy makers to promote gender parity (Seierstad, 2016; Bertrand et al., 2019; Matsa and Miller, 2013). This topic is related to the possible association that might have with different outcomes like financial and enviromental performance, social responsibility, among others (Matsa and Miller, 2011, 2013, 2014; Sanchez-Riofrio et al., 2021). However, the research about the impact of female managers on firms' economic performance shows ambiguous results (Arena et al., 2015).

The ambiguity of the results in the literature is explained by many factors. First, the identification strategy is very important, because various researchers analyze the relationship between gender leadership and firm performance by using different econometric methods. Nevertheless, most of the papers do not overcome endogeneity issues which do not allow to find causal effects. Antonakis et al. (2010) mention that studies which try to find a causal effect are scarce because researchers of board diversity and female CEO topics lack techniques to overcome endogeneity issues.[4] In this sense, Adams (2016) suggests further research on board diversity to better understand the effect it might have on firm performance and mentions different tools that could be used to address endogeneity issues: fixed effects to overcome omitted variable bias, instrumental variables to avoid reverse causality issues, natural experiments to estimate difference-in-difference models (DID), and theoretical arguments to reinforce the direction of the causal effect. Moreover, there are other methods that are used to address endogeneity; for example, the Olley and Pakes (1996), Levinsohn and Petrin (2003), Wooldridge (2009) approaches. These methods exploit instruments based on lagged input decisions of the firm as their source of identification. More recently, Ackerberg et al. (2015) and the Gandhi et al. (2020) presents new identification strategies that solves the problem associated with flexible inputs in the production function.

In this line, the main contribution of this paper in terms of methodology is that we allow the decision to have a female CEO and women participation in the boardroom to be treated as endogenous in the law of motion of productivity. This treatment of the gender variables in our approach allows us to get causal effects on firm performance, specifically in productivity, which is rarely analyzed. In the Appendix section, Table 13 shows that there are few studies that analyze productivity between CEO decisions and TFP because the simultaneity and endogeneity problems that might arise from the decisions of inputs choice.[5] In this research, we take advantage of the methodological advances in the use of production functions and the resolution of endogeneity problems in other observed variables and we modify it to our variables of interest, such as the gender of the CEO and the gender composition of the board.

The second issue of the ambiguity of the results in the literature is the use of several proxy variables to measure the relationship between female managers and firm performance. Specifically, gender board diversity can be classified into three measures: indices such as the Blau index and the Shannon index[6] (Shehata et al., 2017); the participation (percentage) of women on the board

[4]To see studies that address the endogeneity issues, see Table 13 in the Appendix section.

[5]Rovigatti and Mollisi (2018) review the advantages and disadvantages of different production function and control function approaches that deal with simultaneity and endogeneity issues. More recently, Gandhi et al. (2020) develop a new parametric identification strategy for gross output that can be employed even when additional sources of variation are not available.

[6]The Blau index is calculated as $B = 1 - \sum_{i=1}^{n}(\pi_i)^2$ and the Shannon index is $S = -\sum_{i=1}^{n}(\pi_i)(ln\pi_i)$, where

of directors (Wiley and Monllor-Tormos, 2018; Garanina and Muravyev, 2021), and a dummy variable that indicates whether there is a female director or CEO (Green and Homroy, 2018). To examine firms' performance, studies have used return on assets (ROA), return on equity (ROE), return on capital employed (ROCE)(Ahmadi et al., 2018), Tobin's Q[7] (Nguyen et al., 2015), and productivity measured as the ratio of operating revenue of each firm and the number of its employees (labor productivity measure) (Luanglath et al., 2019) or by calculating the TFP (Tsou and Yang, 2019). To deal with this issue, we use two gender variables: CEO gender and gender board participation as our measure of female leadership in firms. Moreover, we focus on the analysis of one measure of performance: productivity, because boards have more leverage on this outcome variable than other more commonly used financial performance measures that are also riskier than TFP.

Third, the analysis of female directors and firms' performance depends on the context (Post and Byron, 2015). Authors like Chen et al. (2018) use firm size as a contextual variable, and Li and Chen (2018) estimate the moderating effect it has on the relationship of board gender diversity to firm performance. In this research, we also consider size, industry and region as control variables, especially because in the country of study, firm size plays an important role as there is a very unequal distribution (a lot of micro and small firms). Also, there is a large concentration of firms in the main provinces, and it is well known that there are industries in which women manage more firms than other industries (e.g., services).

In the Appendix, in Table 13, we present a non-exhaustive list of empirical papers that summarize the different regions of study, measures, methods, findings and whether the studies about gender and firms' outcomes address endogeneity issues that may appear. As we can see, most studies are done in developed countries like the United States or countries from Western Europe such as France or Italy. Besides, the samples they analyze are only a part of the economy, such as commercial banks, manufacturing firms or firms that are part of each country's stock exchange. In general, the results of the effect of gender on performance are not conclusive, and the methodologies used do not capture the possible endogenous effect of having a female CEO or board diversity, which could bias the results. This paper tries to cover all these gaps by looking at firms from all the sectors of a developing economy in Latin America.

3 CEO gender diversity in Ecuador

According to the National Institute of Statistics and Census (INEC, in spanish) from Ecuador, the global employment rate[8] of men between 2007 and 2018 ranges between, 94% to 97 %, whereas the

π_i is the percentage of members in each category of the group (women or men) and n is the total number of board members. In both cases, the index increases as the representation of men and women in the organization is more equal. The properties of the Shannon index are similar to those of the Blau index although the Shannon index will always show a larger number than the Blau index and is more sensitive to small differences in the gender composition of boards because it is a logarithmic measure of diversity.

[7]Tobin's Q is the ratio of the firm's market value to its book value of assets. Market value is book assets minus book equity plus market value of equity.

[8]Global employment rate is the percentage that results from dividing total employment by economically active population (labor force).

female employment rate goes from 91% to 96%.[9] Figure 1, in the Appendix section, displays how the global employment rate of women is always below men. Similarly, the adequate employment rate of males from 2007 to 2018, as shown in Figure 2 in the Appendix, has greater values than the female rate.[10] In the case of adequate employment, the gap between men and women is more visible, as the women rate ranges between 30% to 39%, whereas the men rate ranges between 45% to 56%. The maximum adequate employment rate of women (39%) over the years is considerably lower than the minimum rate of men (45%), which implies that the female employment rate over time period is always below even the lowest male employment rate in the period.

In the case of wages, Figure 3 in the Appendix section shows the average monthly wage by gender. The wages of males have always been higher than females, but the last years (from 2014 to 2018), the gender wage gap has decreased as shown in Figure 4 in the Appendix. However, the gap is still large, 17.8%, which means that for every dollar a man earns, women in Ecuador earn $0.82. Hence, women continue to face disparities in the labor market, and these inequalities, based on gender roles and their stereotypes, have been accentuated. They still spend a much higher proportion of time on housework and care than men, and these gaps are more pronounced in the presence of children at home (Serrano et al., 2019).

Regarding CEO gender gaps, Figure 5 in the Appendix shows the percentage of women CEOs in Ecuadorian firms, which increased from 2007 to 2018. Although the INEC shows that women's access to education has increased since the 1990s, women continue to be underestimated for managerial positions.

In terms of firm size, Figure 6 in the Appendix shows that the percentage of female CEOs in microenterprises increased two percentage points from 2007 to 2018, while in large firms it increased five percentage points. However, during the whole period, the highest participation of women was in microenterprises and small firms, and in general, the participation of women was low compared with that of men. The National Council for Gender Equality, in the National Agenda for Women, highlights that discriminatory attitudes and practices are manifested daily in different areas, such as in access to credit, which limits the development of owners of small and microenterprises (CNIG, 2018).

There is also generally scarce participation of female CEOs in economic sectors, even though in certain specific sub-sectors women are involved in more than 40% of administrative areas of companies. Figure 7 in the Appendix shows the participation of women as CEOs according to different economic activities: natural resources, manufacturing industries, construction, and services. The firms with the highest percentage of women as CEOs are found in the construction and services sectors. The latter is composed of the education and commerce sectors, which have a high participation of women as CEOs (43% and 37%, respectively).

[9]The information was taken from the official web page: https://www.ecuadorencifras.gob.ec/estadisticas/

[10]Adequate employment rate is the resulting percentage from the division between total adequate employment and the economically active population. Adequate employment refers to employed people who, during the reference week, receive labor income equal to or higher than the minimum wage.

4 Theoretical framework and empirical strategy

4.1 Gender CEO decision

We start by framing our empirical model of the probability that the gender of the CEO is not previously self-selected by the firm. Therefore we use a specification where we test the existence of the self-selection/continuation mechanism in which the most productive firms choose the gender of the CEO based on their same past decision. The idea behind this is that due to possible endogeneity problems an important issue that may arise is reverse causality/simultaneity.[11]

To address the reverse causality/simultaneity, we provide some evidence that supports that past productivity does not predict the hiring of a female CEO. Formally, we run a regression of the form:

$$gender_{it} = \beta_0 + \beta_1 \omega_{it-s} + \beta_2 k_{it-s} + \beta_3 l_{it-s} + \beta_4 m_{it-s} + \epsilon_{it-s} \tag{1}$$

where $gender_{it}$ is the CEO gender, which takes the value of one for females and zero otherwise, ω_{it-s} is the productivity of firm i in year $t-s$, k_{it-s} is the capital stock, l_{it-s} is the number of employees (labor input), m_{it-s} is the total intermediate inputs and ϵ_{it-s} is the error term. Our coefficient of interest is β_1, which shows whether firm lagged productivity is related to the probability of having a female CEO. In order to support the assumption of no reverse causality, we expect to find a non-significant relationship. Furthermore our production function in the presence of input endogeneity, explained in the next section, controls for simultaneity issues related with the inputs decision (see, for example, Gandhi et al., 2020; Doraszelski and Jaumandreu, 2013; De Loecker, 2013). The CEO gender variable and gender board participation are included in the law of motion of productivity. This allows us to endogenize the Markov process and treat the simultaneity decision to have a female CEO and productivity.

Finally, other source of endogeneity issue may arise from omitted variables/unobservable factors. In our setting, This source of endogeneity may be present as follows because the lack of information regarding firm, management and CEO characteristics. To address the omitted variables/unobservable factors concern, we extend our production function in the presence of input endogeneity (baseline model) by including the variable *tenure*, which represents the number of years the CEO has held the CEO position. We believe this variable is a good proxy for management and CEO characteristics because a CEO with better managerial characteristics is more likely to hold the CEO position for a longer period. In addition, we include firm fixed effects to control for firm-specific characteristics that do not vary over time. As in the baseline model, we also include year, industry and region fixed effects. These estimates add evidence that supports that omitted variable bias is not a concern in our empirical strategy.[12]

[11] In our setting, the reader might be concerned that reverse causality/simultaneity might be a source of endogeneity because the influence of firm productivity on the decision to appoint a female CEO or have more females in the boardroom (see, for example, Dang et al., 2020; Sila et al., 2016; Adams, 2016; Adams and Ferreira, 2009)

[12] Results from this exercise and their interpretation are displayed in Tables 10 and 16.

4.2 Impact of CEO gender on productivity

In this subsection we use a production function in the presence of input endogeneity to estimate firms' TFP. We rely and adapt the model proposed by Gandhi et al. (2020) (GNR).[13] Our model assumes a Cobb-Douglas production function where firm i in period t has an output Y_{it} that represents the gross revenue and is a function of capital K_{it}, labor force L_{it} and total intermediates M_{it} as follows:

$$Y_{it} = e^{(\omega_{it}+\epsilon_{it})} K_{it}^{\beta} L_{it}^{\alpha} M_{it}^{\gamma} \tag{2}$$

where ω_{it} captures a productivity shock and absorbs the constant term. Also, it is known by the firm manager at the beginning of period t but unknown by the econometrician. ϵ_{it} is a standard i.i.d. error term that is neither observable nor predictable by the firm. By taking logarithms in equation (2), we can rewrite the production function as:

$$y_{it} = \omega_{it} + \beta k_{it} + \alpha l_{it} + \gamma m_{it} + \epsilon_{it} \tag{3}$$

Similar to Navas et al. (2020) our model is a Cobb-Douglas production function, so we will consider that our constant of integration will be given by $-h(k_{it}, l_{it}) = \beta k_{it} + \alpha l_{it}$. Therefore, following Gandhi et al. (2020), Navas et al. (2020) and Merlevede and Theodorakopoulos (2021) we need to estimate the following equation:

$$Q_{it} \equiv y_{it} - \epsilon_{it} - \gamma m_{it} = \omega_{it} + \beta k_{it} + \alpha l_{it} \tag{4}$$

where Q_{it} is a function of an observable, M, and of other two elements which can be obtained from the share regression estimation: $s_{it} = ln\gamma + lnE(e^{\epsilon_{it}}) - \epsilon_{it}$, the intermediate input elasticity and the ex-post shock (Navas et al., 2020).[14] Now, we can rewrite ω_{it} as a function of Q_{it} and of other observable variables multiplied by the corresponding elasticities:

$$\omega_{it} = Q_{it} - \beta k_{it} - \alpha l_{it} \tag{5}$$

In our empirical approach we consider both capital (as standard) and labor (due to the strong Ecuadorian employment protection legislation) as state variables. Moreover, to take into account the possibility of the existence of an endogenous productivity process we let the dynamics of productivity to potentially depend on the CEO $gender_{it}$:

$$\omega_{it} = g_t(\omega_{it-1}, \mathbf{gender}_{it-1}) + \xi_{it} \tag{6}$$

where $\mathbf{gender}_{it-1}$ is a vector that measures a firm's decision about CEO gender. For nota-

[13]There are other proxy variable methods such as the Olley and Pakes (1996), Levinsohn and Petrin (2003), Wooldridge (2009) and Ackerberg et al. (2015) that deal with this simultaneity (or transmission bias) problem.

[14]For further details see the online appendix of Gandhi et al. (2020), Navas et al. (2020) and Merlevede and Theodorakopoulos (2021).

tional convenience, we assume that $\mathbf{gender}_{it-1}$ is simply a CEO gender dummy, but the vector $\mathbf{gender}_{it-1}$ can be extended to capture gender board participation (gbp), measured as the percentage of females/males on the board and the number of years that the firm was managed by a female/male CEO, among others. The unexpected shocks from having a female CEO are captured by ξ_t, which is an innovation term (or a year-specific productivity shock) uncorrelated by definition with capital stock. In other words, we argue that future productivity (ω_{it}) can be decomposed into expected productivity ($g_t(\omega_{it-1}, \mathbf{gender}_{it-1})$) and a random shock ($\xi_t$) that represents the uncertainties inherent in the CEO gender decisions such as firm leadership, better management practices, etc.[15]

In this sense, we hypothesize that the law of motion for productivity allows the persistence in productivity (ω_{it-1}) and the effect of the CEO $gender_{it-1}$ on future productivity to depend on a firm's productivity level:

$$\omega_{it} = \xi_t + \rho\omega_{it-1} + \eta gender_{it-1} + u_{it} \tag{7}$$

where ξ_t represents an unexpected productivity shock in period t, which is uncorrelated by definition with k_{it}; u_{it} is independent of ω_{it-1} and $gender_{it-1}$ with a known distribution. We hypothesize that the gender of the CEO at date $t-1$ will enhance firm productivity at time t because of the managerial experience, and this increased productivity further affects future managerial decisions of the CEO, which in turn has an impact on future productivity. De Loecker and Goldberg (2014) argue that firms might find it necessary to replace old, inefficient managers with more competent ones or adopt better management practices. Although these considerations feature prominently in casual discussions of trade and productivity, we are aware of only a handful of papers that formalize these arguments (e.g., Bloom et al., 2013).

Furthermore, some authors argue that firms could increase their productivity in response to shocks because firms expect to undertake actions to become more efficient. Nevertheless, some of these actions such as the replacement of current managers with better ones or adopting better management practices may be unobservable for the researcher, so they will be subsumed in the residual ω_{it} (e.g., De Loecker and Goldberg, 2014).[16] In this model, we relax this assumption and propose that the gender of the CEO is an observable action that could affect future productivity. In this sense, our main coefficient of interest is η, which reflects the dynamics of productivity to potentially depend on firm's decision about CEO gender.

Also, the firm's decision to have a female CEO is denoted by $gender_{it-1} \in \{0, 1\}$. Moreover, we assume that the decision to have a female or a male CEO is endogenous because the company owners and/or the board decide who is the CEO depending on long-term goals, salary, experience and other firm characteristics. To this extent, we recognize that productivity evolves endogenously

[15]We are inspired by the Doraszelski and Jaumandreu (2013) approach, which hypothesizes the same arguments with R&D expenditures.

[16]It is clear that not only the CEOs gender can affect firm productivity. Other characteristics such as the quality of managers and management practices could also have a causal effect on productivity (e.g., Bloom and Van Reenen, 2010; Bender et al., 2018). Because of limitations of our database, we cannot make inferences about these other variables.

in response to firms' actions, as in equation (7) (De Loecker and Goldberg, 2014), so it is necessary to at least modify the law of motion for productivity.

The specification of equation (7) allows us to correct for selection bias of more/less productive firms that endogenously decide the gender of the CEO. Furthermore, we are able to separate the productivity shock that is contained in the CEO gender decisions, which will allow us to see whether the CEO gender decisions affect firms' productivity if the firm increases its management practices.[17]

However, we can still recover valuable information regarding the gender board participation (gbp), measured as the percentage of females/males on the board and the number of years the CEO has held this position, in other words, the tenure of the CEO. To exploit these information, we extend our baseline model (equation (6)) and again endogenize the law of motion for productivity, in two forms:

(1) we introduce the term gbp_{it-1}, which captures the participation of women on the board of directors. Replacing $gender_{it-1}$ with gbp_{it-1} in equation (7), we get:

$$\omega_{it} = \xi_t + \rho\omega_{it-1} + \eta gbp_{it-1} + u_{it} \tag{8}$$

where gbp_{it-1} is a continuous measure of female participation on the board of directors of firm i in period $t-1$ and takes values between zero and one. If the firm's board of directors is made up only of women, this variable is equal to one, whereas if there is no woman on the board of directors, the variable takes the value of zero. In equation (8), our main parameter of interest is η. If the dynamics of productivity potentially depend on firm's decision about more participation of women on the board of directors, then ($\eta > 0$). It is relevant to mention that the decision to have more females on the board of directors is also an endogenous decision (as in the CEO gender dummy approach). For this reason, we modify the law of motion for productivity to allow past decisions to have more/fewer females on the board of directors to affect future productivity.[18]

(2) we extend our baseline model by adding the CEO job tenure ($tenure$) and the interaction with $gender_{it-1} * tenure_{it-1}$ in equation (7), we get:

$$\omega_{it} = \xi_t + \rho\omega_{it-1} + \eta gender_{it-1} + \vartheta tenure_{it-1} + \chi gender_{it-1} * tenure_{it-1} + u_{it} \tag{9}$$

where $tenure_{it}$ is a continuous measure of the number of years the CEO has held this position (similar to, for example, Bertrand and Schoar (2003), Peni (2014) and Kaur and Singh (2019)). In equation (9), our main parameter of interest is χ. A positive and significant coefficient in the interaction term might suggests that females with more years of CEO job tenure outperform their male counterparts ($\chi > 0$). More importantly, we assume that $tenure_{it-1}$ and the interaction term $gender_{it-1} * tenure_{it-1}$ are endogenous, because years of experience as a CEO is not reversible

[17]However, we cannot control for some CEO characteristics like marital status, race, number of children, and other unobservable characteristics because our data set does not provide this information.

[18]Many authors like Green and Homroy (2018), Wiley and Monllor-Tormos (2018), Ward and Forker (2017) and Adams and Ferreira (2009), among others, argue that gender board participation (gbp) could affect firm performance.

once the productivity shock occurs. In this sense, the law of motion of productivity is modified, allowing past *tenure* experience and the CEO *gender* decision to affect future productivity.

The idea behind this is that Stewardship theory (Donaldson and Davis, 1991) considers the tenure of CEOs as a provision that provides continuity to the organization; the CEO understands organizational values and operations very well because they have served the firm for several years. This long tenancy makes CEOs more accountable for their actions and also provides a sense of ownership to the firm, which helps align the CEO's objectives to those of the organization (Kaur and Singh, 2019). Consequently, authors like Baysinger and Hoskisson (1990), Ryan Jr and Wiggins III (2001), Huson et al. (2004), Simsek (2007), Xueming et al. (2013), Peni (2014) and Kaur and Singh (2019) argue that CEO job tenure is related to firm performance. Nevertheless, the relationship is not conclusive. Some of them found a positive relationship, while others found the opposite. More importantly, the interaction $gender_{it-1} * tenure_{it-1}$ allows us to test whether the effect of tenure is different for female compare with male CEOs.

Equation (3) is estimated using the GNR approach with the modifications proposed in equations (7), (8), and (9) on the law of motion of productivity to correct possible endogeneity and simultaneous decision on inputs problems and the decision of CEO gender. Notice that *gender*, *tenure* and its interaction $gender * tenure$ are endogenous variables. We allow the law of motion for productivity to depend on lagged values of each variable. This notion is inspired by the Doraszelski and Jaumandreu (2013) approach.[19]

5 Data and preliminary analysis

We use the balance sheets and financial statements registered on the official website of the Superintendencia de Compañías, Valores y Seguros (SCVS). This data base is novel, under-explored and unbalanced panel data from 2007 to 2018 built with the population of formal registered Ecuadorian firms. It provides detailed information about gross revenue, net tangible assets (capital stock), investments, number of formal employees, domestic intermediates purchases, foreign intermediates purchases, electricity, fuels, and many other firm characteristics (e.g., age, wages, exports), all measured in real values (using the respective annual price deflater). The data base also includes information about the industry (economic activity) based on ISIC Rev. 4 classification, the creation and closing date of the firm, firm size (measured as amount of gross revenue or as number of employees), and region, state and city location.[20] Moreover, the information from the SCVS allows us to have information about boardroom composition and the gender of the CEO of each firm by year.

Since we use an administrative database, we filter inconsistencies of reported information. We

[19]Doraszelski and Jaumandreu (2013) argue that modeling the law of motion for productivity has an advantage over simply estimating a production function with an exogenous Markov process. This is because the instruments have to be uncorrelated with the innovation to productivity (unexpected productivity shock) ξ_t but not necessarily with the level of productivity ω_{it}. The authors also argue that modeling the law of motion mitigates the endogeneity problem (of using endogenous variables) in estimating production functions.

[20]Camino-Mogro et al. (2018); Camino-Mogro and Bermudez-Barrezueta (2021); Camino-Mogro (2021) are some of the papers that use this dataset.

discard firms that reported zero or negative values in gross revenue, number of formal workers, total fixed assets, or consumption of intermediate inputs because those variables are the inputs for estimating the TFP. Additionally, we drop firms that reported the number of formal workers but zero values in wages. Finally, we take out the firms that were inactive in all the years of the analysis. In the Appendix section, Table 14 shows how we construct the main variables used for the estimation of the production function and TFP.

Table 1: Mean firm performance characteristics for female and male CEOs

	All firms		Large firms		MSME firms	
Variable	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Y	1.51	3.30	18.20	25.30	0.63	0.79
L	22	38	154	208	16	18
K	0.33	0.83	2.68	5.77	0.20	0.27
M	0.28	0.79	3.64	6.43	0.10	0.15
D	0.23	0.60	2.76	4.65	0.09	0.14
F	0.05	0.19	0.88	1.78	0.05	0.01
$Exports$	0.18	0.40	3.06	3.54	0.03	0.04
$Wages$	0.07	0.18	0.73	1.22	0.04	0.05
$Lprod$	1.90	2.05	2.93	2.93	1.84	1.94
$Kprod$	8.39	8.56	9.49	9.67	8.33	8.43
TFP	8.85	9.00	9.38	9.57	8.82	8.97
age	12	13	16	20	10	11
$No.Obs.$	62,146	176,776	3,107	18,155	59,039	158,621

Note: Values are in millions of U.S. dollars, except for workers (L), which is in number of people, TFP, which is in levels, and labor and capital productivity, which are in logs.
Source: Superintendencia de Compañías, Valores y Seguros.

Our final database is an unbalanced panel that contains 238,922 observations and 48,757 formal firms. Also, this paper focuses on the analysis of CEO gender and board participation in different industries. Therefore, we classify the economic activities into four sectors: *i*) natural resources, *ii*) manufacturing industry, *iii*) construction, *iv*) services (see, Appendix 15 for detailed information on which economic activities are in each sector). The main purpose of this segmentation is to analyze different patterns of CEO gender and board participation in TFP. For instance, it is well known that there is usually more female participation in the service sector or industries with technological intensity, whereas the participation of women in managerial positions is still scarce in labor-intensive industries. These four sectors are important in economic activity because they have a considerable number of firms in each group. The number of observations varies from 22,371 (natural resources) to 158,415 (services) depending on the sector classification.

Table 1 presents the mean firm performance characteristics for female and male CEOs divided by large and micro-small-medium (MSME) firms. The mean values suggest that firms with a male CEO have substantially better economic performance than firms with a female CEO. In terms of productivity, the difference is smaller. Firms with a male CEO have more gross revenue, labor, capital stock, total intermediates, domestic intermediates, foreign intermediates, exports,

wages, labor productivity, capital productivity, and TFP, and are older than firms with a female CEO (this trend remains when firms are classified by size). On average, firms with a male CEO have 2.17 times more gross revenue than firms with a female CEO, 1.72 times higher employment, 2.51 times capital stock, 2.82 times total intermediates, 2.60 times domestic intermediates, and 3.8 times foreign intermediates, and pay 2.57 times higher wages than a firm with a female CEO. The difference is slightly smaller in productivity measures. A firm with a male CEO has the same labor productivity, capital productivity and TFP as a firm with a female CEO. When we analyze these differences in each size group, we find similar characteristics, but the differences are larger when comparing a large firm managed by a female CEO with an MSME firm. Overall, the smallest difference is found in productivity measures and, in particular, in TFP.

This pattern is very similar when we disaggregate the economic activities into our four sectors. Overall, firms with a male CEO have greater economic and productivity measures than firms with a female CEO in each of the sector classifications. In Table 2, we show the mean firm characteristics for female and male CEOs grouped in the four sector classifications. This evidence suggests that even when we divide the economic activities into sectors focused on labor (natural resources and construction), value added (manufacturing industry) and services, firms with a male CEO continue to perform better than firms with a female CEO. Therefore, it seems that firms that have a female CEO do not have a performance premia compared with those that have a male CEO, at least on average. Again, the smallest difference is in productivity indicators, particularly in TFP, which suggests that a more in- depth analysis is needed.

Table 2: Mean firm performance characteristics for female and male CEOs: by sectors

	Natural Resources		Manufacturing		Construction		Services	
Variable	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Y	2.32	4.25	2.60	6.74	0.47	1.39	1.49	2.90
L	46	73	42	65	8	22	20	30
K	0.91	2.04	0.66	2.08	0.39	0.72	0.21	0.44
M	0.87	1.48	1.28	3.39	0.09	0.29	0.12	0.31
D	0.75	1.38	0.91	2.12	0.09	0.29	0.11	0.26
F	0.12	0.10	0.37	1.27	0.01	0.01	0.08	0.08
$Exports$	0.79	1.40	0.58	0.99	0.001	0.03	0.08	0.20
$Wages$	0.26	0.47	0.17	0.43	0.02	0.12	0.05	0.09
$Lprod$	2.64	2.69	2.12	2.30	1.93	2.09	1.79	1.89
$Kprod$	9.41	9.50	8.62	8.95	9.45	9.26	8.05	8.21
TFP	9.12	9.30	9.02	9.26	8.87	9.04	8.80	8.95
age	13	14	14	18	15	14	11	12
$No.Obs.$	4,484	17,887	5,838	21,181	8,334	22,783	43,490	114,925

Note: Values are in millions of U.S. dollars, except for workers (L), which is in number of people, TFP, which is in levels, and labor and capital productivity, which are in logs.
Source: Superintendencia de Compañías, Valores y Seguros.

Furthermore, in Table 3, we present the main descriptive statistics for the output and inputs included in the analysis along with labor productivity and TFP, considering differences by year, firm size and our four sectoral classifications. We show that output and inputs increase between

2007 and 2018, but labor productivity and TFP decrease in the whole period. In terms of size, it is shown that the larger the firm, the more output and inputs it has. This scenario could be related to the fact that larger firms need more inputs for production, and as the size of the firm is measured according to sales, this behavior is logical and expected (Camino-Mogro et al., 2018). According to our classification of the economic sectors, we show that the manufacturing industry has the largest output, labor force and total intermediates consumption, while the natural resources sector has the largest capital stock, labor productivity and TFP. However, the service and construction sectors have the lowest output and inputs. This evidence is in line with the well-known industry participation in the Ecuadorian economy, since this country is intensive in natural resources activities and, in particular, a country of primary production.

Table 3: Descriptive statistics

	y	**k**	**l**	**m**	**Lprod**	**TFP**	**Obs.**
Total	12.883	10.681	2.162	9.928	2.008	8.991	238,922
	(1.962)	(2.657)	(1.381)	(2.644)	(1.299)	(0.408)	
				Year			
2007	12.172	9.950	1.924	9.918	3.511	8.563	22,387
	(2.227)	(2.538)	(1.391)	(2.530)	(1.889)	(0.031)	
2018	13.103	10.958	2.427	9.715	1.939	9.016	21,000
	(1.898)	(2.823)	(1.177)	(2.830)	(1.230)	(0.427)	
				Size			
Micro	10.281	8.968	1.099	7.576	1.289	8.636	53,798
	(1.149)	(2.638)	(0.684)	(1.867)	(1.313)	(0.350)	
Small	12.700	10.312	1.919	9.688	1.901	8.942	111,837
	(0.645)	(2.239)	(0.961)	(2.009)	(1.191)	(0.307)	
Medium	14.511	11.942	2.940	11.444	2.479	9.232	52,025
	(0.452)	(1.928)	(1.263)	(2.067)	(1.166)	(0.284)	
Large	16.444	13.877	4.228	13.436	2.935	9.550	21,262
	(0.886)	(2.003)	(1.606)	(2.412)	(1.103)	(0.296)	
				Sector			
Natural Resources	13.510	12.238	2.757	11.635	2.679	9.270	22,371
	(1.824)	(2.275)	(1.587)	(2.511)	(1.489)	(0.355)	
Manufacturing	13.653	11.671	2.791	11.839	2.260	9.209	27,019
	(1.943)	(2.713)	(1.503)	(2.835)	(1.100)	(0.405)	
Construction	12.029	10.891	1.581	9.175	2.048	8.995	31,117
	(1.923)	(2.525)	(1.220)	(2.613)	(1.420)	(0.393)	
Services	12.831	10.251	2.085	9.509	1.865	8.913	158,415
	(1.914)	(2.589)	(1.286)	(2.370)	(1.243)	(0.388)	

Note: All values are in logs.
Source: Superintendencia de Compañías, Valores y Seguros.

To analyze the persistence of the gender dummy variable, we present the probabilities of transition in Table 4. In general, we show that there is high dependence among female and male CEOs. In other words, the gender of the CEO almost does not change over time. Overall, the probability of being male at time t and then male at time $t+1$, $t+2$ and $t+3$ goes from

approximately 93% to 98%. The case of females is similar, going from 85% to 94%, approximately. The probability of changing the gender of CEO in status $t+1$, $t+2$ or $t+3$ is around 2% to 18%.

Table 4: Transition Matrix of CEO's gender

		t+1		t+2		t+3	
		Male	Female	Male	Female	Male	Female
All sectors							
t	Male	97.40	2.60	95.49	4.51	94.00	6.00
	Female	6.31	93.69	10.87	89.13	14.57	85.43
Natural Resources							
t	Male	97.69	2.31	96.00	4.00	94.76	5.24
	Female	7.68	92.32	13.43	86.57	18.44	81.56
Manufacturing Industry							
t	Male	97.97	2.03	96.46	3.54	95.17	4.83
	Female	6.31	93.69	10.78	89.22	14.73	85.27
Construction							
t	Male	97.23	2.77	95.06	4.94	93.38	6.62
	Female	6.22	93.78	10.72	89.28	14.20	85.80
Services							
t	Male	97.28	2.72	95.32	4.68	93.76	6.24
	Female	6.19	93.81	10.65	89.35	14.21	85.79

Source: Superintendencia de Compañías, Valores y Seguros.
Elaboration: the authors.

6 Main results

In this section, we present the main results of our empirical analysis. In particular, we analyze the effect of CEO gender and gender board participation on productivity by using these two variables as exogenous and endogenous processes. For the latter, we use a modified Gandhi et al. (2020) estimator that modifies the law of motion of productivity and allows for an endogenous productivity process to obtain the correct impact of the gender of the CEO and board participation on productivity. Additionally, we use the GNR method (with the modification in the law of motion of productivity) to capture the effect of discrete and continuous gender variables on productivity for each of the four economic sectors to study the heterogeneous effect across sectors. Moreover, we do a similar analysis dividing by size, and as a robustness check, we use matching techniques such as propensity score matching (PSM) to evaluate the causal impact of CEO gender and gender board participation decisions on TFP. Finally, we present other robustness check of the the dynamics of productivity to potentially depend on the CEO $gender_{it}$ changes, by using a difference-in-difference matching (DDM) estimator, controlling for self-selection to capture the magnitude of different productivity growth between firms that decide to change the CEO and also the CEO gender with firms that decide to maintain the CEO and also the CEO gender.

6.1 Gender CEO decision

We start our analysis by showing that our main results have not suspicious of a two-way relationship (reverse causality) between the CEO gender decision and firm productivity, we estimate equation (1). Table 5 shows the results of this estimation. In particular, we find that past firm productivity (ω_{it-s}) is negative and not statistically significant at standard levels in the whole Ecuadorian firms, and in all subsectors. Specifically, we could mention that an increase in past firm productivity at year $t-s$ reduces the probability of having a female CEO. Our result dismisses the idea that better-managed firms show not only higher TFP but also more female CEOs.

Table 5: Selection in the decision of the CEO gender

Estimators	**All sectors**	**Natural resources**	**Manufacturing**	**Construction**	**Services**
			t-1		
ω_{it-1}	-0.051	-0.044	-0.059	-0.039	-0.049
	(0.050)	(0.035)	(0.039)	(0.026)	(0.040)
k_{it-1}	0.054***	-0.016***	0.017***	0.020***	0.049***
	(0.005)	(0.007)	(0.007)	(0.004)	(0.009)
l_{it-1}	-0.011***	-0.003	-0.005	-0.016***	-0.006
	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)
m_{it-1}	0.051***	0.028**	0.006	0.009***	0.029***
	(0.004)	(0.015)	(0.004)	(0.004)	(0.006)
Observations	182,416	17,415	21,634	22,473	120,754
			t-2		
ω_{it-2}	-0.089	-0.042	-0.053	-0.024	-0.067
	(0.065)	(0.034)	(0.033)	(0.029)	(0.058)
k_{it-2}	0.060***	-0.016***	0.008	0.021***	0.050***
	(0.008)	(0.004)	(0.004)	(0.005)	(0.009)
l_{it-2}	-0.011***	0.001	-0.010	-0.017***	-0.005
	(0.003)	(0.005)	(0.009)	(0.006)	(0.005)
m_{it-2}	0.059***	0.027***	0.009	0.014***	0.046***
	(0.005)	(0.006)	(0.004)	(0.006)	(0.004)
Observations	139,797	13,606	17,345	16,274	92,360
			t-3		
ω_{it-3}	-0.069	-0.044	-0.053	-0.089	-0.061
	(0.060)	(0.042)	(0.040)	(0.055)	(0.059)
k_{it-3}	0.056***	-0.018***	0.006	0.021***	0.055***
	(0.010)	(0.007)	(0.005)	(0.007)	(0.009)
l_{it-3}	-0.012***	0.004	-0.015***	-0.017***	-0.004
	(0.004)	(0.005)	(0.007)	(0.005)	(0.003)
m_{it-3}	0.056***	0.020***	0.003	0.006	0.041***
	(0.005)	(0.009)	(0.005)	(0.005)	(0.006)
Observations	112,126	11,058	14,369	12,551	73,939
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses clustered at the firm level. ω_{it} refers to the productivity obtained by using the GNR approach for all sectors and for each one separately. *$p < .10$, **$p < .05$, ***$p < .01$.

6.2 Impact of CEO gender and board participation on productivity

Table 6 shows the results of the OLS, Levinsohn-Petrin (LP) and GNR estimations. For the last two models, the CEO gender ($gender_{it-1}$) and gender board participation (gbp_{it-1}) are considered as endogenous variables. For the results of the Levinsohn-Petrin (LP) and the GNR estimations, we modify the law of motion of productivity and allows for an endogenous productivity process.[21] Columns (1)-(3) present the parameter estimates where the CEO's gender is treated as a discrete variable. The OLS result in column (1) shows that the discrete gender variable ($gender_{it-1}$) is negative and statistically significant at standard levels.[22]

To relax the restrictive assumptions of OLS, we use the LP estimator and the GNR approach that imposes a richer structure in the form of the endogenous productivity process to control for both selection and correlation between inputs and the unobserved productivity shock by having a female CEO as a proxy for an unobserved productivity shock as in equation (7). Column (2) of Table 6 reports the LP estimator under the modified specification for ω_{it} using a third-order polynomial in $(\omega_{it-1}, gender_{it-1})$ as in equation (7). We show that $\eta > 0$ and significant, also indicating a productivity effect of 3.4% from having a female CEO. This result is expected and implies that firms experience an improvement in productivity if they have a female CEO. Furthermore, in column (3) of Table 6, we report the GNR estimator under the modified specification for ω_{it} as in equation (7), and our results suggest that the dynamics of productivity to potentially depend on the CEO $gender_{it-1}$ exists. In specific, we find that $\eta > 0$ and significant, also indicating a productivity effect of 3.1% from having a female CEO. Also, in columns (1)-(3), we show that all inputs coefficients (elasticities) are positive and significant at standard levels, which demonstrates that the specification of our production function is correctly applied.[23]

We prefer the GNR estimator because this estimator proposes a simple, non-parametric estimator for production functions with at least one flexible input but also the identification is established by exploiting information in the first-order condition with respect to the flexible input from the firm's static profit maximization problem, contrary to other proxy variable methods which suffer from identification issues when the production function contains at least one flexible input such as materials (Gandhi et al., 2020; Merlevede and Theodorakopoulos, 2021).

Moreover, in columns (4)-(6) in Table 6, we show the estimation results using the continuous measure of gender, gender board participation (gbp_{it-1}), which is the participation of females on the board of directors. Again, we estimate the production function using the OLS, LP and GNR

[21] We perform the LP estimations by using and modifying the prodest command of Stata, developed by Rovigatti and Mollisi (2018). We also estimate our production function by using the Wooldridge (2009) and Ackerberg et al. (2015) estimators, and the results are very similar in magnitude and significance. These results are available upon request. Finally, for the GNR estimations we follow the Gandhi et al. (2020), Navas et al. (2020) and Merlevede and Theodorakopoulos (2021) Stata codes.

[22] It is well known that using an OLS estimator is not recommended to obtain consistent estimates of production function coefficients; it assumes that a firm's productivity shock is independent of any activity or decision made by the firm (Bournakis and Mallick, 2018; De Loecker, 2013; Van Beveren, 2012; Van Biesebroeck, 2007).

[23] Note that in our specification we do not include the $gender_{it-1}$ variable into the production function because De Loecker (2013) argues that it might be unwise to add a dummy variable as an input in the production function if the dummy information is not included in the productivity process. This is because the impact of the dummy variable on productivity is only deterministic and a firm can substitute any input with having (in this case) a female CEO at a constant unit elasticity.

Table 6: Impact of CEO's gender and board participation on productivity

Estimators	**OLS** **(1)**	**LP** **(2)**	**GNR** **(3)**	**OLS** **(4)**	**LP** **(5)**	**GNR** **(6)**
	(Discrete gender variable)			(Continuous gender variable)		
k_{it}	0.138***	0.046**	0.041***	0.138***	0.045***	0.041***
	(0.003)	(0.022)	(0.003)	(0.003)	(0.021)	(0.004)
l_{it}	0.498***	0.511***	0.537***	0.498***	0.508***	0.534***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)	(0.004)
m_{it}	0.299***	0.307***	0.312***	0.299***	0.295***	0.310***
	(0.002)	(0.004)	(0.002)	(0.002)	(0.007)	(0.002)
$gender_{it-1}$	-0.023***	0.034***	0.031***			
	(0.011)	(0.012)	(0.008)			
gbp_{it-1}				-0.023	0.027*	0.020*
				(0.015)	(0.016)	(0.011)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	238,922					

Notes: Standard errors in parentheses clustered at the firm level with 300 bootstrapped replications in LP and GNR estimations. We modify the law of motion of productivity (ω_t) of equation (7) for the discrete CEO gender variable and of equation (8) for continuous gender board participation. *$p < .10$, **$p < .05$, ***$p < .01$.

estimators, for the last two estimators we modify the law of motion of productivity and allows for an endogenous productivity process as in equation (8). Our results show that the variable gbp_{it-1} is negative in the OLS estimator but not statistically significant at standard levels. However, when we use the LP and GNR estimators which modifies the law of motion for productivity, we find that the dynamics of productivity to potentially depend on the gender board participation gbp_{it-1} exists. In particular, in column (5) and (6), we show that $\eta > 0$ and significant, which suggests that there is a positive effect of having more females in boardroom on productivity that comes from 2 to 2.7 percentage points.

These results agree with many authors that mention that having diverse teams outperform homogeneous teams (Kahane et al., 2013) and that increased female representation may lead to better firm performance (Green and Homroy, 2018). Also, adding female directors diversifies the set of boards' expertise (Kim and Starks, 2016). In general, a more diverse board may be associated with improved decision making, more efficient monitoring, and the displacement of less able male directors (see, for a review, Hermalin and Weisbach, 2003).

In addition, we present the results dividing the analysis into the four sectoral classifications (natural resources, manufacturing industry, construction and services) to analyze the heterogeneous effect of having a female CEO and gender board participation on productivity. For this analysis we use our modified GNR estimator. In Table 7, we present the results of the two measures of gender. First, when we use the discrete variable CEO gender ($gender_{it-1}$), we show that for the construction sector there is a positive and significant effect of 4% on productivity, and in the services sector, the $\eta > 0$ and significant, which suggests that there is a positive effect of

4.5% on productivity for firms that have a female CEO in this sector. This result is expected because the literature suggests that women entrepreneurs are usually concentrated in retail sales and services, while labor-intensive industries remain heavily dominated by men (see, for example, Kalleberg and Leicht, 1991; Bates, 1995; Du Rietz and Henrekson, 2000; Christiansen et al., 2017). However, there is no significant difference between having a female or a male CEO on firm productivity in natural resources and the manufacturing sector. Also, the elasticities of the traditional inputs are different across sectors, but in all the cases, the labor input is the dominant input. Only in the construction sector is capital stock not statistically significant at standard levels. Our results show the heterogeneity effect of having a female CEO on firm productivity across different economic sectors, and also on the use of inputs on the production process.

Table 7: Impact of CEO's gender and board participation on productivity: Different sectoral classifications

Estimators	**Natural resources**	**Manufacturing**	**Construction**	**Services**
Discrete gender variable				
k_{it}	0.071***	0.191***	0.070	0.035**
	(0.025)	(0.045)	(0.050)	(0.018)
l_{it}	0.421***	0.517***	0.700***	0.538***
	(0.011)	(0.009)	(0.009)	(0.004)
m_{it}	0.351***	0.351***	0.213***	0.297***
	(0.014)	(0.006)	(0.005)	(0.002)
$gender_{it-1}$	0.001	0.030	0.040***	0.045***
	(0.043)	(0.018)	(0.018)	(0.007)
Continuous gender variable				
k_{it}	0.070***	0.191***	0.070	0.035***
	(0.033)	(0.044)	(0.049)	(0.019)
l_{it}	0.420***	0.515***	0.695***	0.536***
	(0.014)	(0.009)	(0.008)	(0.003)
m_{it}	0.349***	0.346***	0.212***	0.295***
	(0.011)	(0.006)	(0.005)	(0.002)
gbp_{it-1}	0.019	0.033	0.020	0.010
	(0.055)	(0.025)	(0.024)	(0.010)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
No. of obs.	22,371	27,019	31,117	158,415

Notes: Standard errors in parentheses clustered at the firm level with 300 bootstrapped replications in GNR estimations. We modify the law of motion of productivity (ω_t) of equation (7) for the discrete CEO gender variable and of equation (8) for continuous gender board participation. *$p < .10$, **$p < .05$, ***$p < .01$.

Additionally, Table 7 reports the results when we use the continuous measure of CEO gender (gbp_{it-1}) in the production function. We show that the traditional inputs are very similar (in magnitude and significance) to the results reported when we use the discrete variable $gender_{it-1}$. Nevertheless, the capital stock is not statistically significant at standard levels in the construction sector. Furthermore, we show that gender board participation is not statistically significant in

none of the industries analyzed. This result may occur because even though women have a share on the board of directors, their opinions or advice for the performance of the firm are not taken into consideration. This suggests that it would not only be about increasing female participation within the board of directors, but also that their opinions be considered.

6.3 Differences in firm size and productivity

Many authors argue that female CEOs are concentrated in the services sector and industries with small firms (see, for example, Bardasi et al., 2011; Christiansen et al., 2017). To analyze the differences between having a female or a male CEO on firm productivity, we divide firms into four size measures: microenterprises, small, medium and large firms (according to Ecuadorian legislation). We estimate equations (3) by modifiying the law of motion of productivity as in equation (7) for each size and sectoral classification and using the GNR estimator.

In Table 8, we present the results of the estimation of our modified GNR estimator, dividing the firms into four size classifications. We find that the dynamics of productivity to potentially depend on the CEO $gender_{it-1}$ exists for medium and large firms, and the effect is 3% and 7.2%, respectively. However, in the other firm sizes, no significant evidence is found. Additionally, all the traditional inputs are positive and statistically significant at standard levels. The results of this table are related to the well-known evidence of best business practices that employs large firms. Our results are also in concordance with the hypothesis that large firms have better corporate governance practices and are more inclusive than their counterparts. Thus, the theory that male-led firms tend to perform better, particularly in larger companies, is not proven.

Table 8: Impact of CEO's gender and board participation on productivity: Different size classifications

Estimators	**Micro**	**Small**	**Medium**	**Large**	**Micro**	**Small**	**Medium**	**Large**
	(Discrete gender variable)				(Continuous gender variable)			
k_{it}	0.032***	0.051***	0.072***	0.058***	0.032***	0.050***	0.071***	0.058***
	(0.001)	(0.001)	(0.012)	(0.027)	(0.001)	(0.001)	(0.018)	(0.040)
l_{it}	0.306***	0.180***	0.078***	0.142***	0.305***	0.180***	0.077***	0.141***
	(0.007)	(0.002)	(0.004)	(0.008)	(0.007)	(0.002)	(0.004)	(0.007)
m_{it}	0.137***	0.078***	0.081***	0.228***	0.137***	0.103***	0.081***	0.222**
	(0.011)	(0.004)	(0.003)	(0.018)	(0.012)	(0.008)	(0.003)	(0.007)
$gender_{it-1}$	0.00001	0.003	0.030***	0.072***				
	(0.003)	(0.004)	(0.007)	(0.028)				
gbp_{it-1}					0.092***	0.009*	0.029***	0.154***
					(0.004)	(0.005)	(0.013)	(0.036)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	53,798	111,837	52,025	21,262	53,798	111,837	52,025	21,262

Notes: Standard errors in parentheses clustered at the firm level with 300 bootstrapped replications in GNR estimations. We modify the law of motion of productivity (ω_t) of equation (7) for the discrete CEO gender variable and of equation (8) for continuous gender board participation. *$p < .10$, **$p < .05$, ***$p < .01$.

Also, we show in Table 8 how having more females in the boardroom (gbp_{it-1}) could affect productivity. Our results suggest that an increase of females in the boardroom has a positive effect of 0.92% on productivity in microenterprises, 0.09% in small firms, 0.29% in medium firms and 1.54% in large firms. Again, our results suggest that having more females in the boardroom increases productivity, with higher effect on large firms. This result is particularly interesting because Ecuador is a country with a large number of microenterprises and small firms, but those firms have many constraints like credit, international trade and innovative access, so their economic growth is more complicated than it is for medium and large firms.

Overall, we find that using the discrete or the continuous variable of gender to analyze the impact on productivity has similar effects: there is a positive effect on productivity if firms have a female CEO or more female participation on the board of directors. More important is that this effect is heterogeneous when we divided the sample in different industries. In particular, we show that the gender board participation has not an effect on productivity in each industry. It instead suggests a debate to show that there are no statistically significant differences between having a man or a woman as CEO or increasing their participation on the board. This result therefore suggests that industries that are more intensive in machinery or labor do not necessarily need a man in charge of leadership to achieve short- and medium- term objectives.

Moreover, it is relevant to mention that we show that our empirical model is well suited to both measures of gender: the discrete or continuous variable. However, having unobservable variables (in this case) such as level of education, number of children of the CEO, level of education of parents, place of residence (rural or urban) and place of high school or university studies could improve or clarify the results.

Furthermore, Table 9 shows the results of the estimation of our modified GNR estimator for each size and sector by using the discrete ($gender_{it-1}$) and the continuous gender variables (gbp_{it-1}). First, in the natural resources sector, we show that $\eta > 0$ and significant in small firms, also indicating a productivity effect of 10% that comes from having a female CEO. Similar results are found when we use our continuous measure of gender (gbp_{it-1}). An increase of females in the boardroom has a positive effect on productivity (1.23%) in small firms. Second, for the manufacturing industry, our results suggest that there is no significant difference of having a female or a male CEO in productivity only in microenterprises. In the others size, we find that the dynamics of productivity to potentially depend on the CEO $gender_{it-1}$ exists. In specific, the gains on productivity comes from 3.8% to 10.5% depending on the firm size. Similar results are found when we analyze the gender board participation gbp_{it-1}. Third, in the construction sector, our results show that $\eta > 0$ and significant from small to large firms, which suggests that there is an increase of 5.8% to 7.5% in productivity, depending on the firm size, with a female CEO. Furthermore, when we analyze the continuous measure of gender board participation, we find similar results. Finally, in the service sector, we find similar results that those of the manufacturing and construction industry.

Table 9: Impact of CEO's gender and board participation on productivity: by sectoral and size classification

Estimators	**Micro**	**Small**	**Medium**	**Large**	**Micro**	**Small**	**Medium**	**Large**
	(Discrete gender variable)				(Continuous gender variable)			
Natural Resources								
k_{it}	0.004	0.041***	0.068***	0.158***	0.005	0.042*	0.069**	0.157***
	(0.004)	(0.003)	(0.005)	(0.020)	(0.004)	(0.003)	(0.005)	(0.022)
l_{it}	0.291***	0.181***	0.112***	0.136***	0.295***	0.181***	0.112***	0.134***
	(0.013)	(0.005)	(0.006)	(0.019)	(0.013)	(0.005)	(0.006)	(0.019)
m_{it}	0.185***	0.212***	0.194***	0.224***	0.185***	0.212***	0.194***	0.223***
	(0.055)	(0.015)	(0.010)	(0.020)	(0.042)	(0.017)	(0.009)	(0.021)
$gender_{it-1}$	-0.004	0.100***	0.007	-0.067				
	(0.014)	(0.014)	(0.022)	(0.085)				
gbp_{it-1}					-0.006	0.123***	0.012	-0.063
					(0.020)	(0.018)	(0.026)	(0.093)
No. of obs.	2,708	9,755	7,154	2,754	2,708	9,755	7,154	2,754
Manufacturing industry								
k_{it}	0.028***	0.072***	0.074***	0.260***	0.028***	0.072***	0.074***	0.262***
	(0.004)	(0.003)	(0.007)	(0.019)	(0.004)	(0.003)	(0.007)	(0.019)
l_{it}	0.331***	0.208***	0.090***	0.175***	0.334***	0.210***	0.088***	0.173***
	(0.010)	(0.005)	(0.010)	(0.019)	(0.009)	(0.005)	(0.010)	(0.019)
m_{it}	0.206***	0.204***	0.209***	0.291**	0.206***	0.204***	0.209***	0.291***
	(0.019)	(0.019)	(0.018)	(0.048)	(0.019)	(0.018)	(0.019)	(0.038)
$gender_{it-1}$	-0.014	0.105***	0.077***	0.038**				
	(0.010)	(0.012)	(0.025)	(0.019)				
gbp_{it-1}					-0.017	0.111***	0.044*	0.148***
					(0.013)	(0.015)	(0.025)	(0.090)
No. of obs.	3,106	11,993	7,295	4,625	3,106	11,993	7,295	4,625
Construction								
k_{it}	0.071***	0.028***	0.043***	0.081***	0.070	0.027***	0.041***	0.118***
	(0.002)	(0.003)	(0.010)	(0.026)	(0.002)	(0.003)	(0.010)	(0.027)
l_{it}	0.280***	0.213***	0.144***	0.205***	0.280***	0.214***	0.144***	0.208***
	(0.010)	(0.006)	(0.013)	(0.025)	(0.010)	(0.006)	(0.013)	(0.026)
m_{it}	0.142***	0.109***	0.083***	0.105***	0.142***	0.110***	0.083***	0.082***
	(0.020)	(0.009)	(0.007)	(0.022)	(0.019)	(0.008)	(0.007)	(0.020)
$gender_{it-1}$	-0.011	0.069***	0.075*	0.058*				
	(0.007)	(0.011)	(0.042)	(0.031)				
gbp_{it-1}					-0.013	0.071***	0.059**	0.096**
					(0.010)	(0.015)	(0.031)	(0.052)
No. of obs.	11,996	13,817	4,174	1,130	11,996	13,817	4,174	1,130
Services								
k_{it}	0.050***	0.062***	0.072***	0.024*	0.047***	0.062**	0.071***	0.024***
	(0.001)	(0.001)	(0.004)	(0.014)	(0.001)	(0.001)	(0.003)	(0.009)
l_{it}	0.284***	0.165***	0.059***	0.124***	0.284***	0.166***	0.058***	0.122***
	(0.009)	(0.002)	(0.004)	(0.009)	(0.010)	(0.002)	(0.004)	(0.009)
m_{it}	0.125***	0.076***	0.040***	0.179***	0.125***	0.076***	0.040***	0.174***
	(0.018)	(0.005)	(0.007)	(0.009)	(0.017)	(0.006)	(0.006)	(0.010)
$gender_{it-1}$	-0.004	0.078***	0.042***	0.014***				
	(0.003)	(0.005)	(0.012)	(0.003)				
gbp_{it-1}					-0.003	0.049***	0.016***	0.087***
					(0.004)	(0.007)	(0.007)	(0.043)
No. of obs.	35,988	76,272	33,402	12,753	35,988	76,272	33,402	12,753
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses clustered at the firm level with 300 bootstrapped replications in GNR estimations. We modify the law of motion of productivity (ω_t) of equation (7) for the discrete gender CEO variable and of equation (8) for continuous gender board participation. *$p < .10$, **$p < .05$, ***$p < .01$.

In specific, our results suggest that the dynamics of productivity to potentially depend on the CEO $gender_{it-1}$ exists and comes from 1.4% to 7.8%, depending on the firm size. Again, these results are similar when we analyze the female board participation. Our results suggest that an increase of females in the boardroom has a positive effect on more established firms. Overall, we show that there is a heterogeneous effect of having a female CEO and female participation in the boardroom in different firm sizes of different economic sectors. The effect of having a female CEO in larger firms is, overall, positive in all the sectors, which suggests that females involved in managerial positions in a complex sector and in firms with better corporate governance practices and best business practices could improve firm productivity.

6.4 The moderating role of CEO job tenure experience

In this subsection, we analyze how the effect of tenure is different for females compared with males as CEOs. Consequently, we estimate equation (3) by using our modified GNR estimator, in which we endogenize the law of motion of productivity, allowing the past decision to have a female CEO (*gender*) and past CEO job tenure (*tenure*) to affect future firm productivity as in equation (9).

In Table 10, we show the impact of CEO gender tenure on productivity by different sectorial classifications. Our results for all firms suggest that the effect of tenure on firm productivity is positive and statistically significant for female compared with male CEO ($\chi > 0$). This evidence reveals that the effect of an increase in the number of years as CEO in the firm is larger for women than for men. Similar results are found in natural resources, manufacturing and service firms. Nevertheless, no significant effects are shown in the construction sector.

The evidence found in Table 10 supports the idea that female CEO job tenure is particularly different in the entire formal economy and three sectors and favors the female stewardship theory. The reason for this finding could be related to executive's tenure advances: the executive has more firm-specific knowledge and a better ability to monitor and provide valuable resources, which may improve the firm's performance (Baysinger and Hoskisson, 1990). Moreover, women tend to have higher expectations of their responsibilities, and women have to demonstrate extra competence in order to reach executive positions (Fondas, 1997; Eagly and Carli, 2003; Dunn, 2012), so when they reach this type of position their more cooperative leadership style may be more productive than men's competitive style (Eagly and Carli, 2003).

In Table 16 in the Appendix, we present the results of the impact of CEO gender tenure on productivity by different size classifications. The results suggest that the effect of tenure on firm productivity is positive and statistically significant for females compared with males ($\chi > 0$) in all firm sizes. This result shows the importance of tenure experience, regardless of firm size, to increase productivity.

Table 10: Impact of CEO gender tenure on productivity: Different sectoral classifications

Estimators	All sectors	Natural resources	Manufacturing	Construction	Services
k_{it}	0.041**	0.071***	0.191**	0.070	0.035**
	(0.004)	(0.026)	(0.049)	(0.044)	(0.019)
l_{it}	0.542***	0.428***	0.522***	0.700***	0.542***
	(0.004)	(0.014)	(0.009)	(0.010)	(0.006)
m_{it}	0.317***	0.355***	0.356***	0.217***	0.301***
	(0.002)	(0.011)	(0.008)	(0.005)	(0.005)
$gender_{it-1}$	0.030***	0.005	-0.034	-0.038	0.037**
	(0.012)	(0.059)	(0.024)	(0.029)	(0.010)
$tenure_{it-1}$	-0.006	0.097***	0.046***	0.088***	0.090***
	(0.004)	(0.006)	(0.003)	(0.004)	(0.001)
$gender_{it-1} * tenure_{it-1}$	0.079***	0.030***	0.061***	0.004	0.031***
	(0.002)	(0.012)	(0.005)	(0.006)	(0.002)
No. of obs.	238,922	22,371	27,019	31,117	158,415
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses clustered at the firm level with 300 bootstrapped replications. The LP Endog uses the stochastic process of ω_t of equation (9). *$p < .10$, **$p < .05$, ***$p < .01$.

6.5 Robustness check: Estimating treatments effects

The participation of female CEOs in formal firms is scarce. In Figure 5 in the Appendix, we show that this participation is around 26% during the period of analysis. We also show in Figure 6 and 7 in the Appendix that female CEOs are very concentrated in microenterprises and small firms and in the service sector. This graphical evidence suggests that in many subsectors the representation of female CEOs might be underrepresented. In this regard, to get more robust results, and similar to Bardasi et al. (2011), we use the propensity score matching (PSM) technique to weight our data set in a way so that the observations we analyze are more comparable[24]. The magnitude of the effect of having a female CEO on firm productivity could be obtained by estimating the following equation:

$$PSM_{ATT} = E[\omega_{it}(1)|\rho, D = 1] - E[\omega_{it}(0)|\rho, D = 0] \tag{10}$$

where ω_{it} is the TFP for firm i in year t; ρ is the propensity score of having a female CEO based on the given firm characteristics X, which in our case are capital stock, number of employees, total intermediates, the lag decision of having a female CEO, and industry, year and region dummies. Moreover, ρ is used to find matched treated (female CEO) and untreated (male CEO) firms, allowing like-for-like comparison. D is a dummy equal to one if the firm has a female CEO, while it takes the value zero if the firm has a male CEO. Finally, PSM_{ATT} is the magnitude of different TFP between firms managed by a female CEO and those managed by a male CEO.

[24]We implement the matching approach as proposed by Abadie and Imbens (2006, 2011, 2016) using the teffects psmatch command in STATA.

We regress equation (10) by matching female and male CEOs to our four sectoral classifications using the traditional inputs (capital stock, labor and total intermediates), but we also include the past decision to have a female/male CEO. We estimate the average treatment effect on the treated (ATT) for TFP (ω_{it}), which allows us to compare the TFP of female and male CEOs that are in similar sectors and also to capture the average effect of having a female CEO on TFP. Furthermore, in the PSM estimation, we use the *logit* regression in which a dummy for a female CEO is used as a dependent variable, and the traditional inputs, industry, year and region dummies are used as independent variables. Finally, to obtain the average effects of having a female CEO, we implement the nearest-neighbor matching (k) with $k = 4$.[25]

In Table 11, we present the results of the PSM estimation. We show that there is no statistically significant difference between having a female or a male CEO when analyzing productivity in the natural resources, manufacturing and construction sectors. Nevertheless, for the service sector, we find that having a female CEO is significantly different, by 3.5%, in TFP when compared with firms with a male CEO. This result suggests that the effect of female CEOs on productivity is likely reflecting the fact that female CEOs tend to work in certain sectors which are more productive than others. They prove the robustness of our results not only by using the modified GNR estimator that endogenizes the law of motion for productivity, allowing past decisions to have a female CEO to affect future productivity, but also by employing a matching technique.

Table 11: Female Vs. Male CEOs: propensity score matching

ATT	**Natural resources**	**Manufacturing**	**Construction**	**Services**
Female vs. *Male*	0.013	0.008	0.055	0.035**
	(0.054)	(0.034)	(0.055)	(0.018)
No. of obs.	22,371	27,019	31,117	158,415

Notes: bootstraps standard errors in parentheses. $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.

7 Changes in the CEO and CEO gender

Finally, to present an analysis of the dynamics of productivity potentially depend on the CEO $gender_{it}$ changes, we use a difference-in-difference matching (DDM) estimator, controlling for self-selection. The estimator allows us to capture the magnitude of different productivity growth between firms that decide to change the CEO and also the CEO gender with firms that decide to maintain the CEO and also the CEO gender. The magnitude of the coefficient of gender effects on firm productivity can be obtained by estimating the following equation:

$$DDM_{ATT} = E[\omega_{it} - \omega_{it'}|\mu, G = 1] - E[\omega_{it} - \omega_{it'}|\mu, G = 0] \tag{11}$$

where t' refers to the change year and t is a given year after the change; $\omega_{it} - \omega_{it'}$ therefore

[25]We also use the *probit regression*, implementing $k = 3$ and $k = 1$, and similar results are found. These results are available upon request.

measures the magnitude of the different productivity growth of firm i in a given period after the change. G is a dummy equal to one if the firm change the CEO and also the CEO gender, while it takes the value zero if the firm decide to maintain the CEO and also the CEO gender during the period between t' and t. μ is the propensity score of changing a CEO and also the CEO gender based on the given firm characteristics X, which in our case are the initial level of TFP, and a set of industry, year and region dummies. μ is used to find matched treated (new CEO's) and untreated (non-new CEO's) firms, allowing like-for-like comparison. Finally, DDM_{ATT} is the magnitude of different productivity growth between firms that change the CEO and also the CEO gender and firms that decide to maintain the CEO and also the CEO gender in a given period after entry. We regress equation (11) for the whole firms and for each industry classification: natural resources, manufacturing, construction and services.

To do this exercise, we recover the TFP obtained by using our modified GNR estimator with an endogenous productivity process that allows the CEO gender decision to impact future productivity by using equations (3) and (7). We recover the TFP for the entire economy and for each industry classification. Table 12 reports the magnitude of different productivity growth between the firms that change the CEO and also the CEO gender and the firms which decide to maintain the CEO and also the CEO gender. This exercise is done to capture gender effects on productivity growth.

Table 12: Changes in the CEO and CEO gender: Matched sample

	All sectors	**Natural resources**	**Manufacturing**	**Construction**	**Services**
$\Delta\omega_{it}$	-0.002	0.004	0.0004	0.002	-0.003
	(0.002)	(0.008)	(0.001)	(0.011)	(0.003)

Notes: Estimates include year, industry and region dummies, but they are not reported. We use equation (11), controlling for an initial level of TFP and a set of industry, year and region dummies as explanatory variables. We use the *psmatch*2 Stata command.

Table 12 shows that after the change of the CEO and also the CEO gender, these firms do not increase their productivity in the first year after the change compared to firms which decide to maintain the CEO and also the CEO gender. This evidence suggests that increases in future productivity are not due to changes in the CEO and the CEO's gender (from male to female or vice versa) but may be due to other factors such as permanence of the CEO (stability), experience, achievement of goals, among others. This result shows that the evidence found in the previous section is valid since companies led by women are more productive than those led by men even when we add CEO job tenure.

8 Conclusions

The effect of female CEOs or gender diversity in the boardroom on firm performance is ambiguous. Various authors find different effects. Some find a positive effect; others find a negative or even no effect. These inconclusive results have focused on developed countries, and most of them have not

analyzed productivity. We provide new insights on how having a female CEO and more females in the boardroom are endogenous decisions. Hence, we endogenize the law of motion for productivity, allowing past decisions to have a female CEO and have more females in the boardroom to affect future productivity. In this regard, we use Ecuadorian firm-level data from the period 2007-2018 and divide all firms into four economic sectors and four sizes to find evidence of the heterogeneous effect of female CEOs and female boardroom participation on firm productivity.

This paper is innovative in at least three aspects. First, the empirical literature has made great strides in finding the relationship between having a female CEO and economic performance, and another approach has focused on the effect that women's participation on the board of directors has on performance. However, they have not emphasized productivity. The few studies that have analyzed this effect on TFP do a two-stage estimation. They obtain productivity first and then regress on the gender of the CEO, thus assuming that the decision of who is in charge of the company is completely exogenous. Consequently, this document makes a novel contribution in allowing the decision to have a female CEO and female participation in the boardroom to be treated as endogenous, thereby obtaining more reliable results. Our second contribution is that we do not analyze a single economic sector; we consider all of them and divide them into four sectors grouped in such a way that they represent the intensity of the goods they offer; natural resources, manufacturing, construction and services. We also divide them into classes of firm size, since it is known that women tend to participate more in smaller firms and the service sector. In this way, we manage to capture the heterogeneous effect of having a woman as a CEO on productivity. Finally, we use matching techniques to find a causal effect of having a female CEO on productivity. The results of the three approaches are similar, indicating that our proposed empirical model is robust and also works for both discrete variables such as the gender of the CEO and for continuous variables such as women's participation on the board.

We demonstrate that having a female CEO increases firm productivity. This effect is larger in the services sector (construction and service). Additionally, we find that increased female participation in the boardroom has a positive effect on firm productivity. Nevertheless, when we explore industry heterogeneity our evidence suggest that increased female participation in the boardroom has null effect on firm productivity in each sector. In terms of size, our results suggest that small, medium and large firms benefit from having a female CEO, except in the natural resources sector. A similar effect is found when we analyze the effect of female participation in the boardroom on productivity. Our results are supported using matching techniques. Furthermore, we also find that the effect of an increase in the number of years as CEO in the firm is larger for women than for men. Similar results are found in natural resources, manufacturing and service firms. Nevertheless, no significant effects are shown in the construction sector. Finally, we demonstrate that increases in future productivity are not due to changes in the CEO and the CEO's gender (from male to female or vice versa) but may be due to other factors such as permanence of the CEO (stability), experience, achievement of goals, among others.

Our results are important in several aspects, from the methodological approach we use to insights for public policy makers. As for the methodological issue, we show that treating the

gender of the CEO as an exogenous variable could lead to results contrary to those obtained in this paper. Our assumption is that although the gender of a person is given, the decision to hire a man or a woman as CEO is not exogenous, since the hiring of a person has firm implications in the short and medium term. Therefore, we modify the law of motion of productivity. In terms of public policy, we find evidence that supports the idea that increased gender diversity in the boardroom boosts productivity. In Ecuador, less than 30% of boardrooms are made up of women. Boosting participation of women in the boardroom could be beneficial for firms in terms of productivity. Hence, incentives could be created for firms that achieve an equal proportion of men and women, such as deduction of expenses on tax declarations, reduction of taxes, subsidies, financing in R&D proposals, and others. Finally, future research may derive from the results obtained in this paper. Specifically, it may be interesting to analyze information about the CEO, such as the level of education, the education of the parents, number of children, marital status, area of residence, place of study, and race, among others. Because of the limitations of our data base, this information was not observable. It could refine the results of this study, which are a starting point at which to demonstrate the endogeneity of the decision of the firm manager.

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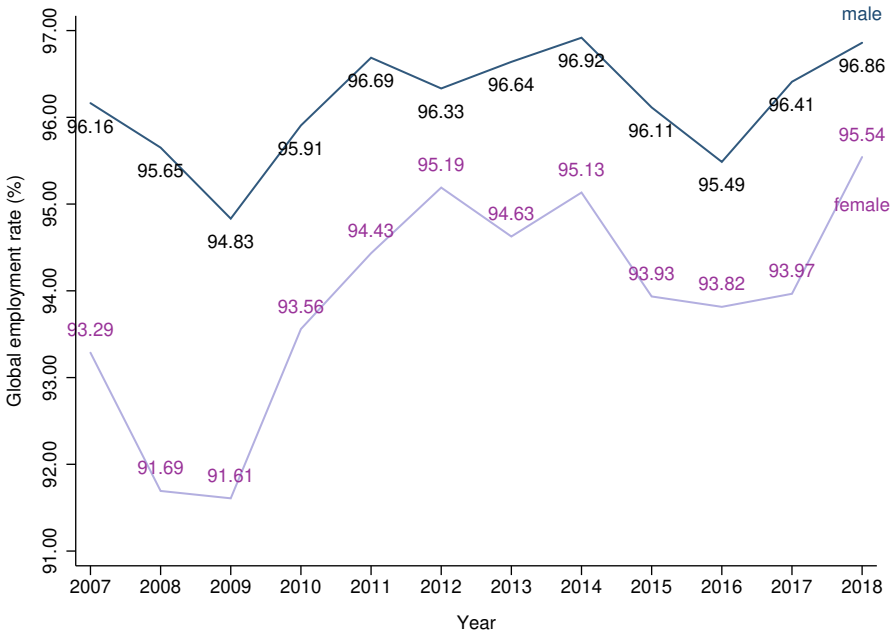
9 Appendix

Table 13: Gender diversity on the board and firms' performance

Authors	Data Country	Independent Variable	Method	Effect	Address endogeneity
Dang et al. (2020)	500 largest companies U.S.A.	% of female directors Blau Index	Control function approach	+ROA	Yes
Isola et al. (2020)	commercial banks Nigeria	% female board participation	RE	none	No
Castillo et al. (2019)	large manufacturing firms Ecuador	% female CEO dummy	FE	+ ROA	No
Jadiyappa et al. (2019)	100 firms India	female CEO dummy	DID	- ROE	Yes
Flabbi et al. (2019)	firms Italy	female board participation female CEO dummy	Two-way FE	+ sales	Yes
Tsou and Yang (2019)	manufacturing firms China	Female ratio workforce	Levinsohn-Petrin	+/- TFP	No
Luanglath et al. (2019)	firms on ASX stock exchange Australia	Blau Index	HMR	+ productivity	No
Green and Homroy (2018)	European firms	% of women on the board	IV	+ ROA	Yes
Nekhili et al. (2018)	394 firms France	female CEO dummy	PSM	+ Tobin's Q	Yes
Chadwick and Dawson (2018)	S&P 500 firms	female CEO, CFO dummy	OLS	+ ROA	No
Moreno-Gómez et al. (2018)	54 public business Colombia	% of women on the board female CEO dummy	FE	+ ROA, ROE	No
Gordini and Rancati (2017)	firms on stock exchange Italy	Blau and Shannon indices	2SLS	+ Tobin's Q	No
Shehata et al. (2017)	34,798 firms UK	Blau index	FE	- ROA	No
Conyon and He (2017)	firms of Russell 3000 Index U.S.A.	% of women on the board	quantile regression	+ Tobin's Q + ROA	Yes
Adusei et al. (2017)	microfinance institutions 76 countries	% of female directors	FE	- ROA	No
Ruiz-Jiménez and del Mar Fuentes-Fuentes (2016)	technology-based SMEs Spain	Blau index	HMR	none	No
Terjesen et al. (2016)	public firms 47 countries	% of female directors % of independent directors	GMM	+ Tobin's Q + ROA	Yes
Marinova et al. (2016)	186 listed firms Netherlands & Denmark	% of female directors	2SLS	none	Yes
Perryman et al. (2016)	Compustat and ExecuComp firms	% of female directors	OLS	+ Tobin's Q	No
Kılıç and Kuzey (2016)	firms on Borsa Istanbul Turkey	% of female directors Blau Index	2SLS	+ROA +ROE +ROS	Yes
Sabatier (2015)	CAC40 France	fraction of female directors	FE, IV frontier model	+ROE	Yes
Liu et al. (2014)	firms on stock exchange China	% of female directors	2SLS GMM	+ ROA + ROS	Yes
Khan and Vieito (2013)	ExeCucomp data U.S.A.	Female CEO dummy	2SLS	+ROA -Risk	Yes
Robb and Watson (2012)	new ventures U.S.A.	Female owner dummy	OLS	none	No
Ahern and Dittmar (2012)	public firms on Oslo Stock Exchange Norway	fraction of female directors	IV	- Tobin's Q	Yes
Adams and Ferreira (2009)	S&P 500, S&P MidCaps, S&P SmallCap firms U.S.A.	% of female directors	IV	- Tobin's Q	Yes
Bardasi et al. (2011)	sample of firms CEE & CIS	Female ownership dummy	FE PSM	none/ Profit rate - TFP	No

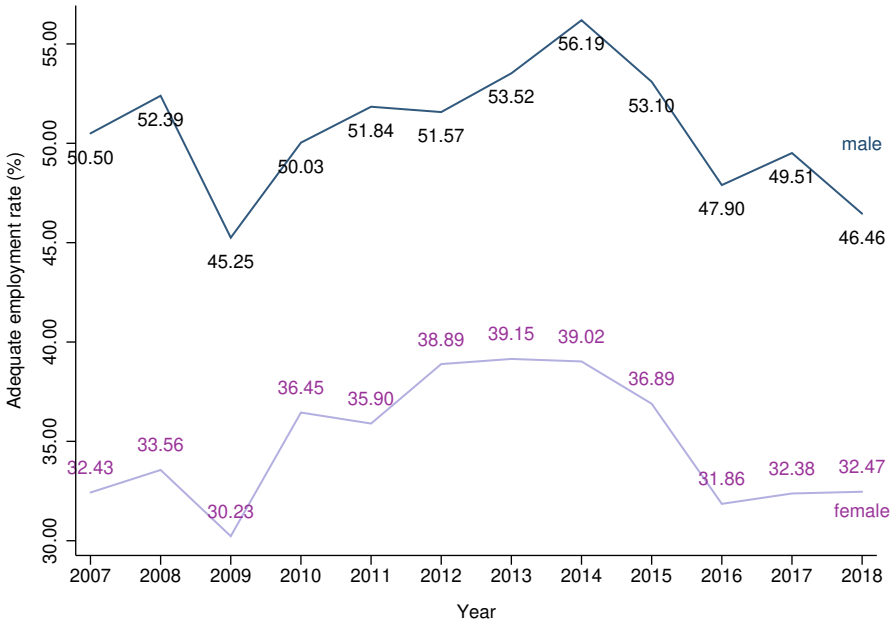
Note: Central and Eastern Europe (CEE), Commonwealth of Independent States (CIS),40 most important companies listed on Euronext Paris (CAC40), Return on Sales (ROS), Return on Assets (ROA), Ratio of firm's assets market value to their replacement value (Tobin's Q), Total Factor Productivity (TFP), Fixed Effects (FE), Random Effects (RE), Propensity Score Matching (PSM), Hierarchichal Multiple Regression (HMR), Abowd, Kramarz, Margolis model (AKM), Instrumental Variable approach (IV), Ordinary Linear Regression (OLS), Two-Stage Least Squares (2SLS).
Elaboration: The authors.

Figure 1: Global employment



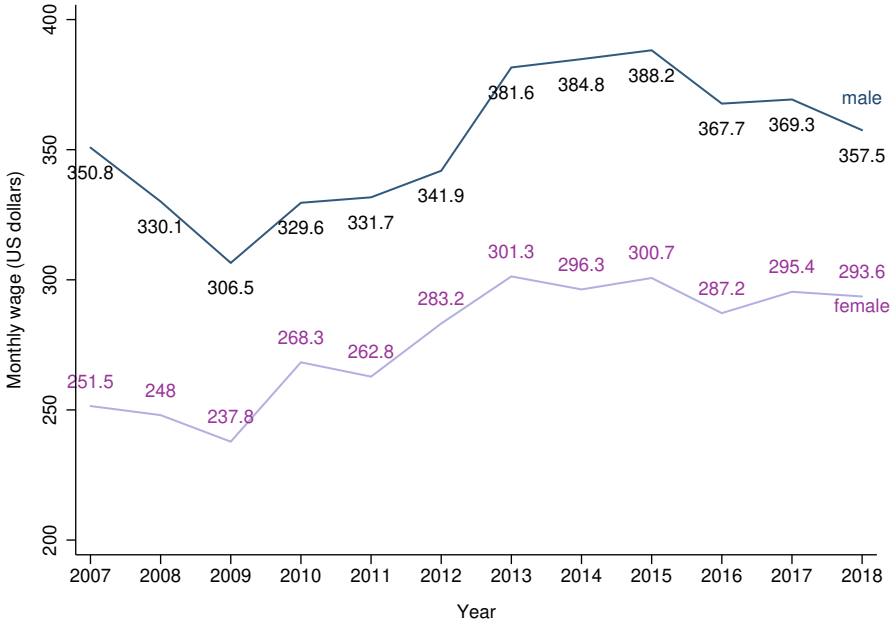
Note: Global employment rate is the percentage that results from dividing total employment by economically active population (labor force).
Source: ENEMDU-Instituto Nacional de Estadisticas y Censos (INEC).
Elaboration: The authors.

Figure 2: Adequate employment



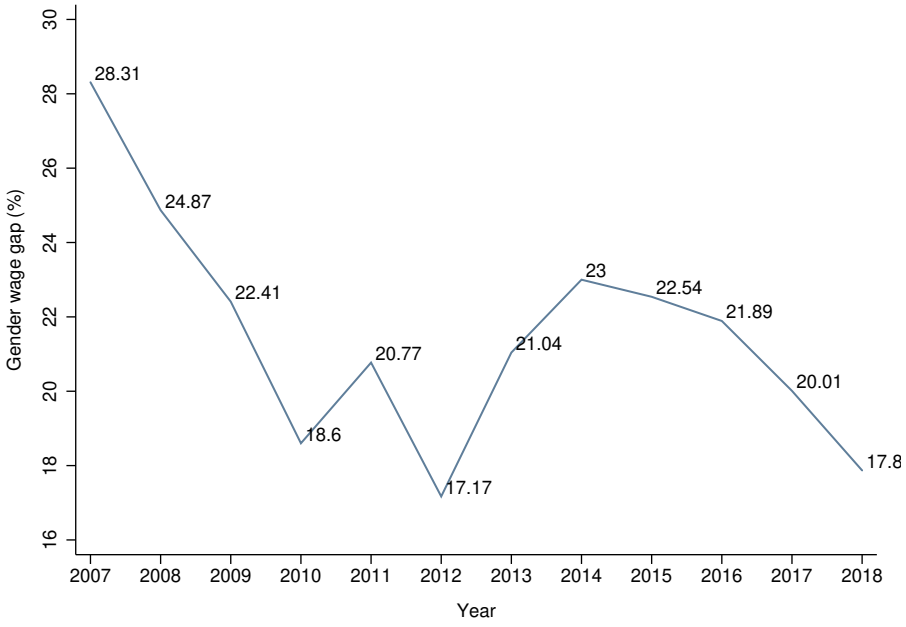
Note: Adequate employment rate is the resulting percentage from the division between total adequate employment and the economically active population. Adequate employment refers to employed people who, during the reference week, receive labor income equal to or higher than the minimum wage
Source: ENEMDU-Instituto Nacional de Estadisticas y Censos (INEC).
Elaboration: The authors.

Figure 3: Wage by gender



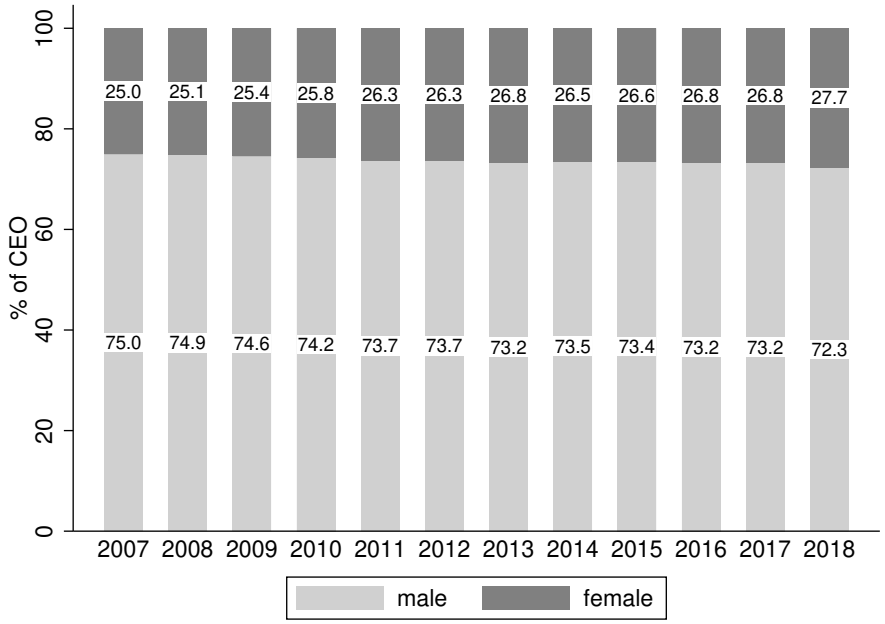
Source: ENEMDU-Instituto Nacional de Estadisticas y Censos (INEC).
Elaboration: The authors.

Figure 4: Gender pay gap



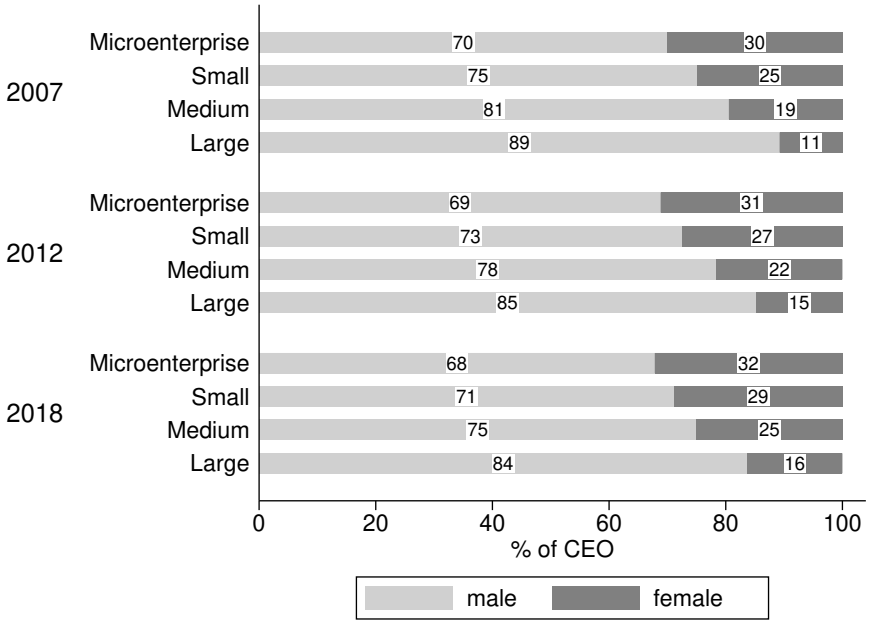
Source: ENEMDU-Instituto Nacional de Estadisticas y Censos (INEC).
Elaboration: The authors.

Figure 5: Distribution of female CEOs 2007-2018



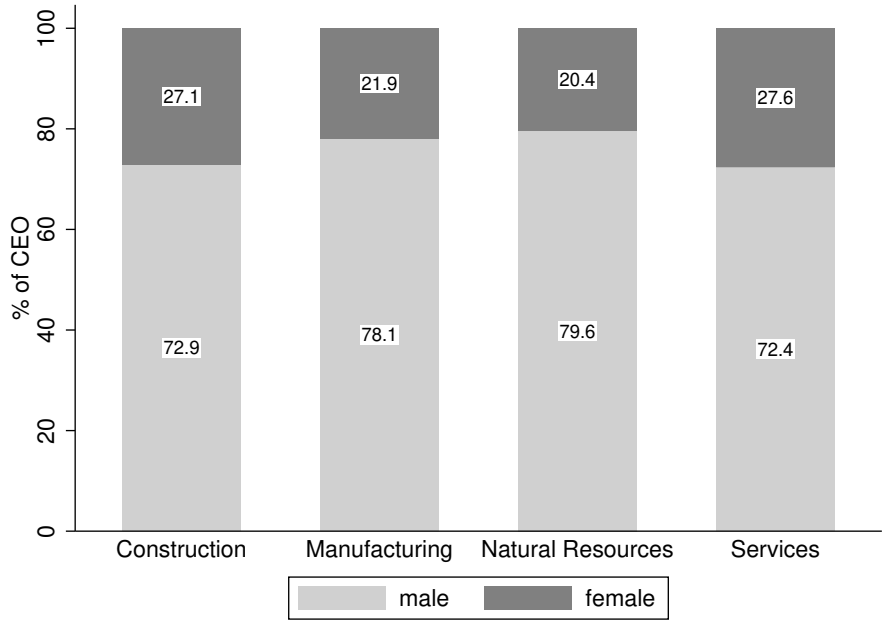
Source: Superintendencia de Compañias, Valores y Seguros.
Elaboration: The authors.

Figure 6: Participation of female CEOs by size



Source: Superintendencia de Compañias, Valores y Seguros.
Elaboration: The authors.

Figure 7: Participation of female CEOs by sector



Source: Superintendencia de Compañias, Valores y Seguros.
Elaboration: The authors.

Table 14: Definition of variables

Variable	Code	Definition
Gross revenue	Y	Total income from sales = revenues from sales of ordinary activities of the company (income from extraordinary activities is excluded from the business of each company, for example, sale of land, machinery, etc.). This variable is deflated using the industry-specific price index obtained from the Ecuadorian National Institute of Statistics.
Workers	L	Number of legally registered employees.
Capital stock	K	Net tangible assets = the sum of the real dollar value of buildings, machinery, and vehicles, assuming a depreciation of 5, 10, and 20 percent, respectively, similar to Camino-Mogro and Bermudez-Barrezueta (2021). We measure the capital stock with the gross investment in equipment in year t (I_{it}), net fixed assets in real value (physical capital in year $t-1$) (k_{it-1}), a depreciation rate (d_{it}) and the price index for equipment at the industry level (P_t) obtained from the Ecuadorian National Institute of Statistics.
Total Intermediates	M	Initial intermediates inventory + Imports of intermediates inputs + local net purchases of intermediates + transport expenses + fuel expenses + spending on office supplies + expenditure on maintenance and repair + basic services expenditure - final intermediates inventory - final inventory of products in process - final inventory of finished products. This variable is deflated using the industry-specific price index obtained from the Ecuadorian National Institute of Statistics.
Domestic Intermediates	D	Initial intermediates inventory + local net purchases of intermediates + transport expenses + fuel expenses + spending on office supplies + expenditure on maintenance and repair + basic services expenditure - final intermediates inventory - final inventory of products in process - final inventory of finished products. This variable is deflated using the industry-specific price index obtained from the Ecuadorian National Institute of Statistics.
Foreign Intermediates	F	Imports of intermediates to produce a final good.
Exports	E	Revenues from sales of firm export activities. This variable is deflated using the industry-specific price index obtained from the Ecuadorian National Institute of Statistics.
CEO Gender	gender	Dummy variable equal to one if the firm i has a female CEO in t, zero otherwise.
Gender board participation	gbp	Continuous variable of female participation on the board of directors of firm i in period t, which takes values between zero and one. The more participation of women on the board of directors, the closer the variable is to one.
CEO job tenure	tenure	Continuous variable of the number of years the CEO has held this position.

Source: the authors, based on data provided by the Superintendencia de Compañías, Valores y Seguros.

Table 15: Sector classification correspondence with ISIC codes

Industry	Subsectors	ISIC codes
Natural Resources	Agriculture, forestry and fishing	A
	Mining and quarrying	B
	Electricity, gas, steam and air conditioning supply	D
	Water supply and waste management	E
Manufacturing	Manufacturing industries	C
Construction	Construction	F

	Real estate services	L
Services	Wholesale and retail trade	G
	Transportation and storage	H
	Accommodation and food service activities	I
	Information and communication	J
	Financial and insurance activities	K
	Professional, scientific and technical activities	M
	Administrative and support service activities	N
	Public administration and defense	O
	Education	P
	Human health and social work activities	Q
	Arts, entertainment and recreation	R
	Other service activities	S
	Activities of households as employers	T
	Activities of extraterritorial organizations and bodies	U

Source: The International Standard Industrial Classification of All Economic Activities (ISIC) Rev.4

Table 16: Impact of CEO's gender tenure on productivity: Different size classifications

Estimators	**Micro**	**Small**	**Medium**	**Large**
k_{it}	0.071***	0.191***	0.070***	0.035***
	(0.015)	(0.008)	(0.011)	(0.017)
l_{it}	0.427***	0.522***	0.700***	0.542***
	(0.014)	(0.009)	(0.009)	(0.004)
m_{it}	0.355***	0.355***	0.217***	0.301***
	(0.011)	(0.006)	(0.005)	(0.002)
$gender_{it}$	0.004	-0.034	-0.038	-0.037
	(0.060)	(0.024)	(0.029)	(0.025)
$tenure_{it}$	0.097***	0.046***	0.088***	0.090***
	(0.007)	(0.003)	(0.004)	(0.001)
$gender * tenure_{it}$	0.030***	0.061***	0.014***	0.031***
	(0.013)	(0.005)	(0.006)	(0.002)
No. of obs.	53,798	111,837	52,025	21,262
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses clustered at the firm level with 300 bootstrapped replications. The LP Endog uses the stochastic process of ω_t of equation (9). *$p < .10$, **$p < .05$, ***$p < .01$.

The effect of digitalized service quality on customer satisfaction: Evidence from Tunisian Islamic banking

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Abstract

Purpose: Based upon an extended SERVQUAL model, this paper attempts to contribute to the Islamic banking literature by examining the impact of digitalization, as a service quality dimension, on customer satisfaction.

Design/methodology/approach: Two dimensions, i.e. digitalization and compliance are added to the existing SERVQUAL model of five dimensions. Results are drawn from a self-completed survey of a convenience sample of 145 Tunisian Islamic bank customers. Factor analysis and regression analysis are used to determine factor structure and determine the impact of service quality dimensions, especially digitalization, on customer satisfaction in Islamic banking.

Findings: The factor analysis extracted five dimensions of service quality, i.e. confidence, compliance, digitalization, tangibles and human skills. The paper demonstrates a positive and significant relationship between the main dimensions of customer service quality and customer satisfaction, except for tangibles.

Research limitations/implications: Although the outcomes lend support to the extended SERVQUAL model, the results are derived based on a relatively small sample size in one country (Tunisia). This limits the generalizability of the study results. It might also be useful to enlarge the study sample and include a comparison between Islamic versus conventional banking about service quality and customer satisfaction.

Managerial implications: To remain competitive, Tunisian Islamic banks need to pay attention to the way the services are delivered and not take it for granted that customers are only focusing on compliance. Dealing henceforth with Generation Y customers, they must persevere in bringing their customer service into the digital era.

Originality/value: This study is one of few which try to investigate the drivers of customer satisfaction for Islamic banks in a Digital Era. It reveals that although customers pay special attention to Sharia' laws, the way services are delivered matters to them too. From now on, digital banking must appear among the Islamic bank features to stay relevant in the Digital Era.

Keywords: Service quality, SERVQUAL model, Customer satisfaction, Digital banking, Islamic banks, Tunisia.

JEL Classification: G21. O33

Paper type: research paper

Introduction

Across the globe, digital technologies are mushrooming in all areas, including banking sector (Ganguli and Roy, 2011). Especially, new developed and implemented technologies are changing people's lifestyle and consumption habits which impacts considerably the nature of companies-customers relationships. This is due to the evolution of the expectations of today's tech-savvy digital consumers who are looking forward the delivery of digital solutions by their banks (Sreejesh *et al.,* 2016).

The digital transformation in the banking sector is likely to continue and further ramp up given the specifics of the post-crisis market environment. Competing from now on in the digital era, banks are called to a greater integration of digital technologies in response to market changes and customers' needs. Moreover, they must persevere into accumulating digital capabilities in order to take their customer service into the next level, allowing so to enhance customer satisfaction rates and make higher profits (Reichheld and Sasser, 1990) as the same time as ensuring effective automation and related cost efficiency (Alstad, 2002).

A dynamic segment that is emerging in the banking sector is Islamic banking. Thanks to the relatively resilient performance of this sector during the most serious financial crisis ever seen, Islamic finance has witnessed remarkable development around the world. Nevertheless, this is not the case in the North African countries. The factors that account for this underdevelopment were summarized by Wilson (2011) as follows: firstly, the limited development of retail banking generally, second the lack of consumer awareness about Islamic banking and third, the low scale of government support. In Tunisian banking, the Islamic banking sector remains embryonic and struggles to gain market share (Boulila and Ben Slama, 2014). In fact, the current Islamic banking system comprises four Islamic banks. The first one is “Al Baraka Bank Tunisia” licensed to offer Islamic banking as an offshore institution since 1983. The second is a regional office of the UAE based Islamic bank “Noor Islamic Bank” established in June 2008. The third and the most expanded one is “Zitouna Bank” launched in May 2010 by the son in law of the deposed president. The last one is “El Wifak Bank” launched in May 2017. However, there is a sustainable development scope for Islamic banking given the relevant political changes in post-revolution Tunisia and the presence of market push (Gallup, 2014) and hence, it is essential for Tunisian Islamic banks to take advantage of opportunities associated with the development of the Islamic financial landscape in Tunisia.

Although the whole notion of Islamic banking hints at the fulfillment of religious obligations of pious Muslim customers, Tunisian Islamic banks shouldn’t take it for granted that customers are only focusing on compliance and must be more conscious about the service quality evaluation according to customers’ expectations given the fact that service quality is closely related to customer satisfaction in Islamic banking (Janahi and Almubarak, 2017). Most banks

are on the path to digital adoption to fulfill the ever-increasing needs of the digital generation, however, Islamic banking constitutes a particular banking segment to which conventional marketing rules do not necessarily apply (Muslim et al., 2013).

So, does the digital transformation phenomenon have any impact on the major service evaluation criteria for Tunisian Islamic banking? And what should be the potential benefits of a customer service digitalization process with regard to customer satisfaction in Islamic banking?

The underpinning theme of this study is that the underlying religious philosophy of Islamic finance can no longer be the only source of competitiveness, but that a marketing strategy of ongoing service quality improvement in light of market changes is even more necessary for banks to remain competitive. Given the above, the elaboration of an adapted measurement model of service quality with consideration for new consumption habits seems to be more prominent than ever to enhance service offerings and meet digital consumers' expectations with the ultimate goal of reaching high levels of customer satisfaction. The paper provides a significant contribution to the literature by exploring the nature of service quality after the digital revolution using the Islamic banking context. To do that, a review of the literature is presented hereafter. The section that follows looks at the methodology and reports on data collection, analysis, and results. The discussion of the findings and subsequent implications is than provided. The final part of the paper draws the concluding remarks and sums up the limitations of the study.

Literature review

Customer satisfaction and service quality

Customer satisfaction is what a consumer feels about a particular service or product after it has been used (Solomon, 1996). It would be considered as one of the primary strategic goals to which every organization shall pay particular attention (Dabholkar *et al*., 1996). That is because almost all studies show a tight connection between customer satisfaction and repurchase intentions, positive word of mouth (Dispensa, 1997), market reputation and customer loyalty (Cronin and Taylor, 1992) leading so to profit increase and cost reduction (Kumar and Reinartz, 2006; Cooil *et al*., 2007). Now, the first thing that came in mind when dealing with customer satisfaction is service quality since satisfaction is particularly sensitive to the level of service quality provided by the organization. In fact, it is suggested that service quality is an underlying determinant of customer satisfaction (Yavas *et al*., 1997), hence, it is important for management to find a concise definition of service quality and search for the most reliable assessment process in order to ensure high quality service offerings.

Service quality is defined by Gronroos (1983) as the fact of meeting what one company's customers expect from its service offerings while it represents the gap which may exist

between what customers expected to get as service and service quality as perceived by them (Parasuraman *et al.,* 1988). Although providing a meaningful measurement tool is essential for service quality management, it is often hard to measure the quality of service due to certain inherent characteristics including heterogeneity, intangibility, perishability and inseparability (Hoffman and Bateson, 2002).

The increasing awareness about the key role of both the concepts of quality and satisfaction in a constantly changing banking market have made of them the focus of a multitude of studies Throughout the body of academic literature, scholars continually refer to Parasuraman *et al*.'s (1985, 1988, 1991) original work. Through numerous qualitative researches, these authors concluded that customers provide a congruous evaluation of service quality regardless of service industry and then conceived a five-dimensions measure scale of service quality and provided concise definitions for each of these dimensions.

- Reliability: the ability to be trusted because of performing the promised with precision
- Tangibles: the tangible aspects associated with the service like the appearance of employees, physical facilities and equipment
- Responsiveness: the willingness of staff to react to customers quickly and positively
- Assurance: the knowledge and courtesy of employees and their ability to convey trust, faith and confidence among customers
- Empathy: the caring and individual attention provided for customers.

A careful empirical testing of the theorized service quality dimensions has led to the recognition of a 22-item scale named SERVQUAL (Parasuraman *et al.,* 1991). The basic assumption underlying the SERVQUAL model is that service quality is interpreted in terms of the gaps which may exist between what customers expected to get as service and service quality as perceived by them. Thus, a low-quality service corresponds to that case in which customers' expectations are greater than their perceptions, while exceeding expectations implies that service quality is deemed high. Since its conception in 1988, SERVQUAL has gained high attention and has been applied in a multitude of service industries, including the banking industry (e.g. Veysel *et al.,* 2018). Nevertheless, the model faced wide criticism, mainly directed at its conceptual appropriateness, its operationalization and the ambiguity of the expectations construct (Buttle, 1996). Moreover, empirical evidence does not support a dimensional stability of SERVQUAL, in fact , the five-dimensional concept of service quality does not hold up when the research is replicated in different contexts (Babakus and Boller, 1992) and the 22 defined items do not load on to the corresponding dimensions regularly (e.g. Carman, 1990). Consequently, there may not be a universal measure of service quality that is relevant regardless service industries. Indeed, the relative importance of these dimensions

differs from one country to another and, also, may depend upon demographic characteristics and cultural background of customers. Despite these criticisms, it is recognized that the SERVQUAL measurement tool represents a generic instrument that enables a meaningful assessment for service quality in terms of assurance, reliability, tangibles, empathy and responsiveness (Saleem *et al*., 2016).

Customer satisfaction and service quality in Islamic banking

Service quality is more likely to gain weight in the banking industry given the constantly changing banking environment. In fact, the highly competitive financial market is pushing the banks, including Islamic banks, to constantly rethink their service offerings in light of the evolving customers' expectations for service quality aspects. Together with conventional banks, Islamic banks aim to meet customers' banking needs. The main difference between them is merely that Islamic banking conducts its operation based on Islamic banking practices emerging from Sharia principles that abolish interest income and some other prohibited practices related to financial transactions such as excessive uncertainty (gharar), gambling, speculations and illegitimate transactions (Khan, 2010). However, Profits and Loss S (PLS) remains the feature most emphasized by Islamic banking advocates (Zaher and Hassan, 2001). The ban of interest based financial transactions in Islamic religion and the aspiration of pious Muslims to making a practical reality of their religious values has made from Islamic banking a key player in global financial circles over the past four decades.

Customer service is a major organizational process which companies should optimize to enhance customer satisfaction rates, reach a wider market, and increase earnings (Jahanshahi *et al.,* 2011). So, roughly speaking, a large number of the studies analyzing the relationship between service quality and customer satisfaction within Islamic banking have adopted the original SERVQUAL tool as it was conceived by its authors and some of them have used an adjusted version of it. Abdullah and Kassim (2009) explored the dimensional structure of banking services offered by Qatari Islamic banks.

They defined a set of four quality dimensions that are tangibles, human skills, online banking, and empathy. However, they noted that only two dimensions that are empathy and human skills were significant when examining customer satisfaction. Al-Tamimi and Al-Amiri (2003) studied the service quality pattern of UAE Islamic banks else.

One of the contributions of the study is the confirmation of the validity of SERVQUAL for Islamic banks, at least for their sample. They also realized that empathy and tangibles were the most important dimensions. In another distinctive study, Amin and Isa (2008) focused on the association between service quality as perceived by Malaysian customers and their satisfaction level with Islamic banks using an adjusted SERVQUAL model consisting of six dimensions. In fact, they added a new dimension under service quality dimensions which they

called “compliance” given the foundation philosophy underlying Islamic banking. In conclusion, the researchers suggested that that the standard pattern of Islamic banking service quality should consist of the six dimensions and that the quality of Islamic banks service offerings was correlated with their customers satisfaction scores. Furthermore, it's important to highlight the exceptional work of Owen and Othman (2001) who suggested a new service quality assessment tool for Islamic banks which they called CARTER. The novel set of service quality was defined based on a customized Parasuraman et *al's* (1985, 1988, 1991) five dimensions in order to suit for Islamic banking industry specificities. Yet, a new dimension named “Compliance with Islamic law” had to be included to the existent five-dimensional concept that refers to the ability of the Islamic bank to fulfill with Islamic law and operate under the Islamic banking principles. This dimension includes such items as “Run on Islamic law and principles”, “no interest rates are applicable for neither loans nor savings”, “provision of Islamic products and services”, “provision of free interest loans” and “provision of PLS based products”. The study of Owen and Othman has probably some uniqueness despite the handicap of the model's validity (Hafsa ,2013). The problem derives mainly from the sample which took part in this study because it had to represent the clients of only one bank. Later on, some researchers like Osman et al. (2009) and Janahi and Almubarak (2017) opted for the testing of the CARTER's validity in different Islamic banks from other regions.

Customer satisfaction and service quality in the digital era

In the course of time, and due to the digital revolution, society is being confronted with an unprecedented shift away from an industrial to a digital orientation. A new customers' generation who grew with internet democratization and who is more prone to technological developments. Consequently, the digital transformation has become an obligation rather than a choice for today's organizations, banks are not excepted given the breakthrough development in fintech solutions. Financial technology, often shortened to Fintech, has become a widely used term today which refers to the adoption of new technologies by the financial services institutions, especially banking institutions. However, by further examining the history of banking activity development, it appears that this is not a brand-new concept. In fact, the banking sector is seen as the vanguard sector of fintech-based service revolution (Barras, 1990) so that the banking landscape has witnessed the development of a multitude of fintech innovations that includes Electronic Fund Transfer at the Point of Sale (EFTPOS) , Automated Teller Machine (ATM), internet banking, mobile banking, etc. Owing to ever increasing competition within banking services, banks have clearly embarked on the development of technology-driven strategies since empowering customers with technology-based service delivery systems generates cost-savings and improves operational efficiency

(Alstad, 2002) and should boost customer satisfaction level, allowing to strengthen customer retention and generate further revenues (Reichheld and Sasser, 1990).

With more widespread internet penetration and mobile devices especially smartphones, the innovations became more intense from the 2000s onward which may be the starting point for the digital revolution. There is often a great difference between the era of internet during the 90's and the digital era at present. In fact, digital has been dramatically reshaping the habits and preferences of consumers, whose lives are more and more involved with digital innovation, leading to a profound impact on the banking industry (Ganguli and Roy, 2011). Nevertheless, the impact is not all negative for traditional banks. There are still considerable customer segments showing a preference for brick and mortar experience. However, over time, banks may face a considerable reduction in their customer base when digital natives, who have been immersed in technology their entire lives (Prensky, 2001), form the majority of the population unless the banking sector embraces digital transformation. That seems to be more relevant as previous studies show that differences do exist in acceptance and usage levels of technologies across customer segments depending on their beliefs about technology (Dabholker, 1996).

Digitalization refers to the process in which the use of digital technology by an organization is adopted or increased (Castells, 2010). With reference to banking, that means to acquire technology-centric capabilities that enable new methods of interaction and service delivery to improve customer's experience. Owing to the technological evolution in the banking sector, we will probably witness another revolution in banks' marketing strategies (Dootson et al., 2016). Although digital banking is technology related, it is service-oriented and designed around the needs of digital natives that grew up with computers as a daily part of their lives and that are living in a broadly interconnected world. To reach a younger and more digitally savvy customer base, marketing efforts should hinge revolve around the offering of personalized services and digitally empowered experiences in order to enhance customer satisfaction since the latter is widely assumed and assessed to determine repeat sales, positive word of mouth recommendations and mostly customer loyalty (Bearden and Teel, 1983).

In most of the previously undertaken studies, it was suggested that service quality dimensions are the determinant criteria that influence the customers' decision over the choices in the banking selection. Nevertheless, Islamic banking constitutes a particular segment in which the traditional rules of marketing in the banking industry may not apply due to religious-based reasons. As a matter of fact, religion is considered to be the most important bank selection factor (Metawa and Al Mossawi, 1998). However, the evidence did not bear out the claim that Islamic banking reflects Islamic values, in fact, previous studies found that the selection of Islamic banks is not founded solely on the customers' religious beliefs (Dusuki and Abdullah,

2006). Therefore, Islamic banks must persevere in working on the demand of, or response to its customers' needs and wants because it is obviously these factors that develop their perception of quality. The latte, however, is strongly influenced by customers' demographic characteristics (Urban and Pratt, 2000), the development of a valid and distinct measure of service quality is even more vital to address customer needs in an increasingly digital world. Customers are already ahead of many banks in how they use digital technology to manage their financial lives, in fact, according to EY report (2016), 81% of GCC Islamic banking customers are expected to be ready to switch to the bank offering a greater digital experience. This shift towards digital banking means that banks' marketing management model is changing, making it crucial for Islamic banks to understand the impact of digital banking on customer satisfaction. Previous research has focused on the relationship that may exist between customer satisfaction and e-service quality within the banking sector (e.g. Isaac, 2011) and the factors influencing customers' acceptance of e-banking (e.g. Martins et al., 2014), but digital banking should not be treated as a separate dimension among those which define and shape the service quality concept as pursued in this paper. In fact, digital banking should not only be considered as a kind of service but also as a new feature that must exist among the essential features a bank must acquire.

In brief, overall satisfaction with a service arises from complex and multidimensional process. Thus, developing service marketing theory requires an understanding of customers' needs in order to translate these into the delivery of services matching those needs. The research conducted by Parasuraman et al. (1985, 1988, 1991) claimed that the developed theoretical model will successfully act as a basic template for the assessment of service quality. Nonetheless, this research was conducted thirty years ago. Thus, what may have constituted as significant previously may not be entirely relevant to today's customers.

Against this background, this study adopts the SERVQUAL model on the basis of the explanations mentioned above. However, it also considers two other dimensions. The first one, named “compliance”, refers to the ability of the Islamic bank to comply with Islamic banking principles. The second one, called “digitalization” refers to the extent to which Islamic banks are embracing digital transformation. This factor is defined by variables such as the provision of online services, whether the bank offers electronic payment solutions, whether it is active in social media and whether it provides mobile banking services and apps.

Method

Measurement instrument

A self-reporting questionnaire was designed taking account of previous research. The instrument contains three sections. The first section was designed to elicit demographic information of Tunisian Islamic banking customers. In the second one, the theoretical service

quality dimensions as advanced by Parasuraman *et al.* (1988) and Owen and Othman (2001) were adjusted in order to suit the research context. Thus, an additional dimension, digitalization, including four statements was added. The original items were translated to French since this language is the most used in the business industry in Tunisia. A pre-test was then conducted with some Tunisian Islamic banks' customers, and minor modifications were made accordingly to ensure that the questions were not repetitive. A total of 28 items are used to capture respondent views about service quality. Moreover, the paper had to deal only with service quality perception in order to be more effective (Dabholkar et al., 1996). Respondents were invited to rate their answers on a five-Likert scale with a view to improving response rate and avoid respondent fatigue. Through the latter section, overall satisfaction is measured using a four-item measure identified on the basis of previous studies (Owen and othman, 2001; Manrai, 2007 and Munusamy et al., 2010).

Sampling and data collection

Data collection has been made based on online questionnaire for the customers of the two leading Islamic banks in Tunisia "Zitouna" and "Al Baraka". The sample which is composed of 145 respondents from all Tunisian governorates, was chosen using the convenience sampling technique. Based on the general guidelines by prior researchers on the sample size (Kerlinger, 1986) and in view of the number of items used in this study, a minimum of 145 respondents are required. Although the small size of the sample, the study met the minimum number of respondents required from the statistical perspective. We audited the reliability of the survey results based on the Cronbach alpha coefficient using SPSS. All service quality dimensions, namely compliance, assurance, reliability, tangibles, empathy, responsiveness and digitalization showed high reliability (0,815, 0,826, 0,896, 0,835, 0,761, 0,899 and 0,825 respectively). Moreover, alpha for the overall model had a high score (0,948). This result is obviously within the range accepted by Nunnally and Bernstein (1994), indicating the measure was robust.

Examination of demographic characteristics indicates that the percentage of male and female respondents is almost equally distributed among the surveyed Islamic banks customers (48 percent female, 52 percent male). The sample consisted mostly of young customers (83 percent aged between 20 and 38) because they have greater access to technology, and they are more likely to reflect digitally savvy customer needs.

Table 1: Reliability test

	Number of items	Cronbach's alpha
The overall model	28	0,948
Compliance dimension	4	0,815
Assurance dimension	4	0,826
Reliability dimension	5	0,896
Tangibles dimension	3	0,835
Empathy dimension	4	0,761
Responsiveness dimension	4	0,899
Digitalization dimension	4	0,825

Data analysis and results

Descriptive statistics

The descriptive statistics of the 28 service quality items as well as four customer satisfaction measurement items are shown in table I. Overall, it seems that Tunisian Islamic banking customers dare not fully satisfied with their banks' services (mean = 3,44). With respect to service quality dimensions, Tunisian Islamic banks are found to be performing best on "tangibles", displaying a mean rating of 4,06. More importantly, "compliance" dimension exhibits the lowest mean rating (3,45). This would imply that Islamic banking customers in Tunisia lack confidence that their banks are compliant with Islamic banking principles.

Table 2: Descriptive statistics

Variable	Average mean
Compliance	3,45
Assurance	3,94
Reliability	3,66
Tangibles	4,06
Empathy	3,53
Responsiveness	3,61
Digitalization	3,54
Satisfaction	3,44

Service quality measurement

Factor analysis was carried out to establish the factor structure of the service quality model relative to the industry and service context under study. Bartlett's test for sphericity was used to test the null hypothesis that the correlation matrix between the 28 items has an identity matrix. The null hypothesis was rejected ($\chi 2$ = 2917,128 df = 378, p = 0.000). The Kaiser Meyer-Olkin measure of sampling adequacy yielded a coefficient of 0.919 which is interpreted as marvelous (Kaiser, 1974). These two tests mean the items have adequate common variance and acceptable factorability (Tabachnick and Fidell, 1996).

Table 3: Bartlett's test

Bartlett's test	$\chi 2$	df	p
	2917,128	378	0,000

Table 4: KMO measure

Kaiser Meyer Olkin measure	0,919

Thus, the 28 items were factor analyzed, producing five oblique factors to retain given that they have eigenvalues greater than one (Kaiser, 1974).Oblique factors were preferred because they rotate to simple structures and agree more with psychological theory than do orthogonal factors (Kline, 2000). The five-factor solution accounted for a combined 67,884 per cent of total variance. A total of 28 items loaded on the factors but two items had to be removed because their factor loadings are less than 0,4 (Floyd and Widaman, 1995). The reliability of the factors was calculated using the Cronbach's alpha. All five factors demonstrate reliability, with Cronbach's alphas all above the required 0.8 cut-offs (Hair et *al.*, 2006). Factors extracted, along with their labelling and analysis, are discussed hereafter. The first factor is labelled "confidence" and it comprises items from the basic Parasuraman et *al.'s* (1988) scale regarding the two dimensions of assurance (Items 5, 6, 7 and 8) and reliability (Items 9, 10, 11 and 12). The "compliance" factor encompasses the need for confidence about the compliance of Islamic banks with Shariah principles (Items 1, 2, 3 and 4). We label the third factor "digitalization", as these items pertain to the ability of the bank to offer digitally empowered experience to its customers (Items 25, 26, 27 and 28). Consistent with Parasuraman et al. (1988), the fourth factor "tangibles" refers to the quality of the intangible aspects and visible attributes of the service (Items 14, 15 and 16).The last factor includes items pertaining to the responsiveness (Items 21, 22, 23 and 24) and the empathy (Items 18,

19 and 20) dimensions as proposed by Parasuraman et al. (1988), accordingly, we named it "human skills".

Table 5 : Factors, factor loadings and reliabilities for quality construct

Extracted factors	r	σ²	Vp	α	Deleted items
Factor 1: confidence		45,48	11,49	0,923	I 13: Insisting on error-free records
I 9: Keeping a promise to do something by a certain time	0,767				
I 5: The behavior of employees instilling confidence in their customers	0,706				
I 10: Showing sincere interest in solving a customers' problems	0,683				
I 8: Employees having the knowledge to answer customers' questions	0,678				
I 11: Performing the service correct at the first time	0,669				
I 12: Providing the service at the time the service was promised	0,640				
I 6: Customers feeling safe in their transactions	0,620				
I 7: Employees being consistently courteous with their customers	0,409				
Factor 2: compliance		8,29	2,15	0,815	
I 3: Provision of Islamic products and services	0,935				
I 1: Runs in Islamic principles	0,851				
I 2: No interest paid nor taken on savings and loans	0,646				
I 4: Provision of profit-sharing investment products	0,507				
Factor 3: digitalization		7,3	1,89	0,825	
I 28: Provision of mobile banking services and apps	0,819				

I 25: Provision of online services	0,790				
I 26: Offering electronic payment solutions	0,672				
I 27: The bank is active on social platforms	0,494				
Factor 4: tangibles		4,66	1,21	0,835	
I 14: Modern looking equipment	0,801				
I 15: Visually appealing physical facilities	0,663				
I 16: Neat-appearing employees	0,570				
Factor 5: Human skills		4,2	1,09	0,905	I 17: Employees giving customers personal attention.
I 22: Employees are never being too busy to respond to customers' requests	0,643				
I 23: Employees giving prompt service to customers	0,560				
I 20 Having the customers' best interest at heart	0,550				
I 18: Operating hours convenient to all their customers	0,546				
I 21: Employees always being willing to help customers	0,530				
I 24: Employees telling customers exactly what services will be performed	0,506				
I 19: The employees understanding the specific needs of their customers	0,444				
Note: Extraction method: minimum residuals MINRES. Rotation method: Oblique rotation					

Satisfaction

The Kaiser Meyer-Olkin measure of sampling adequacy yielded a coefficient of 0.797 which is interpreted as meritorious. The four items used to measure satisfaction form a single factor

accounting for 70,126 per cent of total variance. A Cronbach’s alpha of 0,825 establishes reliability for the measure.

Table 6: Factors, factor loadings and reliabilities for satisfaction construct

Extracted factor	r	σ²	Vp	α	Deleted Items
Satisfaction		70,13	2,80	0,841	
Did you recommend your bank to your friends and family members?	0,90				
Your overall satisfaction with your bank's' services?	0,821				
Did you have the intention to switch to another bank in the future?	0,716				
Did you have the intention to purchase other services or products from your bank?	0,665				

Regression analysis

In order to study the impact of the service quality factors (the five factor scores as the independent variables) on the satisfaction of Tunisian Islamic banking customers (the dependent variable), multiple regression analysis was applied. The results of the multiple regression analysis are reported in Table 7.

The service quality dimensions accounted for a significant amount of variance in satisfaction (R^2 = 68,3, F = 59,91, p = 0,000). All service quality dimensions tend to be highly correlated with satisfaction, except for tangibles.

The greatest influence on satisfaction is made by “Confidence” (ß = 0,376, t = 4,850, p = 0,00) and then “Human skills” (ß = 0,297, t = 4,127, p = 0,00). Hence, the need for a positive personal interaction inspiring trust and engagement is a significant predictor of customer satisfaction in Tunisian Islamic banking. The next strongest contribution is made by “Compliance” (ß = 0,207, t = 3,895, p = 0,00). Accordingly, running on Islamic law principles is of special interest to Islamic banking customers. “Digitalization” is found to have the fourth strongest influence on satisfaction (ß = 0,190, t = 3,414, p = 0,001). Therefore, the results show that digitalization of Islamic banking is in the customer's' interest. “Tangibles” makes the smallest contribution (ß = -0,029, t = -0,485, p = 0,628) which is not statistically significant. The results provide predictive validity for the model, with examination of the t-values indicating that “Human skills”, “Confidence”, “Compliance” and “Digitalization” contribute to prediction of satisfaction.

Table 7: Relationships between service quality factors and satisfaction

	Beta weights	t
Confidence	0,376* *	4,850
Human Skills	0,297* *	4,127
Compliance	0,207* *	3,895
Digitalisation	0,190* *	3,414
Tangibles	-0,029	-0,485
R^2 **Adjusted R^2** **F-value**	0,683 0,671 59,91* *	
Notes: Dependent variable: satisfaction. *Significant ($p < 0,05$); * *significant ($p < 0,01$)		

Discussion

In today's digital era, Islamic bank managers need to understand what criteria are being used by customers to evaluate their services as the consumer behavior patterns are changing due to the current digital trend. The current research makes important contributions to the field of banking services by identifying the major service evaluation criteria for Islamic banking by Tunisian Customers. The analysis of the 28 items expected to assess the service quality in this study allows to identify five dimensions of service quality in the case of Tunisian Islamic banking. These dimensions are confidence (reflecting reliability and assurance), compliance, digitalization, human skills (reflecting empathy and responsiveness) and tangibles.

In the previous empirical studies, which employed SERVQUAL instrument in modified form, a wide variety of service quality structure has been revealed, the number varying according to the examined service sector (Buttle, 1996). Consequently, keeping in mind that the adjusted SERVQUAL instrument was used in a context (the Tunisian Islamic banking sector) totally different from those investigated by Parasuraman et al. (1991), it seems to be not surprising to identify a distinct standard for banking service quality evaluation.

As expected, the findings of this study prove that providing the best service quality may result in higher satisfaction levels among Tunisian Islamic banking customers. This result goes online with previous research that stated that there was a strong link between service quality and customer satisfaction in Islamic banking (Owen and Othman, 2001). Although Islamic banking customers are satisfied with the overall service quality provided by their banks, it is not guaranteed that their customers do not switch to other banks. Therefore, Islamic banks need to strengthen their customer relationship management through the enhancement of

customers' trust towards Shariah compliance. In fact, our results suggest that Islamic banking customers attach great importance on the compliance dimension. The latter may determine the decision-making behavior of pious customers on whether they will continue the relationship with Islamic banks (Hassan and Lewis, 2007). Although Shariah compliance was well ranked as a determining factor, it was not the most significant factor. This result is in line with those of Hayat and Khuram (2011) who specified that the majority of Islamic banks customers value product features and quality of service as major factors for making selection of Islamic banks at the expense of religious beliefs. Therefore, Islamic banks need to better examine the drivers of their market identity and must consider service quality as equally important to “Sharia compliance” in designing the marketing strategy of Islamic banking services. The development of a valid and distinct measures of service quality according to the upcoming digital customer needs remains one of the most important aspects to make customers, especially with the quick spreading digital transformation all over the world. Indeed, our results prove that digital banking is a major determinant when it comes to overall customer satisfaction and that Generation Y displays a clear preference for digital channels. That result was not surprising since customers' intentions to use technology are heavily influenced by their attitude towards the technology (Gurjeet and Sangeeta, 2013). Given the fact that Tunisia, and the world by and large, is becoming increasingly more digitalized, the ease of switching banks will increase customers' expectations (Heffernan, 2005). The challenge for Islamic banks is to adapt their strategy to match Millennials habits and behaviors who are looking for digital banking offerings matching their lifestyle needs. Be that as it may, some considerations should be taken in account when implementing digital banking. Convenience and security issues play a crucial role (Anthony and Yamit, 2017; Cajetan and Patrick, 2018). By 2025, Josh (2014) estimated that Generation Y would represent nearly half of the total active population in the world. Hence, to remain competitive, Islamic banks must thrive to move away from traditional banking to develop products and services that truly reflect the digital transformation today's young customers demand. More importantly, the research findings clearly suggest that human-based service delivery is the most relevant customer satisfaction criteria most customers ever have. People still like human interaction and trust people more than technology, even if customers are increasingly interacting with technology. This result goes online with Luiz and Anne (2000) who stated that “bank customers' attitudes towards the human provision of services and subsequent level of satisfaction will impact on bank switching more than when the same service delivery is made through automation”. Better experiences are not exclusively about better technology. Human resources factor also matter and customers are always in need for a positive personal interaction inspiring trust and engagement (Jabnoun and Al-Tamimi, 2003). In other words, digital is not an end in itself, but it is serving as a means to reach organizational objectives of Islamic banks. Consequently, Islamic banks must leverage appropriate

technology with the aim of developing new digitalized systems, but most importantly commit to a new engagement model that focuses on the human touch while matching the customers' level of expectation with the new systems. Finally, “tangibles” is found to have the least impact upon satisfaction which is not significant. In our opinion, “tangibles” are important, but automatically expected by Tunisian Islamic banks customers. In fact, Islamic banking is a relatively recent phenomenon in Tunisia, and Islamic banks have mostly new buildings and modern looking equipment. Thus, tangibles may constitute a hygiene factor (Herzberg, 1982), so that it is considered by customers as an expected requirement but leads to no dissatisfaction rather than to satisfaction.

Conclusion and recommendations

A rich stream of literature in the areas of service quality and customer satisfaction has evolved and reproduced over the past two decades. Nevertheless, such studies in Tunisian Islamic banks remain scarce. In this age of digital transformation, Islamic bank managers need to understand what criteria are being used by customers to evaluate their services. The main area of interest in this paper is to explore the Islamic banking service quality pattern and its potential impact on customer satisfaction after the digital revolution using the Tunisian context. The study proposed that the SERVQUAL dimensions would replicate in the Islamic banking industry but with certain modifications given the foundation philosophy underlying this banking sector. Most importantly, the research proposed that digitalization is an essential determinant of service quality and overall customer satisfaction for today's digital customers. The findings reveal that Islamic banks need to pay attention to the way the services are delivered and not take it for granted that customers are only focusing on compliance. To remain competitive, Islamic banks must update their service quality set to align with the upcoming digital customer needs. However, it is important not to neglect the core role of human-based service delivery in driving engagement, loyalty and customer satisfaction.

Limitations and future research

Since the sample is derived from only one country, i.e. Tunisia, generalizability of the results is limited. Further research should be considered to gather more information regarding the impact of the digital transformation on the evaluation of service quality and customers' satisfaction by Islamic banking customers. Second, the study utilized a small convenience sample instead of a random sample. Therefore, it is suggested to enlarge the sample size for better generalization of the findings. Moreover, although the web-based survey approach has enabled the research to prevent respondents submitting incomplete questionnaires, which is an advantage, any study based on a predesigned questionnaire suffers from the limitation of dishonesty and differences in understanding and interpretation. Finally, although tests for

reliability and validity provide initial support for the adopted measures, there remains a possibility that not all service quality dimensions are captured. Thus, qualitative interviews with customers are recommended to explore any other aspects that may contribute to the development of a more meaningful measurement of service quality.

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The Impact of Digital Governance on Technological International Firm's Performance

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Abstract:

Purpose

This study aims to examine the effect of digital governance (smart formation, audit, engagement of stakeholders, and administrator's technological expertise) on performance of international technological firms

Design/methodology/approach

The author used Panel data regression of 53 international technological firms for the period 2015-2023.The data were collected from the annual reports, financial data websites and analyzed using fixed and random effects to test hypothesis.

Findings

The empirical results overall showcase a positive impact of digital governance on performance of international firms in the technological industry

Research limitations/implications

This research provides some valuable insights into the implementation technology in the corporate governance landscape, which may help companies, improve their organizational efficiency, enhance their internal control operations, and acquire a competitive edge in the market

Originality/value

Unlike prior literature, this work does not focus solely on one aspects of governance, but on a multitude of aspects such as smart formation, audit, engagement of stakeholders, and administrator's technological expertise, and how technology can enhance those to achieve a better performance, this provides firms with a thorough and comprehensive understanding that might prove to be helpful

Keywords: Digital governance, robotic process automation, performance

JEL classification:

Paper type: Research paper

1. Introduction

The disruptive technologies such as blockchain and artificial intelligence have raised the imbalance in the industry and put firms in a position where taking action is vital to remain competitive; however, adopting the latter and opening up to the digital world is not without its challenges. It suffers from multiple challenges that plague it: possibilities of cyberattacks, exposure of individual data, and opportunities for manipulation of human consciousness and behavior and the programmatic nature that promotes rigidity and harms flexibility (Zhu et al., 2006). This raises the need for an intricate system of rules and policies to ensure the well-being of the organization and the safeguarding of its interests in this era of rapid evolution of digital technologies. The current situation indicates that while there are advantages such as increasing organizational competitiveness by streamlining processes and improving customer satisfaction enhancing transparency and accountability, it is not without drawbacks such as data privacy and data security (Kirana & Majid, 2022).

In the current research landscape, there is a lack of comprehensive strategies addressing digital challenges. The majority previous studies do not explain the empirical implications of digital governance in the lenses of smart training, audit, stakeholders. This is emphases the important role of our proposed research in examination might enhance understanding regarding digital governance, adding to the understanding of the implications in different sectors. In this light the academic literature shows a positive impact of digital governance on performance, for example (Thompson et al., n.d.; Vashist et al., 2021) deduced that e governance has led to enhanced market intelligence, business development and higher profitability, it is also linked to enhanced employee performance specifically in terms of creativity, personal efficacy and effectiveness (Khan & Vijayashree, 2015).furthermore it mitigates agency problems by improving internal control and reducing managerial control (Li et al., 2023).

In this perspective, the main research question is “What is the effect of the digital governance on financial performance of technological firms in the international context?"

Thus, the present work aimed to provide theoretical implications by investigating the impact digital governance on financial performance of international technological firms based on data collected from annual reports.

Our paper has the following empirical contributions: digital governance (smart formation, audit, engagement of stakeholders, and administrator’s technological expertise) positively influences a firm's financial results in the international context. This concurs with several literatures like (Tiwari, 2022 ; Lunardi et al., 2012);

The remainder of the article is organized as follows: Section 2 presents the literature review. The development of our principal hypothesis is described in Section 3. Section 4 describes the applied research methodology, and Section 5 reports and discusses the major empirical results. Finally, Section 6 provides concluding remarks.

2. Theoretical framework

Many authors attempted to explain the underlying effect of digital governance on performance. This relationship is deep-rooted in the finance literature, and many theories can explain it. This all stems from the modern definition of firms, which is a network of contractual relationships among various stakeholders (Laffont & Martimort, 1997). This interdependent relationship can lead to agency costs. Agency theory examines the relationship where one party (the principal) delegates tasks to another (the agent). However, it assumes that agents may have a different goal and better information leading to the asymmetry of information and potential conflict of interests (Eisenhardt, 1989). In this vein digital governance may mitigate this problem by providing decentralized platforms based on algorithms, since trust resides in the algorithm system itself and is not dependent on personal relationships (Lumineau, et al. 2023), thus mitigating such issues.

From another lens, Behavioral finance is a theory that integrates both psychological and behavioral principles into traditional finance, thereby challenging touted established theories like the efficient market hypothesis (Veni & Kandregula, 2020). Behavioral finance recognizes that individuals are prone to acting irrationally due to many concepts like cognitive biases, emotions,

and social factors; this can lead investors to make uninformed decisions. However, the emergence of technology limits the involvement of humans, which translates to less uninformed decisions and biases; for instance, algorithms can be fair and unbiased, thus avoiding human biases (Sunstein, 2021). In this light, automation can reduce human errors and mitigate cognitive biases; however, this can lead to new types of automation biases (Parasuraman & Manzey, 2010).

2.1. Digital Governance

Organizations today face a complex environment and an excessive amount of data flows, which requires active problem solving. This gave birth to an area of research that aims to resolve this issue and bridge the existing knowledge. This is where digital governance, a field of research that has emerged, comes in, as it provides an essential upper structure for managing and protecting digital property and information responsibly. This is supported by (Manoharan, et al. 2023), who articulate, “Digital governance refers to the implementation of policies, practices, or processes in relation to the management of the digital assets of an organization.” This encompasses websites, mobile sites, social channels, and other Internet-enabled products and services. It clarifies responsibilities for content, design, technical infrastructure, security, funding, and project management. Digital governance promotes transparency, accountability, and government responsiveness, ultimately creating public value through e-democracy." Digital governance uses modern innovative technological solutions such as platforms that are crucial for value creation and appropriation, affecting overall platform performance (Chen and al. 2021). One of the most prominent technologies is AI and block chain, as these two have paved the way for technology-centric firms to take further steps in advancing the business strategies and to develop more sustainable, cohesive relationships with stakeholders and can reduce the principal-agent conflict, thus leading to more active yet unhostile shareholders. Blockchain can create verification mechanisms for transactions (Al-Breiki et al., 2020; Zheng et al., 2017). Also, using artificial intelligence (AI)-based firms can enable automatic checks on accounting data, enabling the detection of red flags and other issues early, thus enhancing firm monitoring (Commerford et al., 2022; Möhlmann et al., 2021). These emerging technologies can enhance the main pillars of corporate governance (transparency, accountability, responsibility, and fairness), and implementing them will make sure that any digital activities are performed with transparency and responsibility, thus reducing the incidences of fraud and other malpractices. Hence, the importance

of adopting these frameworks cannot be overstated, as failure to do so may put companies at a disadvantage from other competitors' consuming these technologies (Huang & Wang, 2023).

2.2. Differences between analogic and digital governance

Digital governance and analog governance are two different ways of managing affairs. For (Tirole, 2001) and (Khan, 2011), analog governance refers to policies, processes, and structures to plan, coordinate, direct, and control the operations of firms (Khan, 2011), while good governance enhances the results of firms and resolves agency issues by connecting the interests of managers and owners of equity. In contrast, digital governance uses information and communication technologies, for example, blockchain technology and artificial intelligence, to render the public administration more efficient, effective, transparent, and accountable. For instance, research has indicated that the use of e-governance tools such as ERP and CRM systems, as well as other web-based collaborative toolsets, has an appreciable influence on the levels of engagement, innovation, and social effectiveness of firms (Alkhodary, 2023). In definition and within the context of organization structure, governance in the digital world is flat, especially in cases that involve using blockchain technology (Chen et al., 2020), as opposed to analog governance, which is hierarchical and the power and authority to make decisions is vested in a few individuals (Ushida & Angel, 2021, Heo & Yi, 2023). It eliminates the need for intermediaries and facilitates peer-to peer transactions while expanding transaction possibilities by connecting peers directly to peers in innovative ways (Cong & He, 2019). Regarding communication channels in analog, it transpires mostly through face-to-face interactions, while in digital governance, communication is done through a platform. It is an easier and more efficient approach, and it increases trust. Unlike analog governance, where trust is actor-based, in digital governance, trust is derived from algorithmic protocols and is not dependent on personal relationships (Lumineau, et al. 2023). Decision-making in analog governance is vertical, while in digital governance, it is horizontal and involves multiple collaborators. Nevertheless, the challenges that come with digital governance are numerous, for instance, high cost of implementation, cybersecurity threats, the digital divide, and regulatory issues (Jin, 2024). On the contrary, analog governance encapsulates numerous issues, for example, dependency on resources, opportunism, conflict of interests, dependency on presence, etc. Another notable difference is the coordination, while analog

governance is bilateral (it traditionally involves two parties), digital governance is unilateral. (Hanisch et al., 2023).

2.3. The mechanisms of digital governance

The well-implemented governance framework ultimately leads to creating and capturing value in the light of asymmetry of information, agency problems, etc. This requires the creation of mechanisms to ensure productive exchange relationships and to achieve desired governance benefits. The mechanisms include verifying inputs and outputs (control), attenuating relationships (trust), aligning competing interests (incentives), and dividing and allocating tasks (coordination).

Control is a crucial mechanism that facilitates the verification of inputs and outputs and the enforcement of desired behaviors or outcomes. Control can be centralized, either distributed, or decentralized, and its implementation depends on the specific needs and objectives of the digital initiative; moreover, the platform owner exercises it over complementary with the goal to achieve a desirable behavior

A second variable is incentives. Incentives are also a critical component of digital governance; assessing the outcomes and elaborating a reward-based system is essential to motivating stakeholders to participate actively and contribute to the platform's success. Incentives are distributed autonomously through the platform and are re-evaluated through self-adapting algorithms. For example, Google Maps contributors who share reviews, photos, and knowledge are rewarded with points, which can be exchanged for rewards or used in exclusive community events (Tajedin, et al. 2019). Furthermore, they are attributed levels in proportion to their work.One other incentive tool relies on the blockchain in itself. Adding information in a block chain requires the validation of the collaborators; each validation can reward them with tokens such as shares, discounts, and other benefits. However, if they fail to validate correctly, some of their stakes will be lost; this serves as a disciplinary measure to maintain integrity and privacy. Incentives are important as they can help reduce conflicts between parties, e.g., agency problems due to the separation of decision- and risk-bearing functions (Fama & Jensen, 1983).

The third mechanism is coordination. According to Malone and Crowston (1990), coordination refers to the act of managing the interdependencies between activities so that actors work together harmoniously to achieve a goal. Effective coordination mechanisms are essential for aligning the activities of various stakeholders within digital governance platforms. These mechanisms ensure that all parties work towards common goals and adhere to established standards (Nielsen & Yasuoka 2014). Coordination mechanisms should facilitate value co-creation by enabling stakeholders to contribute their unique capabilities and resources towards shared objectives. To accomplish this digital governance initiative, often leverage various tools, like project management software, communication platforms, and regular meetings. This software typically accesses large datasets containing employees' profiles, such as age, certificates, and years of experience, to make schedules and distribute tasks optimally.

The final mechanism is trust. Trust is a concept that refers to the willingness of individuals or groups to rely on each other and collaborate toward common goals. Digital platforms are transforming trust in business relationships, enabling a new form of trust that resides in the algorithms itself and does it is not dependent on relationships (Lumineau, et al., 2023). These platforms utilize algorithms and smart contracts to govern inter-firm cooperation, though challenges remain in algorithm development, implementation, and governance (Das, 2020). The digitalization of trust has shifted corporate governance from trust in people to trust in compliance and measurement, facilitating co-creation and innovations, though improvements in planning and transition activities are needed

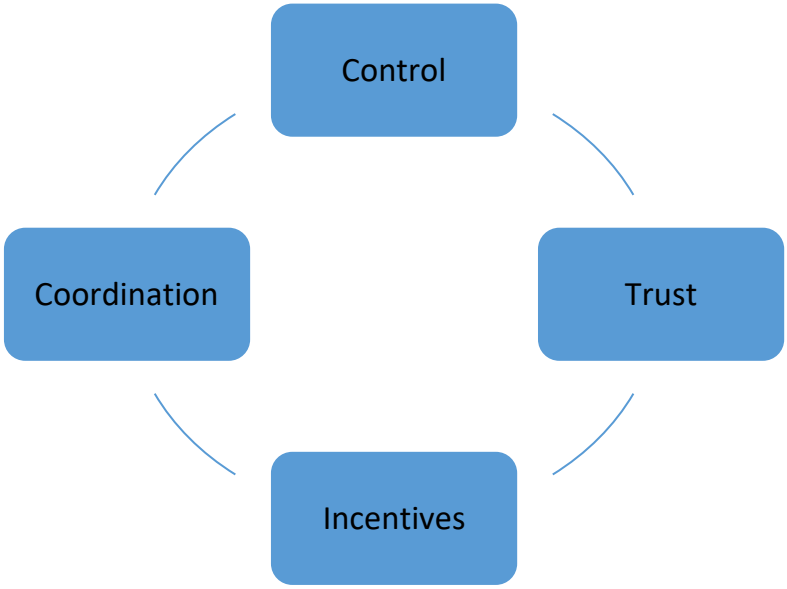

Figure 1: Mechanisms of digital governance

3. Prior literature and hypothesis development

3.1. Smart formation and firm's performance

Smart formation is a modern approach to learning that integrates information and communication technologies into educational practices, thereby completely shifting traditional learning environment. In addition, it encompasses various approaches including the use of interactive applications, intuitive tools based on human learning patterns and the integration of entertainment with education (Boytchev, 2010). In addition, by systematically incorporating smart training into corporate context, firms can support lifelong competence development and maintain the skills of employees in the face of ongoing digitization (Senderek, 2016). Digital technologies provide a strong incentive system that is set and self-reevaluated loop where inputs continuously serve as output (Vergne, 2020).

This interactive reward system mixed with entertainment and increased transparency help mitigate agency costs ensuring a fair and engaging learning environment. Smart formation literature indicates that and adoption in smart training can lead to significant cost reductions, increased profitability, and improved organizational learning in various industries (Gavril et al., 2017). Besides, employing technological solutions such as analytical technology tools can decrease

subjectivity human biases while enhancing objectivity (Hăhăianu & Dobre, 2017). For this cause, the argument mapper tool is a good example sine it counters cognitive biases, employ structured argument mapping and visualization techniques to help analysts tackle complex problems (Wright et al., 2017).

Most prior literature showed a positive impact of smart training on performance of firms. (Arh et al, 2012) found that companies with better organizational learning performed better financially and non-financially. Similarly, (Gavril et al., 2017) in his research conducted in Romanian multinational companies revealed that implementing smart learning strategies results in 40-60% cost reduction, complete measurability of the learning process, and standardized training outcomes. In the same vein, (Olafsen & Cetindamar, 2005) found that smart formation can enhance employee knowledge which led to increased performance of Norwegian companies. These findings cement the idea that smart training is positively associated with firm's performance; hence, we pose the following hypothesis:

H1: Smart training has a positive impact on the firm's performance

3.2. Smart auditing and firm's performance

Increasing corporate accountability and regulatory compliance pressure in this era of data abundance have led to the need for continuous, efficient auditing; this gave birth to smart auditing. This approach is technology-driven and uses robotic process automation (RPA). This process involves assessing current audit processes, gathering data from various sources to complete audit reports, classifying data, and assessing risks. According to (Cohen et al., 2019), robotic process automation is a technology that seeks to automate business processes and repetitive office tasks using software robots that interact with systems through their user interface.

Both behavioral finance and agency theory show the positive effect on RPA. On one hand RPA can prevent misstatements and provide better quality evidences thereby reducing audit risks and associated fees (Christiaanse & Hulstijn, 2012), moreover it can enable faster examination of raw accounting data with further details than manual methods leading to a cost reduction in the audit process (Lanza, 1998) resulting in more efficient and transparent process thus mitigating agency costs. In this way RPA can also reduce biases and enhance professional skepticism by mitigating

the impact of cognitive factors on audit quality (Marnet et al., 2016) and reduce cognitive errors on judgmental and decision making tasks with the use of big data (Ahmad, 2019).

In addition, it can eliminate human error and increases the consistency and preciseness of tasks, thus lowering the risk of oversight and miscalculation in the auditing process. (Kruskopf et al., 2019) thus enhancing financial performance

Several studies examined the association between smart auditing and performance (Sithole et al., 2023) reported up to 60% enhancement in quality performance and significant reductions in non-quality costs and downtime. Similarly, (Samuelsen , 2022) showed that it can eliminate workload bottleneck and lead to process redesign accounting for 62.5% of the time saving while the remaining 25% is attributed only to RPA. In the same vein (Thekkethil et al., 2021), asserts that RPA in the banking industry can automate loan processing and improve fraud detection by eliminating human errors. Moreover (Büyükarikan, 2022) have shown a positive effect relationship between RPA and performance since It enhances transparency and accountability by covering business process in detail, thus ensuring accurate financial reporting and lowering agency costs. Based on the arguments in this study and most prior literature works we can deduce the following hypothesis

H2: Automated auditing has a positive impact on firm's performance

3.3. Technology expert administrators and firm's performance

The role of expert administrators in technology has never been more critical for the performance of firms. As IT-savvy executives can transform technology assets into operational efficiencies, leading to higher profitability (Weill & Ross, 2009) and helping firms, develop technology strategies well aligned with business goals. Moreover, the emergence Artificial Intelligence can add new dimensions to how we perceive financial theories, for example, through intelligent data gathering and integration firms can potentially reduce information asymmetry (Moloi & Marwala, 2020).

in this light (Matta et al, 2019) find that a board's IT expertise can reduce information asymmetry and improve innovation., this could result in more aligned behavior between principals and agents, as intelligent systems can swiftly identify and reduce information discrepancies (Moloi &

Marwala, 2020). In this vein, based on behavioral theory biases such as Optimism, loss aversion, and overconfidence can affect investment choices and capital structure decisions (Azouzi & Jarboui, 2012). Nonetheless expert administrators in technology can mitigate these risks by implementing technology. In the lending sector, (Chen et al., 2022) showed that introducing fintech algorithms can reduce biases against nonlocal borrowers, as a result decreasing both loan to value ratio and default rate differences. Most studies have shown a positive relationship between technology expert administrators and performance, for instance (Weill and Ross, 2004) find that US firms whose boards have IT expertise make 25% higher profits than firms with poor IT governance given the same strategic objectives. Similarly, (Feng et al, 2024) deduced that the board technological expertise can improves internal corporate control especially in firms with high market competition and operational risk. However, not every implementation of information technology is successful, for example, Hewlett Packard lost 40 million dollars on a failed 30 million IT implementation (Koch, 2007). This is why then the upper management neglect information technology it can create severe problems for the firm (Rai et al. 2002; Venkatesh and Bala 2008; Masli, et al. 2016). Therefore, having information technology experts within the board of management should be of utmost priority. Expert leaders can effectively leverage technology and lead to better operational efficiency by streamlining processes and workflows; this agility and flexibility of administrators can drive the overall performance of the firm.

Based on the mixed results, we formulate the main hypothesis without direction, as follows:

H3: Technology expert administrators has a positive impact on firm's performance

3.4. Stakeholder's trust and engagement and firm's performance

Ward & Chapman (2008) defined stakeholders as groups or individuals who influence and are influenced by the achievement of organizational goals. Cleland & Ireland (1999) has divided stakeholders in projects into mainly two categories: internal and external stakeholders. Internal include employees, shareholders, and project management teams. On the other hand, external stakeholders consist of customers, suppliers, government and regulatory bodies, and mass media. Building relationships with stakeholders enables the firm to sustain its positive financial performance (Laughland & Bansal, 2011). In fact, this tapes into the stakeholder's theory which emphasizes that organizational success depends on creating value for all primary stakeholders not

just shareholders (Gutterman, 2023). Moreover, in this theory's perspective companies tend to extend and create mutual associations with stakeholders by improving socially oriented standards (Freeman & Dmytriyev, 2017). Digital technologies such as Blockchain can offer potential improvement in socially oriented standards compliance by monitoring through decentralized, immutable data management (Allena, 2019) thus increasing stakeholder's engagement and performance; this can be further increased by leveraging platforms. Which are an important step in adopting digital governance.

These platforms can facilitate connection between stakeholders and act as an intermediary that bridges conventional partners and promote information sharing (Moro Visconti, 2019), this increased engagement can mitigate agency costs and align interests (Yun-dal Sun & Jiakai Xia, 2022). In addition, they offer productive and successful routes for communication with other stakeholders, thus increasing engagement. This level of engagement can make stakeholders feel that their input is valued and considered important, which leads to greater trust and collaboration. Most previous studies found a positive effect on stakeholder's engagement on performance

Asser & Kamau (2024) noted the correlation between stakeholders' involvement and performance to be highly positive, with correlation coefficients of 0.502 and 0.580 for involvement and support, respectively, while (Kenyoru, 2015) found that more stakeholder engagement tends to positively impact the firm's performance. Similarly, Al-Haddad & Al-Abed (2021) showed a significant improvement on performance efficiency in terms of time, cost, and quality. Accordingly, the relevant hypothesis worth formulating at this level is the following

H4: Stakeholders trust has a positive impact on firm's performance.

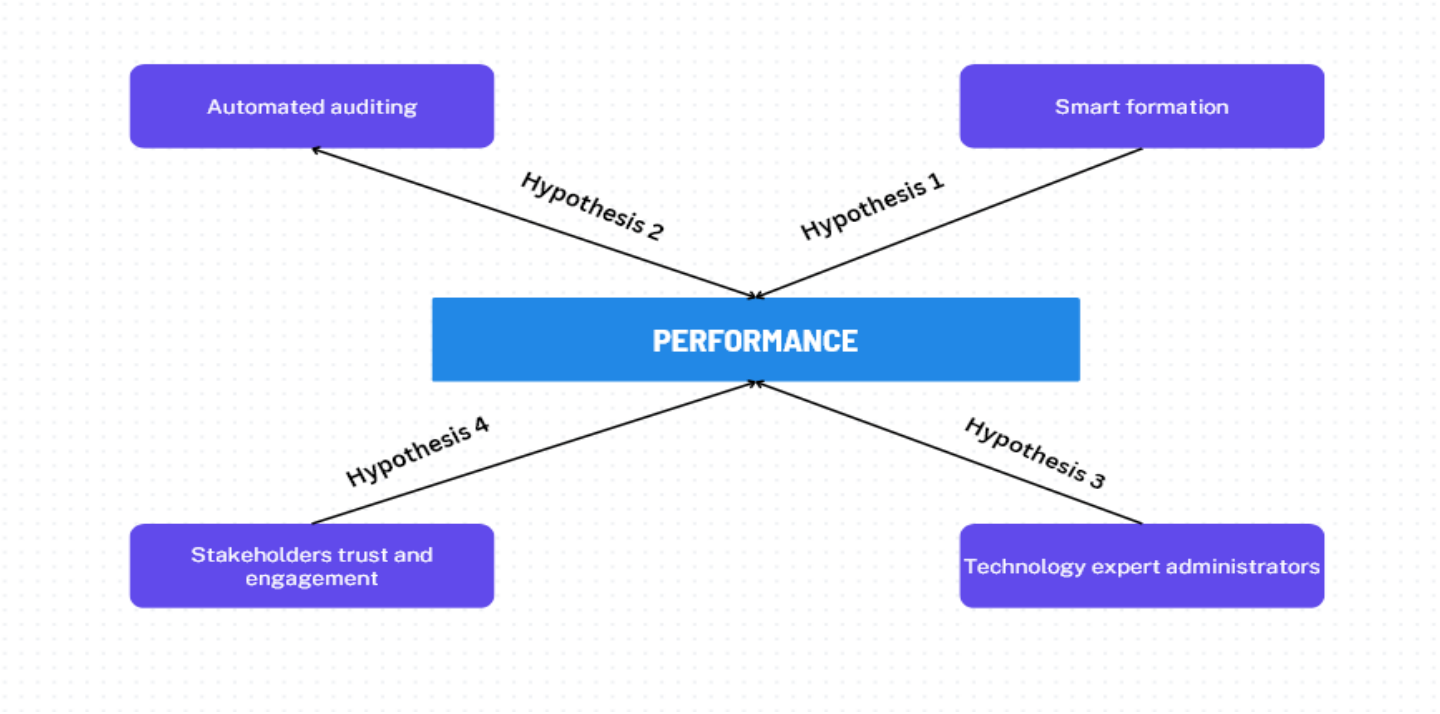

Figure 1: The direct effect of digital governance variables on performance

Source: Authors' own work

4. Research Methods

For this study, we opted for a quantitative research approach to examine the relationship between digital governance and financial performance. Data was collected from various firms by extracting information from their annual reports and financial data websites. A longitudinal design was adopted, where panel data was gathered from 2015 to 2023. This period was chosen due to significant technological advancements during this period, which allows us to more clearly assess their impact... All firms included in this database are technology companies.

4.1. Sample Selection

Our sample at the beginning consisted of 84 international firms, however, we excluded 29 firms due to non-availability of essential pieces of information, this left us with a final sample of 53 firms. This addressed the issue of missing data which usually causes problems in research. In this light, the sample of this study consists of 53 international technological firms for the period from 2015 to 2023, this resulted in 477 observations, and all the data required for this study is available.

Table 1 depicts the distribution of the sample by country and table 2 categorize the tech firms by specific category industry.

Table 1: Sample Selection and Breakdown by Country and Industry

Country	**No. of firms**	**Obs**
Panel A: Sample selection		
Initial sample	84	756
Firms with missing data	29	261
Final sample	53	477
Country	No. firms	%

Panel B:Sample distribution by country		
Country	No. firms	Obs
United states	28	52,8%
Japan	12	22,6%
China	3	5,6%
Netherlands	2	3,7%
Switzerland	2	3,7%
Germany	2	3,7%
France	1	1,8%
South Korea	1	1,8%
Taiwan	1	1,8%
Argentina	1	
Industry		
Panel C: Sample distribution by industry		
Semi-conductors and graphic processing	18	34%
Internet service and software	16	30%
Consumer electronics and software	8	15,1%
Industrial electronics and automation	4	7,5%
Software and hardware	4	7,5%
E-commerce and cloud computing	3	5,6%
Total	53	100%

Notes: Panel A describes the sample selection, Panel B provides the distributional properties of the full sample by country and Panel C presents the sample distribution by industry. Observations are the total firm-year observations by country and industry

Source: Authors' own work

4.2. Data Collection

This study uses secondary data, which is collected from annual reports, secondary data are widely used in examining the relationship between governance and financial performance. Multiple studies have employed desk research methodologies and analyzed annual reports to investigate this connection (Wakabi & Balikuddembe 2024; Hassan & Abubakar, 2012; Aggarwal, 2013). The

data was analyzed using regression analysis models, the fixed and random effects were employed after the Hausman test to choose the appropriate model.

4.3. Measurements of variables

Selecting the right variables for your model is a crucial step towards methodically verifying the hypothesis of the study, in our case; we will provide the definition, measurements, and justifications for the selected variables.

Table 2: Description of variables

Variables	Codename	Measurements	Source
Dependent Variable			
Firm's Performance	P	It is measured by three variables: Return On Investment, Return On Equity, Market to Book	Richard et al (2009)
Independent Variables			
Smart formation	LogPPE	Log-profit per employee = Log Total sales divided by the total number of employees	Bryan, L. L. (2007).
Automated Audit	ARL	Audit Report Lag : The number of days between the fiscal year's end and the announcement of the annual report	Ahsan et al, (2018) Rusmin & Evans (2017)
Technology expert administrators	ITE	Take 1 if the CEO is considered to have IT expertise based on work experience or education background, and 0 otherwise	Haislip, et al. (2018).
Stakeholders trust and engagement	Sy	A dummy variable coded 1 if the firm adopts the market-oriented system and 0 if it adopts the bank-oriented system	Jayeola (2015) Horváthová (2016)
Control Variables			
Firm Size	Log-FmSize	Natural logarithm of total assets	Karlsson (2020)
Debt to equity ratio	DER	Total debt divided by equity	Ahmed (2010)
Firm's Age	Log-FmAge	Number of years since the company has been founded	Elaoud and Jarboui (2019)

Sales Growth	GROWTH	Percentage change in sales	Jarboui (2019) Riguen et al. (2018)
Coronavirus	COVID-19	Take 1 if the study period is 2020 and 0 otherwise	Bae et al. (2021), Chouaibi et al. (2021)

Note: This table reports the definitions of the variables used in our study

Source: Authors' own work

4.4. Model specification

To test our hypothesis, we estimated the following equations:

Model 1

$$P_{it} = \alpha_i + \alpha_1 LogPPE_{it} + \alpha_2 DER_{it} + \alpha_3 LogFmSize_{it} + \alpha_4 LogFmAge_{it} + \alpha_5 Growth_{it} + \varepsilon_{it}$$

Model 2:

$$P_{it} = \alpha_i + \alpha_1 ARL_{it} + \alpha_2 DER_{it} + \alpha_3 LogFmSize_{it} + \alpha_4 LogFmAge_{it} + \alpha_5 Growth_{it} + \varepsilon_{it}$$

Model 3:

$$P_{it} = \alpha_i + \alpha_1 ITE_{it} + \alpha_2 DER_{it} + \alpha_3 LogFmSize_{it} + \alpha_4 LogFmAge_{it} + \alpha_5 Growth_{it} + \varepsilon_{it}$$

Model 4:

$$P_{it} = \alpha_i + \alpha_1 SY_{it} + \alpha_2 DER_{it} + \alpha_3 LogFmSize_{it} + \alpha_4 LogFmAge_{it} + \alpha_5 Growth_{it} + \varepsilon_{it}$$

Where :

Pit = Firm's Performance measured by three variables: Return On Investment "ROI" = Net investment Profit/Total investment, Return On Equity "ROE" = Net Profit/Total equity, Market to Book "MTB " = market capitalization / book value of equity

LogPPE $_{it}$ =Logarithm of profit per employee, ARL $_{it}$ = Audit Report Lag, ITE $_{it}$ = Information Technology Expertise, Sy $_{it}$ = system, DER $_{it}$ = Debt to Equity Ratio, Log-FmSize $_{it}$ = Logarithm

of firm size, Log-FmAge $_{it}$ =Logarithm of firms age and Growth $_{it}$ = Sales Growth, Ɛ: Error term; i: firm subscript; and t: time subscript.

The regression models were estimated using multiple regression analysis for panel data via STATA analysis software (version 18). Given the different nature of the panel data, we had to follow the order of some econometric steps and conduct some tests to obtain robust estimates. First, the F statistic test is designed to test the presence of any individual effect. Indeed, this test produced a significant Chi-square value, indicating the presence of individual effects, hence the heterogeneous nature of the sample. Finally, the heteroscedasticity test conducted on panel data by applying the Breusch-Pagan test yielded significant chi-square; Thus, the null hypothesis of constant variance was rejected, and the models suffer from a heteroscedasticity problem (see Table 5).

5. Empirical results

5.1. Descriptive statistics

This table provides a detailed description of the variables for the sample of 441 firm-year observations. We find that the average performance value is $5.74.10^{-10}$. Moreover, it ranges from a minimum average of -15.27 to a maximum of 2.4. These results indicate a huge difference between the technological firms with the best and worst performance in the sample. Moving forward to smart formation, the average profit per employee for the technology companies sampled during the study period is 4.46. The annual data shows that the average profit per employee for the study period ranges from -5.4 to 5.94. This suggests that implementing digital strategies to improve skill transfer and retention, employees tend to increase their productivity and efficiency, hence the observed increase. Turning to automated audits, we observe that the audit report lag ranges from a minimum of 19 to a maximum of 136, with a standard deviation of 22.52. These results indicate a marked variation in audit report lag among the sampled technology firms. These results also suggest it is clear that the introduction of technology (i.e., RPA solutions) has an impact on the audit process, increasing the speed of the audit process while reducing costs (Moffitt et al., 2018; Eulerich et al., 2020).

Table 3: Descriptive statistics

Variables	Obs	Mean	SD	Minimum	Maximum
P	477	5.74.10-10	1.034	-15.27	2.40
Log-PPE	477	4.46	1.8	-5.14	5.94
ARL	477	53.45	22.52	19	136
ITE	477	0.6121	0.4877	0	1
Sy	477	0.7554	0.43	0	1
Log-FmSize	477	4.57	0.57	2.7	6.2
DER	477	0.559	1.17	-9.369	7.57
Log-FmAge	477	3.74	0.612	2.30	5.17
GROWTH	477	0.127	0.187	-0.533	1.2
COVID-19	477	0.111	0.3145	0	1

Notes: This table reports descriptive statistics. Variables' definitions are provided in Table 2

Source: Authors' own work

5.2. Correlation Analysis

The table above highlights the Pearson correlation coefficients calculated for the all the variables in the study. Analysis of the coefficient matrix shows that there is no strong correlation between the variables when referring to the benchmark of 0.8 (Kennedy, 2003). Consequently, there is no serious problem of multi-collinearity. Our variables can be put together in a regression model. The results show that the VIF of all the variables ranges from one to 1.79 <1.02, displaying little to no multi-collinearity in the models (Cohen and Cohen, 1983).

Table 4: Correlation matrix and VIF test

Variables	1	2	3	4	5	6	7	8	9	VIF
Log-PPE	1.00									1.12
ARL	-0.1230	1.00								1.51
ITE	0.1797	-0.30	1.00							1.22

Sy	0.1866	-0.533	0.3712	1.00					1.79
DER	-0.1919	0.01	0.018	0.0012	1.00				1.06
Log-FmSize	0.014	-0.05	-0.015	-0.2698	-0.1121	1.00			1.25
Log-FmAge	0.062	0.05	-0.052	-0.2299	0.041	0.2552	1.00		1.2
Growth	0.052	-0.02	-0.044	0.1125	0.014	-0.246	-0.2933	1.00	1.17

Notes: This table presents the correlations coefficients for the variables used in the study. Variables definitions are outlined in Table 2

Source: Authors' own work

5.3. Discussion

Table 6 presents the multivariate regression analysis on panel to empirically test the hypothesis on the impact of digital governance on performance of technological firms. We began by employing the Hausman test to choose the most suitable regression mode. In this case, the random effect was chosen for the first and four model whereas fixed effect was suitable for the second and third model. After that, we ran the heteroscedasticity test it means that the variance of the error terms is not constant across all levels of independent variables, which can lead to misleading estimations with the random effect model. To identify this problem, we conducted the Breusch-pagan test for heteroscedasticity the p-values of both models are less than 0.05, proving that these models are not free from the heteroscedasticity problem. Although an insignificant heteroscedasticity problem has little impact on significance tests (Berry & Feldman, 1985). Therefore, to alleviate this issue, all models will be estimated with robust standard errors to correct for heteroscedasticity and are clustered at the firm level (Petersen, 2009).

Table 5: Regression results

Variables	Fixed effect		Random effect	
	Model 2	**Model 3**	**Model 1**	**Model 4**
Log-PPE	-	-	0.202***	-
ARL	-0.014**	-	-	-
ITE	-	0.543***	-	-

Sy	-	-	-	1.241***
DER	0.08	0.07	0.10	0.09
Log-FmSize	0.71***	0.56***	0.24***	0.54***
Log-FmAge	0.28*	0.39	-0.27	-0.14
Growth	0,11	0.10	0.03	0.34
Adj R-squared (%)	**17.42**	**22.43**	**59.88**	**51.55**
Fisher (p-value)	**4.54*** **	**5.79*** **	-	-
Wald Chi^2	-	-	**15.6*** **	**13.43*** **
Hausman Test	**12.19****	**11.02****	**6.97**	**5.86**
Breusch-Pagan test for Heteroscedasticity	**23.20*** **	**18.25*** **	**40.62*** **	**11.65*** **
N-obs	441	441	441	441

Note: This table reports descriptive statistics. Variables definitions are provided in Table 2. Statistical significance at the 10, 5, and 1% levels are indicated by *, **, and ***, respectively.

Source: Authors' own work

Regarding the coefficient for profit per employee (Log-PPE), the first digital governance variable being examined is positively (ß=0.202) and significantly (at the 1% level) related to performance in international firms. Therefore, our first hypothesis (H1) is validated, suggesting that smart formation improves firm's performance in conformance with existing research results of as Raja et al. (2011) who found that smart training positively correlates with performance.

Similarly, (Maria et al, 2014) concluded that organizational-oriented training positively impacts performance. Therefore, there seems to be a consensus on the positive impact of smart training on performance, which aligns with our findings.

The audit report lag (LAR) is negatively (ß=-0,014) correlated with performance and is statistically significant at 5%, validating the second hypothesis (H2), this goes in line with many authors like (Ahmad & Hossain, 2010), (Rusmin & Evans, 2017) who found that the automation of audit processes can lead to shorter audit report lag. The time it takes to complete an audit, known as audit report lag, is important for the timeliness and reliability of financial information. A long audit report lag may indicate issues with a company's financial reporting or audit process, potentially leading to future restatements and it could potentially affect performance measures such as ROA and ROE (Arianpoor, 2020). On the other hand, shorter audit report lags signal more efficient audit

processes and stronger financial reporting, providing stakeholders with timely and reliable information for decision-making.

Regarding the Information Technology Expertise (ITE) variable, we notice a positive (ß=0,543) and significant relation between the digital expertise of executive directors and performance at 1%. Indeed, we can affirm that our third hypothesis is validated (H3). These findings highlight that the existence technology-expert directors in the organization is important since their expertise can leverage data analytics and digital technologies to make more informed decisions that aligns with the overall strategic goals. Furthermore, they are more agile and accepting of digital technologies thus fostering a culture of innovation and an increases ability to respond to market changes and lowering costs by streamlining operations. This result is consistent with the findings of that technological expertise can lead to make information technology investments (Hall & Liedtka, 2005) and therefore, good outcomes (Chakrabarty & Whitten, 2011).

We hypothesized a positive association between Stakeholder's trust and engagement (Sy) and Performance. As can be seen from Table 5 and in accordance with our expectations, the estimated coefficient of "System" is positive (ß=1,241) and significant at the 1% level. Indeed, we can affirm that our four hypothesis is validated (H4). The difference between market oriented and bank oriented is evident, in our sample, market oriented firms appears to be performing much better than their bank oriented counterpart. This is attributed to many factors including such as the high level of innovation and responsiveness exhibited in market oriented firms, and the high strong access to external financing from institutions. This goes in line with many studies which showcase that the increase of stakeholder engagement positively influences performance efficiency in terms of time, cost, and quality (Al-Haddad & Al-Abed, 2021) another study by (Thomas & Stephen, 2024) discovered that stakeholder engagement, including communication, capacity building, relationship management, and control processes, contributes to sustainable performance, accounting for 70.9% of performance changes.

6. Robustness analysis

At this level we regressed Return On Investment "ROI", Return On Equity "ROE", Market to Book "MTB " as variables to be explained by governance and control variables. In addition, we

divided our models into, pre-covid and post-covid, to assess the underlying impact of our variables in those two respective periods. We used the same software (STATA 15) as the other models. According to table 6, these models indicate that the increased development of technology led to a surge in performance, for example audit report lag (ARL) had a coefficient of (0.06) pre-covid and (0.018) post-covid. In this light (Sadangi et al., 2020) highlighted that the introduction of automation has shown promise in reducing audit cycles. In general, we notice a positive impact of technology on all our independent variable throughout the years. This indicates that there are no significant differences between our main models in interpretation phase and the models in the robustness test, which signifies consistent results across plausible alternative model specifications.

Table 6: Robustness analysis in Pre-covid

Pre-covid																
Variables	PER				TSR				MaCap				P			
	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4
Log-Ppe	0.33	-			0.01				0.01				0.01			
ARL		-0.12				-0.001				-0.001				-0.006		
ITE			0.92				0.49				0.04				0.07	
Sy				4.29				0.12				0.71				0.77
DER	0.06	0.06	0.01	0.01	0.02	0.26	0.08	0.02	0.01	0.01	0.009	0.009	0.05	0.05	0.05	0.05
Log-FmSize	4.09	4.12	4.06	4.66	0.10	0.11	0.17	0.08	0.36	0.37	0.34	0.41	0.26	0.36	0.36	0.47
Log-FmAge	-1.96	-2.34	-2.19	-2.38	-0.01	-0.01	-0.08	-0.01	-0.09	-0.09	-0.04	-0.08	-0.09	-0.19	-0.19	-0.17
Growth	2.19	1.81	1.81	1.92	0.10	0.07	-0.003	0.07	0.25	0.27	0.26	0.26	0.22	0.29	0.28	0.28
Adj R-squared																
Fisher										**4.73*** **					**2.43** **	
Wald Chi2	**6.52**	**5.91**	**3.30**	**3.26**	**22.78***	**26.74***	**22.56*** **	**32.23***	**64.09***		**57***	**48.50***	**26.35***	**28.91***		**42.43***
Hausman Test	**3.10**	**3.25**	**3.04**	**3.11**	**8.08**	**8.26**	**9.51***	**8.12***	**5.51**	**16***	**9.91***	**0.67**	**10.54***	**2.55**	**2.37** **	**10.6**
N-obs	477	477	477	477	477	477	477	477	477	477	477	477	477	477	477	477

Source: Authors' own work

Table 7: Robustness analysis in Post-covid

Post-covid																
Variables	PER				TSR				MaCap				P			
	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4
Log-Ppe	0.34				0.034				0.02				0.02			
ARL		-0.06				-0.004				-0.01				-0.018		
ITE			1.45				0.07				0.039				0.27	
Sy				0.27				0.14				0.78				1.25
DER	0.97	0.94	0.93	0.94	0.04	0.02	0.04	0.02	0.005	0.01	0.007	0.005	0.004	0.009	0.007	0.019
Log-FmSize	4.85	4.31	4.37	4.34	1.39	0.17	1.22	0.14	0.37	0.33	0.23	0.46	0.69	0.35	0.37	0.6
Log-FmAge	-8.42	-8.51	-8.20	-8.39	0.60	-0.03	0.54	-0.02	1.00	-0.269	0.95	-0.17	-1.3	-0.15	-0.16	0.007
Growth	1.73	1.66	1.53	1.5	0.53	0.13	0.51	0.12	0.10	0.15	0.12	0.13	0.72	0.07	0.14	0.02
Fisher					**2.48 ** **	**2.73* * * **	**2.21* **				**0.65**		**1.49**			
Wald Chi2	4.44	**4.15**	**4.60**	**3.58**				**20.27 *** **	**17.03* ** **	**27.50 *** **		**57.11 *** **		**24.21 *** **	**16.94 *** **	**34.82 *** **
Hausman Test	**5.37**	**19.76* ** **	**7.05**	**6.23**	**17.2 8*** **	**15.62 *** **	**15.22* ** **	**14.81 *** **	**5.37**	**7.28**	**17.95* ** **	**12.27 ** **	**11.50 ** **	**5.71**	**6.63**	**7.49**
N-obs	477	477	477	477	477	477	477	477	477	477	477	477	477	477	477	477

Source: Authors' own work

7. Recommendations

Since technology is ever-evolving, it is always a challenge for any technology firm to keep pace with changing times. Therefore, this research provides comprehensive recommendations concerning implementing digital governance in firms.

First, it means smart education of employees in firms by infusing technology into the trainees. This will include digital applications that simulate a mock environment where mistakes can be made without real-life implications. Besides, the firms must implement a reward/incentives system that rewards employees who complete the courses or formations with bonuses...Moreover, digital governance cannot be implemented at once since it will be difficult and expensive. Thus, firms can adopt hybrid governance, a mix of digital and analog governance. This is because digital governance exhibits high initial setup costs and functions best under large digital exchanges. Analog governance is best suited for small digital exchanges. Finally yet importantly, firms should have a digital governance committee that consists of various representatives from each department to oversee digital governance initiatives and development by scheduling meetings that touch on progress, addressing challenges, and updating policies if needed.

8. Conclusion

All the variables of digital governance (except for technology expert administrators) have shown positive impact on performance Thus it can be inferred that digital governance positively influences performance. This goes in line with existing literature results of (Tiwari, 2022), enhances organizational competitiveness by improving business and merchandising performance, customer satisfaction, and market recovery post-COVID-19 and (Guilherme et al, 2012) necessity for firms to increase their performance and have a competitive advantage in the market.

Furthermore, with the ever-changing technological front up on organizational governance and performance, it becomes essential for these institutions to embrace change and explore technological changes that are available on the market. From the empirical study and with the theoretical recommendations as part of the knowledge, firms will be in a better position to improve digital governance practices to improve their performance.

Suggesting that there are possible directions for the continuation of the research, the limitations of the study have to be mentioned. Accommodation of digital governance as a subsector of organizational structure mainstream will define operations and performance in the era of digital economics.

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The Effect of Labelling and Message Type on Purchase Intention Towards Vegan Food

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Abstract

The global vegan food market has grown considerably, owing to increased interest in plant-based diets and sustainability. However, strong resistance to vegan labelling—stemming from scepticism, taste apprehensions, cost, and ingrained dietary habits—continues to hinder adoption. Prior research has predominantly focused on vegetarian consumers, overlooking how non-vegan consumers react to vegan-labelled products. Understanding and addressing this resistance is essential for expanding the vegan market.

This study explores how message type (uptrend vs. health-focused) moderates the effect of vegan labelling on purchase intention. Results indicate that while vegan labelling tends to lower purchase intention, this effect is mitigated when uptrend messaging is introduced. Conversely, health-focused messaging fails to mitigate the negative effect of vegan labels, making non-labelled products more appealing. This suggests that social influence is more effective than health-focused messaging in overcoming resistance.

Furthermore, green self-efficacy mediates these effects, indicating that when consumers feel capable of making sustainable choices, they are more inclined to accept vegan products. This study identifies psychological resistance to vegan labelling and the role of social norms, offering actionable strategies for expanding vegan food consumption in resistant markets. The findings contribute to practical marketing applications and long-term growth strategies for the vegan food industry.

Keywords: Vegan food, Vegan labelling, Uptrend messaging, Health-focused message, Green self-efficacy, Purchase intention

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1. Introduction

The global vegan food industry has experienced significant growth, driven by advancements in food technology, increased availability of plant-based alternatives, and heightened consumer awareness about sustainability. However, despite this growth, the widespread adoption of vegan food remains limited (Berke and Larson, 2023). Although some consumers acknowledge the environmental and ethical benefits of vegan food, concerns related to taste, price, and ingrained dietary habits continue to impede market expansion (Bolderdijk and Cornelissen, 2022; Yule and Cummings, 2023).

This challenge is particularly prominent in markets where plant-based food consumption has yet to become mainstream. In certain cultural contexts, meat consumption is often associated with affluence and nutritional adequacy, rendering the adoption of vegan food less instinctive for many consumers. Prior research suggests that vegan labelling—which explicitly signals a product as plant-based—may elicit negative perceptions, especially among consumers unfamiliar with plant-based alternatives, as it is occasionally perceived as restrictive or indicative of compromises in taste and quality (Berke and Larson, 2023). Conversely, several studies indicate that vegan labelling can enhance consumers' likelihood of choosing plant-based options by reinforcing positive associations (Hielkema and Lund, 2022).

Importantly, while prior research has primarily examined differences in consumer attitudes based on the binary presence or absence of vegan labels, it has often overlooked the communicative implications of labelling itself. Labelling is not merely a factual indicator but a form of message framing that can elicit affective and cognitive responses, so shaping consumer perceptions. The affective and interpretive dimensions of vegan labelling have seldom been the primary focus of empirical research, despite its potential as a communication cue.

To build on this perspective, our study addresses the inconsistent findings in the literature by highlighting the need for effective messaging strategies that leverage vegan labelling as a communicative tool to shape consumer attitudes—particularly in markets where plant-based consumption remains widely unaccepted. Unlike previous research that has primarily identified motivations for adopting a vegan diet—often framed around personal health or sustainability concerns (Ghaffari et al., 2022; Rosenfeld et al., 2024)—our study focuses on reducing scepticism among consumers in emerging vegan markets. Rather than appealing solely to individual moral or health-based motivations, we aim to develop messaging strategies that mitigate resistance and reshape perceptions. By doing so, our research seeks to establish a

conceptual foundation for promoting plant-based food not only as a matter of individual choice but as part of a broader shift towards a sustainable food system.

Specifically, our study examines how social influence can mitigate consumer resistance to vegan food by analysing the interplay between vegan labelling and message type (uptrend vs. health-focused messaging). Given that consumer responses to vegan food prompted by vegan labelling are not always favourable (Berke and Larson, 2023), understanding the interaction between different message frames and consumer perceptions might aid in formulating effective marketing strategies. Additionally, we explore the role of green self-efficacy as a psychological mechanism influencing consumer decisions.

Through this approach, our study addresses critical gaps in existing research on vegan food consumption and provides marketers with actionable and scalable communication strategies to promote voluntary behaviour change. Rather than focusing on consumers who are already inclined towards plant-based diets, we direct the attention to those who are more resistant and investigate targeted messaging techniques to effectively engage this segment. As the global food industry increasingly prioritises sustainability, identifying message strategies that resonate with sceptical consumers will be vital for expanding the reach and impact of vegan food marketing.

2. Theoretical background and hypothesis development

2.1 Attitude towards vegan food and vegan labelling

A vegan diet is defined as ‘a dietary pattern that excludes meat, meat-derived foods, and, to different extents, other animal products’ (Hargreaves et al., 2023). Similarly, a plant-based diet primarily comprises plant-based foods with minimal intake of animal products (Barnard et al., 2019; Hargreaves et al., 2023). Labels such as ‘vegan’, ‘plant-based’, ‘healthy’, and ‘sustainable’ are commonly used to indicate foods that exclude meat and dairy (Sleboda et al., 2024). Although each term highlights different attributes, our study refers to all diets that exclude meat and dairy collectively as vegan diets for conceptual consistency.

Consumer attitudes towards vegan food are influenced by a range of factors that can either promote or hinder its adoption. On a positive note, consumers may be motivated by health benefits (Fox and Ward, 2008), ethical considerations related to animal welfare (Martinelli and De Canio, 2021), environmental concerns (Martinelli and Canio, 2022), or religious beliefs (Ruby, 2012). Conversely, individual traits including right-wing authoritarianism and social

dominance orientation have been shown to contribute to negative perceptions of veganism (Judge and Wilson, 2019). The anticipated stigma associated with veganism acts as a psychological barrier that deters some consumers from purchasing vegan products (Markowski and Roxburgh, 2019; Shah and Joshi, 2024).

Similar to the mixed attitudes towards vegan food, research on vegan labelling has yielded inconsistent results. Some studies suggest that vegan labels enhance product appeal, as evidenced by increased sales of dishes labelled as 'vegan' versus those labelled as 'plant-based' (Rosenfeld et al., 2022). Storz (2022) attributes this to the greater clarity of the 'vegan' label, whereas the 'plant-based' label may cause ambiguity regarding the product's composition. However, several studies suggest that vegan labelling may have the reverse effect, amplifying consumer aversion to vegan food (MacInnis and Hodson, 2017; Ruby et al., 2024). In such instances, vegan labelling reinforces perceptions of dietary restriction, leading consumers to opt for non-vegan alternatives over the labelled vegan option (Hielkema and Lund, 2022). Moreover, while vegan-labelled products are often perceived as healthier, they are also associated with lower taste expectations, which might ultimately lower purchase intention (Stremmel et al., 2022).

Given these conflicting results, the extent to which vegan labelling facilitates or hinders consumer acceptance remains unclear. One possible explanation is that prior studies have explored the effects of labelling across different contexts and consumer groups (Berke and Larson, 2023; Malila et al., 2025; Rosenfeld et al., 2024). These inconsistencies underscore the need to examine the influence of vegan labelling on implicit attitudes towards food purchases, particularly among consumers who maintain conventional dietary habits.

This study aims to address this gap by examining the effects of vegan labelling among consumers who do not regularly follow a plant-based diet and exhibit initial scepticism towards vegan products. Specifically, we seek to predict the varied reactions to vegan food purchases by investigating how vegan labelling influences purchase intention and how different message strategies may mitigate resistance.

2.2 Message type

In the context of dietary choices, several messaging strategies have been employed to promote plant-based food consumption, yet their effectiveness remains unclear. A common approach is health-focused messaging, which highlights the potential benefits of plant-based diets, including reduced risk of certain diseases and overall improved health (Heideker and Stuel-Fischer, 2017). However, nutritional concerns regarding vegan diets, particularly the intake of protein and essential nutrients, continue to significantly affect consumer reluctance (Craig, 2010). Transitioning to a plant-based diet often necessitates significant lifestyle changes; hence, messages advocating what individuals 'should' eat may provoke defensive reactions rather than encouraging adoption (Kwasny et al., 2022).

In contrast to health-focused messaging, which appeals to personal well-being, uptrend messaging emphasises social conformity and collective behavioural trends. Prior research suggests that individuals derive utility not only from personal benefits but also from conforming to group norms (Sparkman et al., 2017). When consumers perceive that a behaviour is becoming mainstream, they may be more inclined to embrace it to maintain social relevance and avoid feeling left behind (Berger and Heath, 2007). This psychological mechanism, known as preconformity, asserts that individuals adjust their behaviour in anticipation of future societal trends, hence reinforcing the persuasive power of uptrend messaging (Sparkman and Walton, 2017).

We propose uptrend messaging as a means to overcome the limitations of prior research that emphasises health-focusing messaging. It can leverage descriptive social norms to diminish resistance and boost consumer engagement (Costello et al., 2024). Descriptive norms refer to individuals' perceptions of how prevalent a behaviour is within a social group (Cialdini et al., 1991). Research shows that people are more inclined to conform to behaviours that they perceive as becoming increasingly popular (Costello et al., 2024). In the context of sustainable consumption, highlighting the rising adoption of plant-based diets can reframe vegan food as socially normative rather than restrictive or niche (Raptou et al., 2024).

2.3 Moderating role of message type (uptrend vs. health benefit) in mitigating negative perceptions of vegan labelling

Consumers' reactions to vegan-labelled products are complex and often shaped by the message type accompanying the label. Although vegan labelling is intended to promote ethical and sustainable consumption, it can inadvertently elicit psychological resistance among non-

vegan consumers (Berke and Larson, 2023). Certain studies highlight the positive impact of vegan labelling on ethical consumption awareness (e.g. increased perceived sustainability and health consciousness), whereas others contend that it may trigger resistance due to perceived restrictions on personal choice or concerns regarding taste and satisfaction (Berke and Larson, 2023; Sleboda et al., 2024). Considering these divergent perspectives, it is crucial to examine under what conditions vegan labelling enhances or suppresses consumers' purchase intention.

Without the appropriate message type, vegan labels may reinforce scepticism rather than encourage adoption (Berke and Larson, 2023). These conflicting results also suggest that vegan labelling alone does not universally enhance purchase intention, but rather depends on how it is communicated to consumers. Message type serves as a lens through which consumers interpret vegan labelling—either reinforcing scepticism or diminishing resistance—by shaping perceived norms, motivations, and behavioural expectations. This underscores a critical theoretical gap: understanding the conditions under which vegan labelling can enhance rather than suppress consumer interest. Thus, we propose that a key factor that may shape consumers' responses to vegan labelling (presence vs. absence) is message type (uptrend vs. healthy-focused).

We first consider the effect of uptrend messaging in mitigating the negative impact of vegan labelling. Uptrend messaging may serve as an effective strategy for reducing negative perceptions of vegan labelling. Descriptive social norms, which emphasise the growing prevalence of certain behaviours, have been shown to boost engagement by framing an action as widely accepted (Cialdini et al., 1991). Studies indicate that when individuals perceive a behaviour as gaining social momentum, they are more inclined to conform to it, even if they are initially apprehensive (Costello et al., 2023; Sparkman and Walton, 2017).

From a consumer behaviour perspective, uptrend messaging leverages social proof, encouraging individuals to adopt behaviours that are perceived as becoming more mainstream. Highlighting the growing number of consumers embracing plant-based foods into their diets may minimise scepticism towards vegan-labelled products by shifting their perception of the vegan diet from a niche lifestyle to a broader social trend (Li et al., 2020). Prior research has demonstrated that people tend to align with behaviours that appear to be part of a broader movement, particularly when those behaviours are seen as progressive or culturally relevant (Goldstein et al., 2008).

Conversely, health-focused messaging, while commonly used in green marketing, may be less effective in overcoming psychological resistance to vegan labelling. Although such

messages highlight individual benefits, they do not effectively counteract the perception that vegan food is a restrictive choice (Zhang et al., 2021). Given that consumers often encounter a social dilemma when purchasing eco-friendly products—weighing personal benefits against social responsibility—the effectiveness of health messaging may be limited when consumers perceive vegan food as necessitating a behavioural compromise (Barbarossa and Pelsmacker, 2016).

Consequently, we propose that uptrend messaging will mitigate the negative effects of vegan labelling, resulting in comparable purchase intention between labelled and unlabelled products. However, in the case of health-focused messaging, the negative perception of vegan labelling is expected to persist, leading to lower purchase intention for labelled products.

H1: When uptrend messaging is emphasised, there will be no significant difference in purchase intention between vegan-labelled and unlabelled products. However, when health-focused messaging is emphasised, the purchase intention for vegan-labelled products will be lower than that for unlabelled ones.

2.4. Mediating role of green self-efficacy

Consumers' purchase decisions for vegan food products are influenced by their perceived ability to make sustainable choices, a concept referred to as green self-efficacy. Green self-efficacy denotes an individual's confidence in their ability to engage in environmentally friendly behaviours (Chen et al., 2015), and it has been shown to enhance pro-environmental decision-making and sustainable consumption behaviours (Farooq et al., 2022). Specifically, individuals with higher green self-efficacy are more inclined to act in eco-friendly ways, as they believe their choices meaningfully contribute to environmental preservation (Sh. Ahmad et al., 2022). Given its established role in influencing behaviour, we propose that green self-efficacy serves as a key psychological mechanism that mediates the effects of vegan labelling and message framing on purchase intention for vegan food.

A key reason why uptrend messaging mitigates resistance towards vegan-labelled products is its effect on reinforcing green self-efficacy. When consumers perceive vegan consumption as a growing social trend, they are more likely to adopt such behaviours, as social proof reinforces their belief that transitioning to a vegan diet is both feasible and socially validated (Costello et al., 2023; Cruwys et al., 2020). Research demonstrates that social influence enhances self-efficacy by increasing perceived behavioural control—when individuals observe others engaging in sustainable behaviours, they cultivate a stronger conviction in their own

ability to do the same (Huang, 2016). Therefore, when vegan labelling is presented alongside an uptrend message, it is expected to enhance consumers' green self-efficacy, thereby diminishing psychological resistance and increasing purchase intention. In this way, the previously observed negative effects of vegan labelling are not merely suppressed but are actively counteracted by increased self-efficacy.

However, the use of health-focused messaging in lieu of uptrend messaging may lower the effect of green self-efficacy. Health-focused messaging typically prioritises personal well-being above collective social norms, hence diminishing their potential to bolster perceived self-efficacy relating to pro-environmental behaviour (Rainear and Christensen, 2022). In such instances, particularly when vegan labelling is absent and negative scepticism does not arise, health-focused messaging may lead consumers to perceive the product as a healthy choice. However, the lack of a broader environmental or social framework implies that their green self-efficacy is less engaged (Wei et al., 2024). That is, when a product is unlabelled, health-focused messaging may lead consumers to interpret their choice as a purely personal health decision rather than an act of environmental responsibility, thereby weakening the mediating role of green self-efficacy (Berke and Larson, 2023; Hielkema and Lund, 2022).

Taken together, these arguments indicate that green self-efficacy serves as a key psychological mechanism linking vegan labelling and message framing to purchase intention. Specifically, when an uptrend message accompanies vegan labelling, it bolsters consumers' green self-efficacy, thereby diminishing resistance and increasing purchase intention. Conversely, when a health-focused message is presented, green self-efficacy plays a weaker mediating role, particularly when the product lacks explicit vegan labelling. Therefore, we propose the following hypothesis:

H2: Green self-efficacy mediates the effect of vegan labelling and message framing on purchase intention. Specifically, when an uptrend message is paired with vegan labelling, green self-efficacy strengthens purchase intention. However, when a health-focused message is presented, the mediating effect of green self-efficacy is weaker.

3. Pretest

3.1 First pretest

The initial pretest was conducted to select the representative vegan food to be used in the main experiment. We recruited 54 respondents (51.5% female, M_{age} = 30.5) via M-Turk and provided them with a list of six food types (meat, chocolate, protein bars, hummus, jam,

cookies, sausage, and pasta), which were determined based on prior research. Participants were instructed to assume that all listed foods were vegan and then evaluate each item based on two open-ended questions: 'To what extent do you think _____ is environmentally friendly?' Responses were measured on a 7-point Likert scale (1 = 'not at all', 7 = 'very much so').

As a result, plant-based meat (M = 5.38, SD = .95) and protein bars (M = 5.35 SD = 1.01) were perceived as the most vegan-associated foods by consumers, with no significant difference in vegan perception between the two ($t(52) = .26$, $p = .79$). Therefore, these two items were selected as the representative stimuli for the Study 1 (plant-based meat) and Study 2 (protein bars).

3.2 Secondary pretest

3.2.1 Design

The secondary pretest was conducted to validate the manipulation of message types (uptrend vs. health-focused) and idenfity participant's product attitude according to labeling absence (vs. presence). A second preliminary survey recruited 75 respondents (58% female, $M_{age} = 29$) via M-Turk. Participants were first shown images of vegan food products (with label vs. absence), then read a scenario designed to manipulate the message type, and were subsequently asked to respond to the measurement items.

3.2.2 Measurement

The measurement of product attitude was based on Wang et al. (2008). It included three items ('I like this product', 'I feel favourable towards this product', and 'I prefer this product') rated on a scale from 1 (extremely disagree) to 7 (extremely agree).

The uptrend message and health-focused message were measured based on open-ended questions. The measurement item for the uptrend message was: 'To what extent do you think plant-based alternative meat (plant-based protein bar) is being adopted by people?', whereas the measurement item for the health-focused message was: 'How healthy do you perceive plant-based alternative meat (plant-based protein bar) as a food item?'. All responses were measured on a 7-point Likert scale (1 = 'not at all', 7 = 'very much so').

3.2.3 Results

Our results indicate that consumer attitudes towards vegan-labelled food (both plant-based meat and protein bars) were lower compared to when the same products were presented without

a vegan label (Meat: M_{label} = 2.93, SD = .88, $M_{w/olabel}$ = 4.0, SD = 1.01, t(73) = 2.06, p < .05; Protein: M_{label} = 2.38, SD = .94, $M_{w/olabel}$ = 4.10, SD = 1.20, t(73) = 2.7, p < .05). Therefore, similar to previous studies (e.g. Berke and Larson, 2023), we confirmed that there exists a slightly negative perception towards vegan labelling, thereby validating the premise of our hypothesis.

Furthermore, when the uptrend message was presented, participants' perception that more people are adopting a plant-based diet was stronger than their perception of its health benefits ($M_{uptrend}$ = 5.51, SD = .87, $M_{healthy}$ = 4.20, SD = 1.11, $t(73) = 1.99$, $p < .05$). Conversely, when the health-focused message was presented, participants perceived plant-based food as healthier rather than associating it with a growing trend ($M_{healthy}$ = 5.64, SD = .94, $M_{uptrend}$ = 4.23, SD = .91, $t(73) = 2.12$, $p < .05$). These results confirm that the stimulus manipulation was effective.

4. Study 1

4.1 Design

Study 1 aimed to verify whether vegan labelling elicits negative reactions for the two vegan food products selected in the initial pretest (ensuring alignment with the study's premise) and to confirm the effect of vegan labelling and message type on purchase intention towards vegan products. To accomplish this, we employed a between-subjects design of 2 (labelling: vegan vs. absence) x 2 (message type: uptrend vs. healthy-focused). Based on the pretest results, a plant-based alternative meat was selected as the product type. Additionally, we applied the message type used in the secondary pretest. Finally, a total of 281 respondents (55% female, M_{age} = 31.1) were recruited via Macromill Embrain, a professional research company based in Seoul, Korea.

4.2 Procedure

Study 1 proceeded as follows. First, respondents were randomly assigned to one of the four stimulus conditions. To exclude inattentive respondents, they were required to accurately report the number of vegan labels presented on the stimulus. In the second stage, participants answered questions measuring their perception of the adoption rate (for the uptrend message) or health focus (for the health-focused message). Subsequently, they responded to questions measuring their attitude towards the product. Next, participants reported their purchase intention for the vegan food product presented in the stimulus and provided an estimate of their expected spending amount. Finally, the survey concluded with questions regarding the

respondents' demographic characteristics.

4.3 Measurement

Study 1 measured the number of vegan labels, perceived adoption, and perceived health focus as single items, consistent with the pretest, and assessed the three components of product attitude (Cronbach's α = .819). Additionally, the dependent variable was set as purchase intention (Cronbach's α = .906) was each measured using three items adapted from Kim and Tanford's (2021) study ('I want to purchase this product', 'I am willing to buy this product', and 'I intend to buy this product in the future').

4.4 Results

4.4.1 Manipulation check

The analysis was conducted with 262 respondents, excluding those who provided insincere responses or inaccurately reported the number of vegan labels in the stimulus. To examine the manipulations of message type, a t-test revealed significant differences in perceived uptrend and healthy focus (Uptrend message: $M_{uptrend}$ = 5.41, SD = 1.12, $M_{healthy}$ = 3.59, SD = 1.19, $t(132) = 55.25$, $p < .05$; Health-focused message: $M_{healthy}$ = 5.10, SD = 1.22, $M_{uptrend}$ = 3.60, SD = 1.3, $t(128) = 47.34$, $p < .05$). Furthermore, consistent with the pretest's results, participants exhibited a diminished attitude towards vegan-labelled plant-based meat compared to when the same products were presented without a vegan label (M_{label} = 3.88, SD = 1.45, $M_{w/olabel}$ = 4.28, SD = 1.26, $t(260) = 2.35$, $p < .05$), thereby confirming the fulfilment of the conditions for serendipity.

4.4.2 Hypothesis testing

A two-way analysis of variance (ANOVA) was conducted to test H1 ($F(3, 261) = 3.39$, $p < .01$), revealing a significant main effect of labelling ($F(1, 261) = 4.31$, $p < 0.05$). A one-way ANOVA confirmed that respondents who viewed vegan-labelled products had lower purchase intention compared to those who viewed products without vegan labelling (M_{label} = 3.78, SD = 1.39, $M_{w/olabel}$ = 4.11, SD = 1.14, $t(260) = 2.08$, $p < .05$).

Furthermore, the interaction between labelling and message type was significant ($F(1, 261) = 5.55$, $p < .05$). When uptrend messaging is emphasised, labelling does not significantly affect purchase intention for vegan products (M_{label} = 4.60, SD = 1.24, $M_{w/olabel}$ = 4.64, SD = 1.34; $F(1, 128) = .03$, $p = .84$). Contrastingly, when health benefits are emphasised, the purchase

intention for products with vegan labelling is lower than those without ($M_{w/olabel}$ = 4.34, SD = .99; M_{label} = 3.64, SD = 1.44; F(1, 131) = 10.38, $p < .05$). This indicates that purchase intention for products with a vegan label will be slightly lower than for those without one, and positing that message type serves as a moderating factor, thus supporting H1.

4.5 Discussion

Study 1 focused on plant-based alternative meat as the product category for the experiment. It examined the influence of the presence or absence of vegan labelling and message type on purchase intention. Ultimately, we found that the main effect of vegan labelling is that consumers generally exhibit lower purchase intention when they recognise the presence of a vegan label. However, this effect was mitigated when an uptrend message was included in the advertisement, suggesting that framing vegan food as part of a growing trend can counteract the negative perception of vegan labelling. Additionally, we found that health-focused messaging was more effective for products without vegan labelling. In other words, the negative effect of vegan labelling was not offset by a health-based message, indicating that while health-focused messaging may encourage purchases, it is not sufficient to overcome resistance to vegan-labelled products.

5. Study 2

5.1 Design

Study 2 examines the results of Study 1 using another product stimulus. Additionally, it aimed to verify the mediating effect of green self-efficacy. To achieve this, we employed a 2 (labelling: vegan vs. absence) × 2 (message type: uptrend vs. healthy-focused) between-subjects design. Message type from the previous experiment was adapted to a protein bar setting. We analysed responses from 270 participants recruited via Macromill Embrain and excluded unreliable data, resulting in 259 valid participants (54.4% female, M_{age} = 32.2).

5.2 Procedure

Similar to Study 1, Study 2 presented two message types (uptrend vs. healthy-focused) for participants to recall comparable experiences. As in Study 1, all respondents were assigned to one of the four stimulus conditions. Participants answered questions measuring their perception of the adoption rate (for the uptrend message) or health focus (for the health-focused message). In that context, they responded to questions measuring their attitude towards the product. In

the third stage, respondents' intention to purchase vegan food was assessed, with their green self-efficacy acting as a mediator. Finally, the survey concluded with the demographic characteristics of respondents.

5.3 Measurement

Study 2 evaluated the perception of the adoption rate, health focus, and attitude towards the product using similar items as those in the pretest. Additionally, green self-efficacy was evaluated with three items (Cronbach's α = .861). Intention to purchase vegan food (Cronbach's α = .893) was assessed similarly to Study 1. The utilitarian and hedonic values of individual items were rated using a 7-point Likert scale (1 = 'extremely disagree', 7 = 'extremely agree'). The mediating variable of green self-efficacy was measured using three items (e.g. 'When you see the reward (the toothbrush set or the chocolate box) in this store, I feel extremely lucky'; Cronbach's α = .878), referring to the items utilised in Liu et al. (2022), and it was assessed using a 7-point Likert scale. Finally, purchase intention was measured using a single item.

5.4 Results

5.4.1 Manipulation check

The analysis included 238 respondents, excluding those who provided insincere responses or inaccurately reported the number of vegan labels in the stimulus. To examine the manipulations of message type, a t-test was applied and it revealed significant differences in perceived uptrend and healthy focus (Uptrend message: $M_{uptrend}$ = 5.36, SD = 1.23, $M_{healthy}$ = 3.77, SD = 1.27, $t(120) = 11.68$, $p < .05$; Health-focused message: $M_{healthy}$ = 5.07, SD = 1.22, $M_{uptrend}$ = 3.52, SD = 1.21, $t(116) = 10.66$, $p < .05$).

5.4.2 Hypothesis testing

A two-way ANOVA was performed to test H1 ($F(3, 237) = 3.02$, $p < .01$), revealing a significant main effect of labelling, consistent with Study 1. A one-way ANOVA confirmed that respondents who viewed vegan-labelled products had lower purchase intention compared to those who viewed non-labelled vegan products (M_{label} = 3.78, SD = 1.38; $M_{w/olabel}$ = 4.14, SD = 1.05, $t(236) = 2.22$, $p < .05$).

Additionally, the interaction between labelling and message type was significant ($F(1, 237) = 3.91$, $p < .05$). When uptrend messaging was emphasised, there was no significant difference in the impact of labelling on purchase intention for vegan products (M_{label} = 4.01, SD = 1.13;

$M_{w/olabel}$ = 3.97, SD = 1.33; F(1, 116) = .02, p = .88).

Contrastingly, when health benefits were emphasised, purchase intention for products with vegan labelling was lower than those without ($M_{w/olabel}$ = 4.27, SD = .96; M_{label} = 3.60, SD = 1.42; F(1, 120) = 8.87, $p < .05$). This indicates that purchase intention for products with a vegan label was slightly lower than for those without one, and message type served as a moderating variable, thus supporting H1.

To confirm the mediating effect of green self-efficacy, we used the bootstrap method (Process model 8) for mediation analyses (Hayes, 2017). The interaction effect on spending intention was significant (β = .4761, CI [.0596, .8926]) and had a positive influence on green self-efficacy (β = .7645, CI [.3121, 1.2171]). The significant indirect effect of green self-efficacy was also confirmed (β = .4544, 95% CI [.1624, .7752]).

Therefore, these results support H2, which posits that the interaction between labelling and message type influences consumers' purchasing intention towards vegan food through green self-efficacy.

5.5 Discussion

Study 2 was conducted to change the product stimuli used in the experiment and verify the mediating effect of green self-efficacy. Using vegan protein bars, the study demonstrated an interaction effect between labelling and message type, mirroring the pattern found in Study 1. The indirect effect of green self-efficacy was found to be significant. Therefore, it was confirmed that the influence of the interaction between vegan labelling and message type on vegan food purchase intention is driven by the psychological mechanism of green self-efficacy.

6. Conclusion

6.1 Theoretical implications

Based on our results, we provide the following theoretical implications. First, our study addresses the negative aspects of vegan labelling to identify unresolved consumer biases and persistent barriers in vegan food purchases amid the continued growth of the vegan food industry. Several studies have explored the factors that encourage consumers to adopt vegan foods, typically citing environmental concerns, animal welfare, personal health, and ethical considerations as key motivations. Furthermore, research on the effects of vegan labelling has produced mixed findings, exhibiting both positive and negative influences, making it challenging to develop a comprehensive understanding of the vegan food industry. This study

extends prior research on the negative effects of vegan labelling and expands the understanding of vegan food consumption by examining how psychological resistance triggered by vegan labelling influences non-vegan consumers. In doing so, this study contributes to enhancing the literature on the effects of vegan labelling.

Second, this study suggests advertising strategies that mitigate the negative effects of vegan labelling to promote vegan food purchases. Specifically, we apply the uptrend effect, also known as the upward trajectory messaging effect to vegan food advertising, examining the impact of social contextual factors in promoting vegan food consumption. In South Korea, the vegan food market is perceived as stagnant, with many consumers unconvinced about the benefits of purchasing vegan food. Against this backdrop, our study is noteworthy as it not only identifies messaging strategies that counteract the negative effects of vegan labelling but also delineates the conditions that facilitate vegan food consumption.

Finally, this study is one of the few that examines the psychological mechanisms underlying consumers' vegan food purchases. In particular, by examining the mediating role of green self-efficacy, we identify key factors that can encourage voluntary vegan food purchases among consumers. While most studies on vegan food purchases have focused on universal motivations, such as ethics, animal welfare, and health, our study takes a different approach. We posit that non-vegan consumers may struggle to find a compelling rationale for voluntarily purchasing vegan-labelled products or may encounter psychological barriers in this regard. Based on this premise, we contend that message framing can mitigate latent resistance, identifying green self-efficacy as the key psychological mechanism driving this process. Ultimately, this finding suggests that voluntary choice and confidence in one's ability are crucial factors in vegan food consumption. By establishing this link, this study expands the existing field of research—which has traditionally focused on general vegan food purchasing behaviour—by providing novel insights into the psychological processes influencing consumer decision-making.

6.2 Managerial implications

This study offers several practical implications for businesses aiming to enhance vegan food consumption via the strategic use of labelling and message type. First, companies should implement trend-based messaging strategies that highlight the increasing popularity of vegan consumption to overcome psychological resistance when non-vegan consumers come across vegan-labelled products. Research demonstrates that when consumers perceive a behaviour as increasingly common and socially accepted, they are more inclined to adopt it (Costello et al.,

2023). This approach can be effectively applied by designing marketing campaigns that highlight the mainstream acceptance of vegan food, integrating uptrend messaging in advertising, and leveraging social proof through influencers and community endorsements. Retailers can also incorporate trend-based messaging into store displays and product packaging, reinforcing the idea that vegan food is not just for vegans but for anyone pursuing a modern, widely accepted lifestyle choice. Brands can break psychological barriers and promote broader consumer adoption by positioning vegan food as part of a social movement rather than a niche diet.

Second, our results indicated that health-focused marketing strategies can effectively stimulate vegan food purchases, even in the absence of explicit vegan labelling. Some consumers prefer health-focused messaging that does not overtly emphasise veganism but instead highlights the nutritional and wellness advantages of plant-based foods. Instead of marketing products as 'vegan alternatives', companies can promote them as 'rich in plant-based protein for heart health' or 'a natural source of essential nutrients'. Additionally, placing vegan products alongside conventional health foods in grocery stores, rather than in a separate vegan section, can normalise their consumption and enhance their appeal to a broader audience. Employing neutral or mainstream branding, instead of overtly vegan branding, can further enhance consumer acceptance. By emphasising health benefits rather than the vegan identity, brands can capture a wider consumer base and stimulate greater market growth in the long term.

Finally, our results indicate that green self-efficacy is crucial in linking social influence to actual purchasing behaviour. That is, consumers who believe that their individual choices can make a meaningful contribution to sustainability are more inclined to engage in voluntary vegan food consumption. This finding suggests that businesses should prioritise enhancing consumer self-efficacy by promoting the idea that their food choices have a direct and positive environmental impact. One approach to achieve this is through interactive educational content, such as sustainability impact calculators or digital tools that enable consumers to measure how switching to plant-based foods benefits the environment. Additionally, branding strategies can reinforce this message by utilising empowering language, such as 'Your choice makes a difference' or 'Every meal contributes to a healthier planet', thus enhancing consumers' confidence in their ability to make sustainable choices. By strengthening green self-efficacy, companies can promote long-term behavioural shifts towards plant-based consumption.

6.3 Limitations and future research directions

This study's limitations provide several suggestions for future research. First, this study focuses on South Korean consumers, whose dietary habits and perceptions of vegan food may differ from those in other cultural and regional contexts. Korean cuisine includes many naturally plant-based dishes, and many consumers maintain a diet that blends meat and vegetables, which may influence their response to vegan labelling in contrast to consumers in Western cultures. Given that vegan food consumption is shaped by cultural norms, social values, and traditional dietary practices, future research should expand to different cultural and regional contexts to enhance understanding of consumer perceptions about vegan labelling and trend-based messaging. Comparative studies across countries with varying levels of vegan market penetration could provide valuable insights into the tailoring of labelling and marketing strategies for diverse audiences.

Second, this study did not specifically account for demographic factors such as sex, dietary habits, prior experience with plant-based food, or levels of health consciousness, all of which could influence consumers' attitudes towards vegan food. Men and women, for example, have been found to exhibit different motivations for plant-based consumption, with men often associating meat consumption with masculinity, whereas women are more inclined to embrace plant-based diets for health and ethical considerations. Additionally, prior exposure to vegan products may minimise resistance to vegan labelling, whereas consumers with little experience may react more adversely to such labels. Future research should incorporate a more segmented approach, analysing how individual differences—such as dietary preferences, eating habits, or psychological traits like openness to change—moderate the effects of vegan labelling and message framing. This would provide more precise marketing strategies tailored to specific consumer segments.

Finally, this study focused on plant-based meat and energy bars as representative vegan food stimuli, which may not comprehensively capture the extensive range of vegan food products available in the market. Vegan food encompasses a wide spectrum of products, from minimally processed whole foods like fruits, vegetables, and grains to highly processed alternatives including plant-based dairy, meat substitutes, and functional snacks. Different categories of vegan food may evoke varying consumer responses, depending on their practical (utilitarian) and hedonic (pleasure-driven) value in consumer decision-making. Furthermore, consumers' willingness to accept vegan food may vary based on their perception of familiarity and necessity—some may be more inclined to try vegan versions of familiar foods (e.g. plant-based burgers) over entirely new product categories (e.g. vegan protein bars). Considering that food

choices are influenced not only by labelling and messaging strategies but also by the functional and experiential attributes of the product itself, future research should explore how different types of vegan food influence consumer decision-making.

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Economic Pressures and Labour Rights: Vietnam's Industrial Relations Evolution

Abstract

This paper investigates the dual economic forces driving Vietnam's approach to labour rights Externally, pressures stem from new-generation free trade agreements (FTAs) like the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the EU-Vietnam Free Trade Agreement (EVFTA), which compel Vietnam to improve labour standards and the ratification of the International Labour Organization's Convention 87 (CO87). Internally, there is significant pressure from the labour force itself, characterised by a rising number of wildcat strikes and grassroots worker militancy. As the result, the new Labour Law that came into effect on 1st January 2021 legalised independent workers' voices through the recognisation of internal employee organisation (IEOs), which are not affiliated to the Vietnam General Confederation of Labour or the Communist Party.

This paper covers Vietnam's strategic balancing act between adhering to international labour standards, preventing external influences on the autonomy of the Communist Party, and maintaining control over independent labour organisations. In practice, there has not been one single IEO established in Vietnam since then. The paper argues that Vietnam's ratification of CO87 will likely lead to superficial compliance. While economic integration pressures Vietnam towards improved labour rights, the authoritarian governance model ensures that any industrial relations (IR) reform will be tightly controlled, preserving the dominance of state-affiliated unions and limiting the potential for independent labour movements. Although the Vietnamese IR landscape has undergone significant changes, fundamentally, its nature remains largely unaltered.

Keywords: Industrial relations, Vietnam, Convention 87, Labour Law 2019, transformation

Introduction

Vietnam's rapid integration into the global economy, underpinned by robust export-driven growth, has compelled significant shifts in the country's' approach to labour rights. Under intensive pressure, both internally as a consequence of workers' agitation and externally from international organisations such as the ILO and members of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), the Vietnamese government has made it legal for workers to establish 'internal employee organisations' (IEOs) - tổ chức của người lao động tại doanh nghiệp - local workers' organisations independent of trade union structures, in the new 2019 Labour Law, which came in effect on 1 January 2021.

The 2019 Labour Law is widely considered as a move towards the ratification of the International Labour Organization's (ILO) Convention No. 87 (CO87), which pertains to the freedom of association and protection of the right to organize. However, the fact remains that as of January 2025, not a single IEO has been established in Vietnam and despite discussions on the ratification of ILO Convention No. 87 starting in 2019 and a commitment to ratify it by 2023, Vietnam has not yet signed the convention.

This paper explores both the internal and external pressures driving Vietnam towards the ratification of ILO's CO87. It delves into the complexities surrounding the country's commitments to international labour standards, particularly in the context of its global economic integration. Is there any potential for a more democratic and participatory approach to industrial relations?

This study is part of a larger investigation into the transformation of industrial relations in Vietnam. The foundation of this paper was a longitudinal research in the garment and textile industry in Vietnam, starting in 2013 and resulting in several publications (Cox, 2015; 2017; Cox and Le Queux, 2023). This research covered issues such as the reforms of the Vietnamese Labour Law, Trade Union laws, employees' working conditions, unofficial workers' representatives (UWRs) and labour conflicts. The research was pursued through a case study strategy. There were two groups of interviewees: inside

the enterprises and outside the enterprises. The first group included management of companies, employees at shopfloor level and trade union officials. The second group included government officials at national and local level administering relevant laws and regulations and overlooking the activities of these companies. They provided the official and, in some cases, unofficial views of the Ministry of Labour, Invalids and Social Affairs (MOLISA), the Vietnamese General Confederation of Labour (VGCL), the Management of the Industrial Zone, in which the enterprises are located, the local Planning and Investment Department, the occupational and industrial trade unions to name but a few. The researchers established a long-term relationship with some key informants allowing for regular updates.

Additionally, the research fieldwork is complemented by documentary and media analysis. Documentary refers to official legal documents such as Labour Laws, Trade Union Laws, different Circulars, Decisions, Guidelines, etc. Media published in Vietnamese include news published on mainstream newspapers, including, but not limited to Báo Người Lao Động (The Labourer Newspaper), Báo điện tử VnExpress (vnexpress), Báo Nhân Dân (The People Newspaper), Tạp chí Bảo hộ lao động (Labour Protection Magazine), Tạp chí Cộng sản (Communist Magazine), Tạp chí Lao động và Công đoàn (Labour and Trade Union Magazine), Việt Nam News, Báo Pháp luật Việt Nam (Vietnam Law Newspaper). In addition to content analysis, the argumentation relies on a broader sociological assessment of workers' demographics, work and living conditions.

The paper structure is as follows. To start with, we provide an overview of the Vietnamese political and economic background, highlighting key developments and the impact of the Doi Moi reforms. We then examine the nature of international pressures, with a focus on global economic integration and international labour standards. Next, we address internal pressures, focusing on domestic factors such as the role of trade unions, workers' militancy and local labour market dynamics, government policies and legislative development. To conclude, we critically discuss the potential of Convention No. 87 in effectively halting the 'race to the bottom' in developing Vietnam.

Political and economic background

After the Vietnam War, followed by the unification of Vietnam in 1975, the country adopted a socialist economic model influenced by the Soviet system. However, this centrally planned strategy failed to deliver the expected outcomes and led the country into economic crises. The second five-year plan, spanning from 1976 to 1980, set ambitious targets, such as 13-14 percent annual growth of national income, 8-10 percent growth in agricultural production, and 16-18 percent growth in industrial production. The results were far below expectations, with actual growth rates of only 0.5 percent, 1.9 percent, and 0.6 percent, respectively (Fforde and De Vylder, 1996: 167). During the 1980s, Vietnam's economy was primarily sustained through aid from the Eastern Bloc. A particularly damaging blow to the economy came with the ill-planned currency reform of 1985, aimed at stabilising the economy but instead resulting in hyperinflation and overwhelming external debt (Drabek, 1990). This crisis prompted a reassessment of economic policies and set the stage for the Đổi Mới reforms.

In 1986, during the Sixth National Congress of the Communist Party, Vietnam formally launched the Đổi Mới reform program, designed to liberalise and deregulate the economy. This marked a pivotal moment in the country's economic development. The reform focused on five key areas: (1) Transitioning to a market economy; (2) Implementing an 'open door policy' for foreign investment; (3) Allowing private ownership across all sectors; (4) Adopting an industrialisation model prioritising light industry and agriculture over heavy industry; and (5) Restructuring and downsizing state-owned enterprises (SOEs) (Tran, 1997). Unlike the rapid and radical reforms in Eastern Europe, Vietnam adopted a slower, more cautious approach, maintaining political control throughout the process (Peng, 2000; Gurkov, 2015). The goal of the reform was not to disrupt the political system, but rather to adapt socialism to changing economic realities without causing a political rupture (Fforde 1999). The core principles of socialism have remained in place throughout the process of the economic reform (Vo 2009). The 1992 Constitution (amended and supplemented in 2001) and the 2013 Constitution still show the embrace of socialism as a long-term goal, emphasizing the leading role of the Communist Party.

The results of the economic reforms are remarkable. Economic reforms since the launch of Đổi Mới in 1986, coupled with beneficial global trends, have helped propel Vietnam from being one of the world's poorest nations to a middle-income economy in one generation. In terms of national income, from the GDP per capita of 95 USD in 1990, the GDP per capita of Vietnam has been steadily increasing to 4,346 USD in 2023 (The World Bank 2024b). In the period from 1990 to 2023, Vietnam scored an average GDP growth of 6.5 percent, remarkably with the highest point of 9.54 percent in 1995 (The World Bank 2024a). Vietnam is now considered as one of the most dynamic emerging economies in the East Asia region (The World Bank 2024d). Vietnam has grown bolder in its development aspirations, aiming to become a high-income country by 2045. To achieve this goal, the economy would have to grow at an annual average rate of about six percent per capita for the next 25 years.

Foreign Direct Investment (FDI) has played a crucial role in Vietnam's economic growth. According to Anwar and Nguyen (2010), FDI has significantly contributed to the expansion of Vietnam's economy by increasing capital and facilitating technology transfer, which has led to substantial improvements in productivity and competitiveness. As of October 30, 2024, the country had 41,720 active foreign direct investment (FDI) projects with a combined registered capital of approximately 496.7 billion USD. Foreign investors have directed their capital into 19 of the 21 sectors within the national economic classification system, with the processing and manufacturing sector attracting the largest share, totaling over 299.8 billion USD and representing 61.2% of the total investment. Vietnam's FDI disbursement reached a record high of about 25.35 billion USD in 2024, reflecting an annual growth of 9.4%, as reported by the Ministry of Planning and Investment's Foreign Investment Agency. The FDI sector contributed roughly 20.49 billion USD to the state budget and played a significant role in exports, achieving an estimated export turnover of 290.8 billion USD, including crude oil, which marked a 12.2% increase compared to the previous year. This sector accounted for 71.8% of Vietnam's total exports and recorded a trade surplus of nearly 49.2 billion USD, effectively offsetting the domestic sector's trade deficit of 25.4 billion USD, resulting in a national trade surplus of 23.8 billion USD

(VietnamPlus, 2025).

FDIs can offer significant advantages for economic development in emerging economies (UNCTAD, 2020). Beyond providing substantial capital inflows, they facilitate the transfer of advanced technologies and managerial expertise, thereby enhancing the productivity and competitiveness of local industries (Dunning & Lundan, 2008). The integration of host economies into global supply chains through FDIs also boosts export performance, contributing to foreign exchange earnings and improved trade balances (Balasubramanyam, Salisu, & Sapsford, 1996). These factors collectively support economic diversification and structural transformation.

However, heavy reliance on FDI poses significant challenges and vulnerabilities, particularly when foreign investors decide to halt new investments, withdraw existing capital, or boycott a destination. The sudden withdrawal of FDI can have immediate destabilising effects on the economy. An outflow of capital may lead to a shortage of foreign exchange reserves, which in turn causes currency depreciation and inflationary pressures. This devaluation increases the cost of imports, reduces consumer purchasing power, and creates broader economic instability (Durham, 2004). Sectors heavily dependent on foreign investment, such as manufacturing and services, are especially vulnerable. The withdrawal of FDI from these sectors can result in significant job loss, slowdowns, and closures (Javorcik, 2004). Moreover, in the event of FDI withdrawal, domestic firms may lack the capacity to fill the resulting void, leading to economic contraction (Campos & Kinoshita, 2010). The long-term consequences of FDI withdrawal are equally severe. It can send negative signals to the global market, portraying the destination as high-risk. This perception can deter other potential investors, creating a cycle of reduced investment leading to weaker economic performance, which further erodes investor confidence (Mody & Srinivasan, 1998). Thus, while FDI provides critical benefits, it comes with risks and requires a balanced approach to ensure sustainable and inclusive economic growth.

External pressure to conform to international labour standards

Since Doi Moi, Vietnam has increasingly integrated into the regional and global economy through joining several key economic associations. It became a member of the Association of Southeast Asian Nations (ASEAN) in 1995, accelerating its integration into regional supply chains and boosting trade flows with ASEAN countries (Dosch, 2006). In 1996, Vietnam joined the ASEAN Free Trade Area (AFTA), reducing tariffs and fostering intra-regional trade, which contributed significantly to its export growth and industrial development (Wong et al., 2017). Vietnam also became a member of the Asia Pacific Economic Cooperation (APEC) in 1998 and, most notably, acceded to the World Trade Organization (WTO) in 2006, marking a critical step in its global integration. In recent years, Vietnam has further expanded its economic ties by joining the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) in 2018, signing the Vietnam-European Union Free Trade Agreement (EVFTA) in 2019, and ratifying the Investment Protection Agreement with the European Union (EVIPA) in 2020. These agreements have been instrumental in strengthening Vietnam's ability to attract FDIs, fostering economic growth, and enhancing its global competitiveness. Unlike old-generation FTAs, new-generation FTAs or FTAs WTO-Plus such as the CPTPP or EVFTA not only regulate trade or tariff issues but also go well beyond trade to address areas sometimes with no relation, at least visible and direct, with trade, such as human rights and freedoms, the environment, the fight against poverty, and labor rights, etc. This shift stems from the perspective of ‘fair trade,’ aiming to prevent a ‘race to the bottom,’ where countries reduce the cost of goods and services by disregarding labor standards or harming the environment.

As Vietnam continues to navigate its integration into the global economy, particularly through its reliance on FDIs, adherence to international labour standards becomes increasingly essential to maintain its competitive edge and foster sustainable growth. In this context, the International Labour Organization's (ILO) Conventions play a crucial role, as they establish globally recognized rules that ensure fair and ethical treatment of workers, contributing to both social stability and economic resilience. These conventions set minimum standards for decent work, addressing a wide range of issues such as the right to form trade unions, engage in collective bargaining, eliminate forced

and child labour, and ensure fair wages, safe working conditions, and social protections (ILO, 2021). For countries like Vietnam, ratifying and implementing ILO Conventions is essential for several reasons. Firstly, compliance with ILO standards helps to improve labour conditions, which can enhance the productivity and well-being of the workforce (Jenkins & Krolikowski, 2015). This is particularly crucial for emerging economies, where modernising labour practices is key to achieving long-term, sustainable development (Chand & Tung, 2006). Secondly, adhering to ILO conventions boosts a country's reputation internationally by signaling to foreign investors and trading partners that the nation is committed to fair and ethical practices, thus making it a more attractive, or say 'respectable', destination for investment (Frynas & Mellahi, 2015). Many trade agreements, including the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), include provisions that require signatory countries to uphold ILO standards, linking labour rights with continued access to international markets (Hoekman & Saggi, 2009). Furthermore, these conventions, in principle, should contribute to promote social stability by ensuring that economic growth does not come at the expense of workers' rights, which fosters more inclusive and equitable development (Rodrik, 2011).

There has been indeed a dramatic increase of trade agreements with labour clauses. According to an ILO study in 2015, only four trade agreements included labour clauses in 1995, but that number had increased to 21 in 2005. By 2013, 58 out of the 248 trade agreements notified to the WTO contained such clauses (ILO, 2015: 17). There is also increasing trend to integrate labour provisions into trade agreements between developing and emerging countries. Commentators have noted how the EU and the US for example, are increasingly willing to exercise power through trade — to use its market power to 'export' its laws, standards, values and norms (as distinct from exercising power in trade, that is, to use market power to secure access to export markets) (Axel Marx et al, 2015; Tham, Joo-Cheong & Ewing, 2016).

The International Labour Organization's Convention 87, also known as the Freedom of Association and Protection of the Right to Organise Convention, is a key international treaty that establishes the right of workers and employers to form and join organisations

of their own choosing without prior authorisation. Ratifying this convention signals a country's commitment to upholding fundamental labour rights, particularly freedom of association and collective bargaining. Vietnam's discussions regarding the ratification of CO87 have been ongoing for several years. A significant milestone occurred in June 2019 when the National Assembly ratified ILO Convention No. 98 on collective bargaining. During this period, the Vietnamese government expressed intentions to ratify Convention No. 87 by 2023 (International Labour Organization, 2021). Further developments were reported in February 2024, indicating that Vietnam planned to ratify Convention No. 87 within the year, influenced by its commitments under trade agreements such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the EU-Vietnam Free Trade Agreement (EVFTA). Despite these intentions, as of early 2025, official ratification has not been confirmed (Reuters).

Notably, Canada is presently evaluating Vietnam's labour standards to ascertain their alignment with the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), to which both nations are signatories. Additionally, Hanoi has assured Ottawa of its commitment to ratify Convention 87 by January 2024—a deadline that has now long elapsed. Failure to meet this deadline might provide Canada with grounds to bring Vietnam before the dispute resolution panel of the CPTPP, potentially resulting in sanctions and penalties against Vietnam.

The European Union has also voiced concerns about Vietnam's labour rights standards within the framework of the EU-Vietnam Free Trade Agreement. A delegation from the European Parliament’s Subcommittee on Human Rights visited Hanoi, from 4th to 6th April 2023, following a previous visit by the subcommittee in 2017. During the visit, members of the European Parliament addressed the human rights situation in Vietnam after the ratification of the EU-Vietnam Free Trade Agreement. The delegation expressed apprehensions regarding the deteriorating human rights conditions in Vietnam, particularly regarding the diminishing space for civil society, the misuse of vague provisions of the criminal code to suppress dissenting voices, the harassment of activists, restrictions on freedom of expression, and violations of freedom of religion and belief. Emphasizing the importance of Vietnam's full compliance with its

international and domestic human rights obligations, the delegation reiterated the EU's offer of increased cooperation with Vietnam to enhance the human rights situation in the country. Furthermore, the delegation urged for the immediate and unconditional release of all political prisoners and prisoners of conscience in Vietnam, including leaders of non-governmental organizations, journalists, and environmental activists. Similarly, in 2022, Vietnam signed the Just Energy Transition Partnership with G-7 countries, which will provide Vietnam with $15.5 billion in funding to assist its green energy transition. Vietnam's imprisonment of organized and high-profile climate activists was a sticking point in negotiations.

Internal pressure: Constrained, under-resourced co-opted trade unions and workers' militancy

Vietnamese workers are represented by the Vietnamese General Confederation of Labour (VGCL). It must be emphasized that the role and nature of trade unions do not conform to the Western liberal-democratic model of unionism in which unions are independent representatives of collective employee interests. Instead, trade unions are subordinated to the Vietnamese Communist Party (VCP), who holds a strong stance on maintaining a "harmonious" relationship with capital.

The subordination of trade unions to the Communist Party and the imperative to maintain harmonious labour relations are enshrined in both the Labour Law and the Trade Union Law. The Labour Law of 2012, which took effect in 2013, reaffirms these principles. The control of the VCP is enshrined in Article 1 of the Law on Trade Unions, which states that: "Trade unions are (...) an integral part of the political system of Vietnamese society under the leadership of the Communist Party of Vietnam". The notion of 'harmonious' labour relations is found in both bodies of legislation. For example, Article 4.6 of the 2012 Labour Law specifies that the objective of the labour law is to "develop harmonious, stable and advanced labour relations".

One of the main tasks of trade unions is to negotiate and sign collective labour agreements (CLAs) with employers and monitor the implementation of these

agreements (Trade Union Law 2013, Chapter 2, Article 11). The exercise of collective bargaining at the workplace level is significantly constrained due to the governmentally centralised 'floor of rights'. The structure and content of CLAs are highly regulated by law: the foundation 1994 Labour Law was divided into component chapters, each dealing with a specific subfield, with was leaving little space for company-level bargaining. The same strict guidelines were upheld in the 2012 Labour Law and then in the 2019 Labour Law 2019. As a result, collective bargaining is a secondary only source of rights and obligations in labour relations after the legislation. The lack of monitoring and weak penalties for violating or not signing CLAs are yet other factors explaining the low number of collective agreements signed. Commonly fines range from $500,000 VND (US$22) for small employers to 20,000,000 VND (US$657) for large employers (Decision 95/2013/ND-CP).

Union activity at local level is also largely limited by a lack of financial resources. This problem, identified by the union apparatus, led to a rebalancing ofincome in favour of local units. The 12th Congress of the Vietnam Trade Union Resolution No. 02-NQ/TW of the Politburo on 'Renovating the organization and operation of Vietnamese Trade Unions in the new situation', states that starting from 2022, trade union funding will be adjusted in the direction of reducing the proportion of funding distribution to upper-level trade union and increasing funding for grassroots trade unions. Specifically, in 2022, grassroots trade unions will be able to use 75 percent of total trade union revenue (in 2021, it was 71 percent) and 60 percent of trade union fees (Ministry of Finance 2021). This is a clear sign showing the Vietnam Communist Party (VCP) acknowledged financial difficulties of trade unions and the government's intention to improve the effectiveness of company-based trade unions.

Trade union officers must be paid from trade union funds (Article 15.3 of the Trade Union Law). However, in practice and in the current framework, it is insufficient to maintain a full-time representation function. Trade union leaders earn their income from their jobs, and the 'supplement' provided by the trade union apparatus is negligible. According to the Law, union leaders should be given six days leave monthly for union duties in companies with more than 150 employees, and three days

below that. Yet, it is reported that companies are not willing to allow any time off and union activities are typically carried out outside working hours.

Burdened by these constraints, the unions are limited to a function of relaying management, occasionally intervening to cool things down. Functionally, the role of trade union officials has therefore remained virtually unchanged since the period of the centralised economy which prevailed until the mid-1980s. Rather, their focus has changed: the function of supporting Party cadres has been replaced by that of supporting management. It is into this representative vacuum that workers' collective action developed.

The weaknesses of the system, from the lack of effective trade union representation to deficient inspection and enforcement mechanisms, are well known and the need to address them has always been controversial within the VCP. On the one hand, Vietnam, like most countries in the South Asian region, needs foreign investment for its development. In order to attract international capital, the country provides a reservoir of low-wage labour and a legal framework where it can be exploited without too many problems. Thus, as elsewhere, the 'pacification' of industrial relations (Ford and Gillan 2016) is a strong imperative. However, the rapid and uninterrupted growth in the number and extent of 'wildcat' or illegal strikes in the sense that they are not conducted by unions is worrying investors, who are putting pressure on the government to put a halt to industrial disturbance. Mounting industrial conflict is not new: it has been going on for years. Siu and Chan pointed out in 2015 that Vietnam was the most strike-ridden country in the region. It was recently stated that the resulting instability was such that it undermined the business climate and social order (Vu and Tran 2021).

Yet, as Do (2016) notes, while the government is concerned with economic development, political stability is the priority. The VCP sees strike movements as undermining its credibility: the failure of the Communist Party and its trade union apparatus to reflect the difficulties of workers and to reflect the concerns of the working class is ideologically and politically dangerous, to the extent that the question

of recognising the latter is causing strong divisions within the Party (Ha Linh 2022). Should the situation getting out of control, it could open the field to forces hostile to the Party leadership and pave the way to political upheaval. Reforming trade unions to effectively address workers' demands and mitigating industrial conflicts has thus become unavoidable and an urgent item on the Party's agenda.

Tran (2020) provides a portrait of labour disputes, with a focus on foreign multinational companies, where three quarters of these disputes occur. The textile sector alone accounts for almost half of the conflicts recorded, followed by the footwear and leather sector for almost a quarter. The nature of militant activity in the Taiwanese- and Korean-owned companies dominant in these sectors has been detailed in previous research (Cox 2015).

Remarkably, all the strikes taking place are strikes being led by unofficial representatives, therefore all illegal in the sense that unions are not involved (Tran, 2020). The majority of these are short strikes, lasting between one and three days, and it has been found that workers are successful in 90 percent of cases (Schweisshelm and Do, 2018). They can extend to an entire industrial cluster, depending on the coordination of the informal activist networks involved (Do 2017).

It is estimated that in 80 per cent of cases they concern immediate working conditions (wages, working hours, overtime pay, etc.) as well as employer abuse. These strikes could be avoided, according to Tran (2020: 87, 90), if the parties knew how to negotiate with knowledge of and respect for the law. There are different views on whether the conflicts are more about material interests or rights violations. Clarke and Do (2007) argue that there was a shift towards interest-based strikes where workers struck for higher than government regulated payment. Cox (2017) observed however that these strikes, although appearing to be interest-based on paper, in fact remained right-based, as the government regulated minimum salary level is sub-standard. Tran (2012) claimed that the export-oriented textiles and garments industry may have created employment, but most workers do not earn a living wage. This statement is backed up by numerous reports on the Vietnamese media, newspapers and surveys (for instance, refer to

vnexpress 2022a-b). There is thus a strong correlation between inflation, the determination of the minimum wage and the frequency of strikes. Despite a slowdown in protests, spontaneous strikes still account for most industrial actions (ASL Law, 2025).

Besides, as stated earlier, the violation of rights reflects the lack of inspection services and the weakness of sanctions: in 2014, there were only 50 labour inspectors for over 100,000 companies in Ho Chi Minh city. If these inspectors visited one factory every day of the year, including weekends and holidays, they would only be able to inspect around 18 percent of all enterprises a year. As mentioned, even when inspectors uncover a violation, the sanctions are not punitive. Exceeding the working hour limit or obstructing union establishment causes a fine of maximum 20 million dong (US$1,265).

According to Article 208 paragraph 4 and 5 of the Labour Law, it is forbidden to punish or discriminate against employees involved in a strike. However, we observe, with Weil (2014), that management tactics oscillate between disguised sanctions (e.g. a change of working hours or position, but which can go as far as dismissal in spite of the law) and forms of bribery (promotion or salary increase) aimed at buying off activists or tainting the trust placed in them.

The 2019 Labour Law: legalising independent workers' voices

After much debate, the new 2019 Labour Law (Bộ luật Lao động 2019) was approved by the National Assembly of Vietnam, taking effect in 2021. This marked a significant step in domestic labour reform, which ran parallel to Vietnam's broader objective of aligning its labour standards with international norms, particularly its intention to ratify ILO Convention No. 87 on Freedom of Association and Protection of the Right to Organise. Its preamble reinstates the stereotypical rhetoric of 'harmony' between the parties, echoed in Article 4.7, which states that this principle applies, as state policy, to social dialogue, collective bargaining and labour relations alike. But remarkably, for the first time since the establishment of the Socialist Republic of Vietnam, the legislation

recognises that official local workers' representative bodies now include both local trade unions and IEOs (*tổ chức của người lao động tại doanh nghiệp*), not affiliated to the Vietnam General Confederation of Labour (VGCL) or the Communist Party (Labour Code 2019, Chapter XIII). This new legislation thus breaks with Article 3.4 of the previous legislation which, in line with the Labour Code of 1994, specified that only trade unions affiliated to the VLGC could assume the function of collective representation at the local level, or by the higher level of the trade union structure in non-unionised settings.

In this new legislation, IEOs are defined as worker representative entities at workplace or enterprise levels. The legislation details the parameters of local collective representation in a series of provisions:

Article 172. Establishment, participation and operation of internal employee organisations;

Article 173. Management board and members of internal employee organisations;

Article 174. Charter of internal employee organisation;

Article 175. Prohibited acts by the employer regarding the establishment, operation of and participation in representative organisations of employees;

Article 176. Rights of members of the management board of a representative organisation of employees;

Article 177. Obligations of the employer to the representative organisation of employees;

Article 178. Rights and obligations of the representative organisation of employees in labour relations.

Articles 172 to 174 relates directly to IEOs and 175 to 178 are concerning both official unions and IEOs as representative organisations. Article 178 is important in substance

because it gives IEOs the right to engage in collective bargaining, to take strike action (within the framework of the law on strike action) and to ensure the enforcement of rights, including the inspection of compliance with statutory or negotiated working conditions (hourly rates, pay scales, reward policies, etc.). Overall, the new legal provisions make that IEOs and trade unions have, technically, an equivalent legal status in terms of rights and obligations in the legitimate representation of employees' rights and interests in labour relations. As such, the legislation extends the freedom of association of workers outside the party boundaries, with the choice of either joining a VGCL union or setting up their own representative organisation. Importantly though, unlike VGCL unions, IEOs are identified as being social organisations, to the exclusion of any broader political and economic function.

At the time when debates and deliberations on freedom of association were underway, Tran and Bales (2017) were considering that allowing workers to associate in organisations independent of the CGCL (and therefore not subordinate to the Party) was a 'significant' step in the right direction and a 'positive sign of rapid progress in labour reforms'. The question was however as to whether activists and UWRs will engage into the new legal framework. It is noteworthy to recall that since 1st January 2021, there has not been one single IEO established in Vietnam. Buckley (2021) identifies several obstacles to this. Firstly, he argues that it is not clear that the legislation allows for capacity to act beyond the local company level, thus preventing sectoral or regional coordination which prove to provide considerable leverage to workers' collective action. This point is corroborated by Ca Dao (2019), who sees it as a factor that would weaken independent local organisations and hinder their growth. While unions are allowed (and supposed) to intervene in labour policy debates at all levels, (national and organisational levels), IEOs, in contrast, are only allowed to do so at the enterprise level. Ca Dao (2019) goes further, arguing that the Vietnamese government is trying to constrain the capacity of grassroots activism. While Article 178 allows IEOs to engage in strike action, the provisions around the right to strike in article 198 of the Labour Law applies to all representative bodies: IEOs must therefore abide by the same legal and technical constraints as trade unions (Articles and 200, 201 and 202). There are

many hurdles surrounding the right to lawfully strike: to start with, engaging in mediation is required; if mediation fails, a court must authorise the strike. Strike actions require a five days' notice. Prior to the strike, a list of claims must be displayed, and a ballot must be organised and obtain a majority vote.

Besides, one of our interviews conducted in Ha Noi with the Vietnam General Confederation of Labour in December 2023 revealed that IEOs can hardly be formed in practice, at least for now. The Labour Code lacks specific provisions outlining the fundamental administrative steps necessary for establishing and registering IEOs. It does not specify the documents to be completed or the government office responsible for their submission. While a decree elucidating and legislating such procedures was anticipated to be issued in 2020, it has yet to materialize as of December 2024.

Buckley (2021: 79) concurs with Ca Dao and reaches the conclusion that "rather than being a progressive step forward, freedom of association reforms were an attempt to reduce labour militancy". Added to this is the fact that if the CGTV unions decide to pick up the game - and there are indications that under pressure from the Party they will be more vocal, particularly on wages and occupational health and safety - it is unlikely that IEOs will be able to compete in the absence of the resources and external structures that the official unions enjoy. It is instead likely that workers representative organisations will be absorbed by the CGTV to become unions themselves. Chapter XIII of the 2019 Act provides for this scenario.

There are other sociological factors to consider. Wildcat strikes allow for *ad hoc* mobilisation, fast and responsive to shop-floor realities. The transition from a spontaneous, *ad hoc* mode of collective action to the setting up of structures may turn out to be problematic, without organisational skills - these are workers with low levels of education - it also entails the risk of exposing the militants. Informal leaders generally choose not to expose themselves publicly for fear of reprisals (Tran 2020: 89).

Moreover, it is not certain that setting up structures is useful since the tactic of direct-action works. And according to recent news releases, it seems that to date workers

persist in conducting such tactic (https://bit.ly/3BDC0Kn). Activists manage to mobilise workers effectively, and collective action makes it possible to satisfy their demands, sometimes with the benevolence of union officials, who are themselves employees, who may incidentally benefit from the gains obtained by the strike; the downside of it, however, if that these gains do not find inscription into collective agreements.

It should also be noted that this is usually a transitional workforce. In the case of the textile and garment factories analysed by Cox (2015), 70-75% of the workers are migrant workers who change jobs regularly in search of better pay and return to their home region as soon as they have earned enough money to buy a piece of land or open a small business. For many, they had to leave their families behind because of the constraints of the residence permit system (*hộ khẩu*). It is also common for them to give up their work seasonally to help with agricultural work, as highlighted by Do (2012) in her report to the ILO. Thus, the turnover rate of the workforce is high and does not facilitate the maintenance of a stable structure. Likewise, the existing informal movements lack stable leadership as a result. Last, Tran (2020: 88) denotes a 'cultural' factor: Vietnam is home to a long tradition of underground organising and revolutionary culture, a tradition of informal actions outside the legal framework known as the '*Le*' (autonomous ruling) (Tran, 2013; Däubler, 2018), upon which workers - mostly migrants sharing a community of existence and a strong identity bond - can easily be mobilised in a 'guerrilla spirit' and where informal leaders find legitimacy.

Prospects

It is unavoidable that when Vietnam will eventually sign CO87, domestic laws will have to be further adjusted and amended, especially the content of the 2019 Labour Law and the highly anticipated 2025 Trade Union Law (which replacing the 2012 one). Some degree of collective pluralism at the grassroots level is inevitable. However, Vietnam has long insisted that the process of participating in CO87 must satisfy both the requirements of the Convention and be in harmony with 'unique national factors'. So, the fundamental question really is *how will Vietnam internalize CO87*? What

conceivable space and modus-operandi for genuine workplace pluralism and independent unionism to thrive?

Vietnam has a long political tradition of collective leadership and power sharing among its most senior party leaders. Nguyen Phu Trong was elected as the Communist Party of Vietnam (CPV)'s General Secretary in 2011 and 2016. In 2021, he was re-elected, becoming the third leader of Vietnam to ever secure a third term (after Hồ Chí Minh and Lê Duẩn). CPV is exceedingly on guard and will keep a close eye on the development of IEOs. The Communist Review, which is the official organ of political theory of the CPV's Central Committee (2021) states that the introduction of IEOs has the potential to affect many aspects of the political life of the country and sees the need to 'control' the development of workers' representative organisations, especially in enterprises with foreign direct investment and enterprises outside the state sector. To do so, the Communist Review emphasizes two main strategies: reforming and strengthening trade unions and restricting IEOs' activities at the level of individual enterprises. In their own words, the Communist Review (2022) advises that 'it is necessary to have a good solution to control the scope of operation of IEOs in terms of space (within each enterprise) and activities that must be limited in labour relations. Do not allow these organisations to develop into political forces, especially opposing political forces'.

Ratifying CO87, the constraints on forming independent trade unions will not stem from an institutional framework but from an operational one. Vietnam's one-party system rigorously oversees independent organizations across various civic domains, including religious entities, educational institutions, non-governmental bodies, climate advocacy factions, and labour unions. Despite facing criticism from Western entities and ratifying UN conventions, this grip on control is unlikely to loosen. At the end of the day, Vietnam still holds certain cards in these negotiations. When Vietnam adheres to international standards on the surface, its attractiveness as a burgeoning manufacturing center adjacent to China, with competitive labour costs, is poised to increase. Simultaneously, its broader geopolitical importance for Western countries amid escalating tensions with China is also expected to provide further leverage.

Incidentally, according to several high-profile outlets, the CPV has issued a broad-ranging directive calling for further restrictions against the activities of civil society groups, including trade unions, and increasing scrutiny of foreign organizations and Vietnamese nationals traveling abroad. The document, known as Directive 24, issued in July 2023, was obtained by Project88, a Bangkok-based human rights organization focused on Vietnam. While the organization was unable independently to verify the authenticity of the directive, references to it in several CPV media outlets suggest that it is genuine. As it stated in Project88's English translation, in the Directive 24, the CPV stated 'The comprehensive and deep international integration and implementation of trade agreements has created new difficulties and challenges for national security.' This has provided openings for 'hostile and reactionary forces' to 'increase their sabotage and internal political transformation activities… forming 'civil society' alliances and networks, 'independent trade unions,' creating the premise for the formation of domestic political opposition groups.' As such, Directive 24 calls for increased scrutiny of people taking advantage of international commitments that Vietnam has made to mobilize and form opposition political organizations that implement 'color revolutions' and 'street revolutions.' It is noted that by law, any social unrest that threatens the integrity of the communist regime will be promptly suppressed by the forces of law and order (article 209 of the Labour Law).

Activists have gathered force and can accumulate pressure and strategically coordinate strikes in several companies at the same time in a particular industrial zone or a province. The CPV harbors fear that if they can gather external support, UWRs and IEOs can undermine and potentially overturn the communist regime. Thus, it is predicted that UWRs and IEOs emerging leaders, if any, will be closely watched, and a range of outcomes can be envisaged including the likeliness that they could become themselves co-opted and operate as the 'eyes and ears' of the unions, thus turning into a strategic tool from the Party's point of view in order intervene to prevent the spread of conflicts.

Conclusion

External pressures on Vietnam are primarily a consequence of the country's commitments under new-generation free trade agreements (FTAs), such as the CPTPP and the EVFTA. These agreements impose stringent labour standards that underlie significant reforms in labour policies. The CPTPP and EVFTA mandate adherence to core international labour standards, including freedom of association and the right to collective bargaining, which are fundamental to Convention 87. Compliance with these standards is essential for Vietnam to secure the trade benefits associated with these agreements, thereby enhancing its competitive edge in the global market. This strategic positioning is particularly crucial in a global economic landscape where multinational corporations are increasingly scrutinising labour practices in their supply chains. Improved labour rights, at least on paper, serve to bolster Vietnam's image as a responsible and attractive investment destination.

Internally, Vietnam has faced mounting pressure from its labour force, evidenced by a surge in wildcat strikes and increased worker activism at the grassroots level. These spontaneous and often unorganised strikes highlight the growing discontent among workers over issues such as low wages, poor working conditions, abusive treatment, and limited avenues for genuine labour representation (International Trade Union Confederation, 2012; Cox, 2015). This domestic pressure has compelled the Vietnamese government to reconsider its rigid stance on labour rights and explore reforms that could mitigate labour unrest while maintaining socio-political stability.

The ratification of CO87 is marking a pivotal moment. However, we argue that Vietnam's adherence to CO87 is likely to be merely tokenistic in nature and only result in superficial compliance rather than bringing about substantive changes in labour rights. This posits that the expected economic benefits of CO87 are unlikely to translate into meaningful improvements in labour representation or working conditions. While trade agreements and economic integration exert pressure for better labour standards, there is reason to believe that reforms would ultimately be implemented in a manner that safeguards the CPV's political interests and restricts genuine labour autonomy.

The situation reflects a broader dilemma faced by many developing nations. While the ratification of international conventions can position Vietnam as a more attractive destination for foreign direct investment, it does little to challenge the structural dynamics of global trade, where competition still often revolves around reducing labour costs to remain competitive in global value chains. Priority given to short-term economic growth and investment inflows over the long-term well-being of workers perpetuate a pattern of economic development tied to exploitation rather than sustainable, equitable growth.

In a nutshell, the dual forces of external pressures and domestic labour activism, compels the State to a complex and cautious balancing act of accommodation. The ratification of CO87 is in principle a significant step towards aligning with global labour standards, but its impact on the ground is likely to be constrained by entrenched political and institutional barriers and thus not turn out to be the catalyst expected for industrial democracy and fundamental reforms needed to break the cycle of inequality and exploitation. As Vietnam navigates this intricate landscape, the interplay between economic integration, workplace activism and authoritarian governance will continue to shape the evolving facture of labour rights.

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Institutional Change and Rigidities during the Greek Sovereign Debt Crisis – a Proposal for an Assessment Model of an Economic Adjustment Programme

Mikhail Raev[1]

Resume

The paper surveys how the decisions of the political, social, and economic elite determine the success or failure of the Economic Adjustment Programmes agreed upon between the Greek government and the Troika between 2010 and 2018. The author develops a theoretical framework that connects several fields within the economic and social sciences, such as fiscal sustainability, institutional economics and elite theory. This endeavour resulted in a model that assessed the public positions of key political, social, and economic actors who collectively exercised power over the future Programme's outcomes. It also explained the reasons for Greece's incentives to sign three Economic Adjustment Programmes. Greece could not trade its bonds at the international financial markets for approximately nine years. The Programmes enabled the government to implement institutional changes in the fiscal regime, public administration, and other organisations and rules with lesser budgetary impact from 2015 onwards. At the same time, the government introduced many new formal institutional rules and organisations to administer a positive economic outcome. Focusing on the elite in the decision-making process of formal institutional changes allows for explaining the gradual removal of PASOK from power and the severance of the strong connections and interdependencies between the trade unions and the government, thus enabling the new political parties that formed Tsipras's government to introduce the agreed reforms from 2015 onwards. Along with PASOK, the leaders of the trade unions lost social worth as the ranks of their members shrunk due to the closing of many large industrial production plants since the 1980s. In this sense, their public roles and position gradually lost their significance in the 2010s. Hence, this transformation in the political and social elites allowed for an extreme fiscal and institutional change which the Third Economic Adjustment Programme had introduced in Greece.

Keywords: Greek Sovereign Debt Crisis; Economic Adjustment Programmes; elites and political decision-making process

JEL classification: H8; Z1

Introduction

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The Greek sovereign debt crisis exposed significant problems with the European Union's institutional and fiscal policy governance. A plethora of issues came to light, and many factors were to be held responsible: flaws in national statistical accounting, supervision and reporting to the Eurostat; international credit agencies' culpabilities; the agency of international investment banks; the enormous shadow economy and the undeclared incomes that resulted in unpaid taxes and social and pension contributions; the malfunctioning pension system and innumerable cases of fraud that permit many retirees to receive several pensions; the enormous state administration that drenched the public resources; last but not the least the corrupted politicians and trades union leaders. Of course, the remedies were considered the opposites of these problematic issues, including many austerity policies that provoked heated debate and agitation in Greece and the European Union.

The Greek sovereign debt crisis affected not only the Greek economy, society, and politics but also several member states of the European Union, including Portugal, Spain, and Cyprus. Its side effects included increases in the risk premiums of the Italian and French government bonds. Much has been written about the Greek economic, social, and political transformation, as well as the European response, the spill-over effects, and offsetting. I have not read many answers as to why the Greek Sovereign Debt crisis continued from May 2010 to August 2018, or why it took three Economic Adjustment Programmes for Greece to return safely to the international financial markets. While the state of the economy and the scope of economic reforms were scrutinised, political leaders made decisions regarding state budget spending, cutting, adopting or opposing the implementation or scope of each reform proposal. Hence, a sociological approach is welcomed, and Kevin Featherstone and Dimitris Papadimitriou offered their first study in this respect (Featherstone - Papadimitriou, 2024).

Aims

The paper aims to examine the explicit interconnection between the various social groups and the status group — to use Max Weber's term — that makes political decisions and determines the success of the EC/ECB/IMF Economic Adjustment Programmes negotiated by international lenders with a developed European country. To address this issue, the paper will bridge several fields of economic and social sciences. In the second place, the paper will offer a model for assessing the viability and success of the EC/ECB/IMF Economic Adjustment Programmes. The model will identify the key actors who make or influence the final political decisions to implement any agreed-upon terms. The model will build upon several studies examining

institutional change in social and economic frameworks. It will be applied to the success prospects of these programmes signed by Greece.

State of research

Most scholars consider Greece's default on its sovereign debt in May 2010 an inevitable consequence of several political, social, and economic rigidities and deficiencies that had troubled the Greek economy and politics for decades. Scholars pay attention to various macroeconomic disbalances such as the deteriorated fiscal sustainability, enormous public debt-to-GDP ratio, widespread tax evasion, a generous pension and social security system, vast state administration, and abuse of Greek and European subsidies to support private consumption and business investment (Akram et al. (2011); Alogoskoufis (2012); Arghyrou and Tsoukalas (2011); Kollintzas et al. (2011); Lapavitsas (2019); Mitsopoulos and Pelagidis (2011b); Nelson et al. (2011); Reinhart and Trebesch (2015); Zestos (2016)). Several studies outline labour market rigidities that adversely affected the competitiveness of the Greek economy (Boukalas and Müller (2015); Bozani and Drydakis (2015); Theodoropoulou (2016)). Other researchers examined tax evasion as a possible cause of Greek fiscal unsustainability (Matsaganis and Flevotomou (2010); Mitsopoulos and Pelagidis (2011a)).

Additionally, the development and effects of the Greek sovereign debt crisis inspired many scholars to address issues related to national statistics (Sturgess 2010, Bitzenis&Makedos 2013); international credit agencies' culpabilities (Alsakka et al, 2011; Alsakka & Gwilym, 2013; Gaillard 2013), the agency of international investment banks (Arghyrou & Tsoukalas, 2011); the malfunctioning pension system and innumerable cases of fraud (Tinios &Lyberaki 2012); the enormous state administration (Ladi, 2012); and the corrupted politicians (Andresen 2020).

Theoretical framework

Given Greece's membership in the Economic and Monetary Union, also known as the eurozone, any economic adjustment is limited to the Greek state's institutional framework and fiscal policies implemented through budget expenses or state agencies.

This paper adopts the definition of the European Commission about the sustainability of public finances, i.e., *fiscal sustainability is the ability of a government to sustain its current spending, tax and other-related policies in the long run without threatening its solvency or defaulting on some of its liabilities or promised expenditures* (EC Public Finances 2020). It is an

interpretation of a principle for macroeconomic stability articulated by M. Obstfeld: *monetary policy, if governed by flexible inflation targeting (perhaps of core inflation), will stabilize prices and output reasonably well in most circumstances. Fiscal policy should smooth tax rates over the business cycle, avoiding debt buildups that might threaten government solvency and relying primarily on automatic stabilizers to counter fluctuations.* (Obstfeld 2013)

This paper argues that fiscal sustainability depends on established institutional path dependence, as governments are constrained in their spending decisions by the obligations assumed by their predecessors. Hence, some tenets of institutional economy formulated by Douglass North are drawn to this theoretical framework. North defines institutions as "humanly devised constraints that structure political, economic and social interactions", which consist of formal rules in the form of a codified legal framework and informal limitations such as socially adopted sanctions, customs, and traditions, which usually contribute to the perpetuation of order and safety within it. The stipulation of formal institutions depends on a social group whose number is disproportionately smaller compared to the power it projects and exerts in society (North 1991). North proposed that institutional change is usually slow because the powerful actors in control of the political systems made the institutions for their benefit and so will be reluctant to change them (North 1992).

This allows drawing theoretical findings from the sociological theory of elites, which has been independently furthered in Italy by Vilfredo Pareto (2017), Gaetano Mosca (1939), Robert Michels (1915) and in Germany by Max Weber (1978). The Elite's role in shaping political, social, and economic institutions has long been acknowledged in sociology (Mills 1956, Putnam 1976, Best et al. 2018). Since it was difficult to measure, economists have been more reluctant to accept it as a significant endogenous factor in any state's economic decision-making. Economists consider the decision-making process reasonable based on data and rigorous economic analysis. Institutional economists, such as Douglass North, reintroduced the concept of the elite into the discourse. He defined this social group in rather loose and opaque terms. Bulgarian institutional economist T. Popov assessed the impact of several social subgroups on institutional change. He singled out the following subgroups: 1. the households; 2. functionaries in large corporate structures; 3 the politicians and higher strata of state bureaucracy; 4. The higher command staff of the army; 5. Higher officers of police and security services; 6. High religious leaders; 7. Members of organised crime. Popov pointed out that the social and political elite is most often composed of members from all the second and third social groups that can cause institutional change, but members from the rest could also join it. Usually, the elite in its

core is limited to several thousand members who constantly alter with non-members from the fringes of their social groups and newcomers from the fourth, fifth, sixth or seventh social group. (Popov – Sedlarsky 2012)

A number of studies by North and his co-authors outlined institutional change and how it reshapes the social and economic foundations not only in the distant past but also of post-communist and modern societies. (North 1990, 2001; North et al. 2009). Attempts have been made to empirically evaluate such institutional change (Alston, Eggertsson & North, 1996; Raiser, Di Tommaso & Weeks (2001), Rizopoulos & Kichou, 2001, Chobanov G. 2020). Nenovsky and Rizopoulos presented a study on the extreme monetary change in Bulgaria as a form of institutional change, along with their empirical measurements (Nenovsky & Rizopoulos 2003). The authors have established their theoretical base by merging institutional economics with the organised action groups theory of M. Olson.

Until the European Sovereign Debt Crisis emerged from the Global Financial Crisis, many scholars had dealt with institutional change primarily within the framework of post-colonial or post-communist societies, as they were the most explicit examples. Since they were considered developing states or in transition ones, the institutional change in modern-day developed European states is not subject to such extensive research. The default of several Eurozone member states on their debts redefined the theoretical paradigm, and these states, as well as the European Sovereign Debt Crisis, have attracted research focus over the last fifteen years.

For the purposes of this study, we will draw on some of the observations made by Nenovsky and Rizopoulos regarding the monetary regime change, which has rarely been analysed within the institutional economics theoretical framework (Nenovsky-Rizopoulos, 2003). Greece, however, did not have an issue with its monetary policy, as it is exogenous, being guided and formulated by the European Central Bank. The institutional change in fiscal rules, however, was subject to extensive research efforts (Groves, 1964; Auerbach & Shaviro, 2009). The source of this change could be internal or external. The external one is often triggered by an economic crisis that has ruined the state's finances, and it is often facilitated by the agency of the International Monetary Fund. It has been a long-term subject of IMF efforts, programs, and research (Fisher 1997). Despite developing a solid theoretical basis for analysing institutional change in Eurozone countries, the empirical assessment methodology has not been unambiguously advanced yet (Alston 1996).

Studying institutional change in Greece, triggered by the Economic Adjustment Programmes, could offer a starting point for new theoretical and empirical approaches and the opportunity to construct quantitative indicators of the introduction or opposition to institutional change.

The change in fiscal rules inevitably leads to a clash between interest groups that promote or oppose them. While the Greek Sovereign Debt crisis is a precursor to institutional change, the identification of the leading actors and their positions regarding the three economic adjustment programmes has not been fully taken into account in economic research, as this examination requires the application of sociological methods. Moreover, the dynamics of changing interests and behaviour of the main actors/stakeholders prior to or during these programme periods have also been outside the scope of economic research. We will regard the programmes as negotiated frameworks between internal and external actors, imposing hard budget constraints on the government that affected not only the political parties but also contributed to the redistribution of power among all actors. While the importance of power configurations for institutional change is pointed out by Galbraith (1984), it has been recently emphasised in the collective work on elites edited by Best et al (2018) and Douglass North (1990, 1994, 1997) also underlined the role of organized groups of interest for change, while Yorgos Rizopoulos and Lyazid Kichou (2001) suggested that institutional change can be analysed as a political interaction process between organisations diffusing institutional rules and organisations consuming institutional rules.

We may define fiscal institutions as sets of rules and explicitly codified norms of behaviour. Fiscal institutions shape budgetary policy and are intricately woven into the social, political, and economic fabric of any state. We presume that formal rules, informal rules, and behaviour play a more important role in tax policy and the distribution of fiscal subsidies than previously considered in economic research. The whole set of fiscal institutions forms a specific structure and constitutes the fiscal system.

Generally, fiscal organizations comprise collective economic agents that pursue specific goals within a given institutional fiscal system and protect the interests of the social and political elite. They include almost all political, social, and economic organisations that apply fiscal rules in their activities or influence their conceptualisation and implementation.

We may define institutional change in the fiscal regime as a transition in the set of formal relations between fiscal benefactors (households, companies, the state) and fiscal beneficiaries

(households, companies, the state). Fiscal rules enable the attainment of a momentous equilibrium of formal power configurations between and within different groups of beneficiaries and benefactors. The fiscal regime also directly impacts the interdependence between the informal benefactors and beneficiaries. The fiscal regime change necessitates transitioning to a new formal institutional framework and establishing new formal relationship rules among various social, political, and economic actors. Since the fiscal regime change is subject to reaching a new political equilibrium and its legal codification, it is endogenously determined and of an asymmetric nature. The institutional transformation finds its justification in actors' goals to have unlimited access to public fiscal resources in the process of appropriation and redistribution of political, social and economic wealth. The perceived interests and the conflict between different groups of national and international fiscal benefactors and beneficiaries drive this institutional change. When the asymmetry of positions in the existing fiscal regime reaches a specific critical mark, the perceived interests of the losing party transform into a desire for change and can shift to a new institutional framework. Shifting from one fiscal regime to another implies a transition to a new equilibrium between the beneficiaries and the benefactors.

To accomplish institutional regime change, one group of beneficiaries and benefactors must achieve comprehensive economic, political, and ideological dominance over the rest of the mixed groups or its capacity to compensate the losing party or parties over the course of this transition.

For the purpose of analysis, institutional regime changes may be classified as initiated by an external, internal, and mixed group of organisations. Nenovsky and Rizopoulos pointed out that the smaller the country, the greater the chance for institutional regime change to be initiated by external political and economic organisations. This explains some of the obstacles in institutional regime changes in larger countries. The coalitions among beneficiaries and benefactors are more complex and internal groups need to find an appropriate organisational structure and develop compelling political rhetoric to impose the new institutional framework. External organisations have relatively less power to effect institutional change. In most cases, the fiscal regime change accompanies a budgetary or economic crisis of the older political, institutional and fiscal regime. The established internal organisations retaliate by ceasing the control of rules enforcement and sometimes facilitating their overstepping or overthrowing. To enable the new rules, initiating organisations are prepared to provoke a crisis or exacerbate an

existing one. By the same token, the opposing organisations are ready to initiate a crisis or to prolong its duration.

A proposal

Institutional change is a process that regulates the redistribution of assets and profits among several groups of actors who, in due time, form a complex structure of connections and formal and informal interdependences. Before examining the institutional changes and rigidities during the Greek sovereign debt crisis, we will introduce the key actors and stakeholders, and describe their interests and driving motivations. The actors represent groups of individuals. Different degrees of organisational maturity, the ability to mobilise resources, and the use of political leverage characterise these organisations. The degree of organisational maturity determines the impact of a given organisation on the change in the institutional framework. The prominent actors in the regime change can be split into two non-homogenous groups of beneficiaries and benefactors.

The following table defines the following main actors:

Table 1: A model outlining the relationships and points of view taken by the leading actors pro/contra the institutional change during the three Economic Adjustment Programmes (2010-2018)

Leading Actors/ Agreement	T	
	Actor	Assessment mark
Government – governing parties/ coalitions		
Leading opposition party		
The rest of the opposition parties		
Trade Unions / agricultural and regional associations		
Business associations		
Independent state organisations		
Troika		

T delineates the time span of any economic adjustment programme. The model assesses the public statements of the leading actors, which are the main political parties and their representation in the government, parliament, and power organisations. The trade unions, agricultural and regional associations, and business associations also join the leading internal actors. Independent state organisations, such as the court system, are also considered. The external actor, the Troika (EC, ECB and IMF), is the last important organisation whose public stance influences the change in the institutional framework and fiscal regime.

The public stance of each actor is assessed via the following grade system:

2- strongly positive; 1- weakly positive; 0- neutral; -1 – weakly negative; - 2 – strongly negative. With these marks, we can assess the public positions of the leading actors prior to each Economic Adjustment Programme.

The empirical evidence

The empirical evidence is gathered through a thorough survey of public opinions, conducted among members of political parties, the leading trade unions, regional farmers' associations, and major business associations. These opinions are substantiated by independent state organisations and the external creditors known as the Troika. These public opinions are interviews and press releases, as well as association newsletters or parties' internal documents.

Their assessment allows us to propose the following

Table 2: Model of relationships among the main actors regarding the institutional change in Greece (2010-2018)

Leading Actors/ Agreement	3 May 2010		1 March 2012		12 July 2015 – 20 August 2018	
	actor	mark	actor	mark	actor	mark
Government – governing parties/ coalitions	ΠΑ.ΣΟ.Κ.	+1	1. ΠΑ.ΣΟ.Κ./ Νέα Δημοκρατία 2.ΣΥΡΙΖΑ / Ανεξάρτητοι Έλληνες (ΑΝΕΛ)	-2	ΣΥΡΙΖΑ / Ανεξάρτητοι Έλληνες (ΑΝΕΛ)	+2

Leading opposition party	Νέα Δημοκρατία	-2	Νέα Δημοκρατία	-2	Νέα Δημοκρατία	+2
The rest of the opposition parties	ΚΚΕ ; Λαϊκός Ορθόδοξος Συναγερμός; ΣΥΡΙΖΑ	-2	ΚΚΕ; Λαϊκός Ορθόδοξος Συναγερμός; ΣΥΡΙΖΑ	-2	ΚΚΕ; Партия *Рекатα*; Χρυσή Αυγή; ΠΑ.ΣΟ.Κ.	-1
Trade Unions / agricultural and regional associations	Γενική Συνομοσπονδία Εργατών Ελλάδας; Ανώτατη Διοίκηση Ενώσεων Δημοσίων Υπαλλήλων	-2	Γενική Συνομοσπονδία Εργατών Ελλάδας; Ανώτατη Διοίκηση Ενώσεων Δημοσίων Υπαλλήλων	-2	Γενική Συνομοσπονδία Εργατών Ελλάδας; Ανώτατη Διοίκηση Ενώσεων Δημοσίων Υπαλλήλων	-2
Business associations	Συνδέσμου Ελλήνων Βιομηχάνων και Βιοτεχνών (ΣΕΒ) Ελληνική Ένωση Τραπεζών (ΕΕΤ)	-1	Συνδέσμου Ελλήνων Βιομηχάνων και Βιοτεχνών (ΣΕΒ) Ελληνική Ένωση Τραπεζών (ΕΕΤ)	-1	Συνδέσμου Ελλήνων Βιομηχάνων και Βιοτεχνών (ΣΕΒ) Ελληνική Ένωση Τραπεζών (ΕΕΤ)	+2
Independent state organisations	Ανώτατο Ειδικό Δικαστήριο	-2	Ανώτατο Ειδικό Δικαστήριο	-2	Ανώτατο Ειδικό Δικαστήριο	0
Troika	IMF, ECB, EC	+2	IMF, ECB, EC	+2	ECB, EC, ESM	+2

The explanation

The Greek sovereign debt crisis materialised from a combination of two groups of factors. On the one hand, the Global financial crisis following the bankruptcy of Lehman Brothers in September 2008 led to a series of shockwaves across countries, resulting in a financial meltdown in the months and years that followed. The major international financial actors were looking for new sources of speculative revenue. On the other hand, the 2009 OECD country survey of Greece identified two major risks facing the state finances: the banks' exposure to non-performing loans and the need for follow-up government intervention, as well as the rising social costs of unemployment for the government (OECD Greece 2009).

The Global financial crisis has also fuelled the extreme polarisation of Greek society. Hence, the new PASOK government, which took office on October 6, 2009, had to explain to the European Union authorities the reasons behind the excessive budget deficit caused by the overspending of the previous Nea Demokratia government. Press releases from Brussels and Luxembourg shifted the global focus to Greece, resulting in negative media coverage and highlighting all previous statistical transgressions of the Greek government. Furthermore, the PASOK government of George Papandreou lacked the capacity to manage the PR crisis effectively. Global financial markets anticipated that the Greek government would be unable to refinance its treasury bonds in May 2010. In the midst of this negative PR, Papandreou was compelled to seek assistance from the European Commission, the European Central Bank, and the International Monetary Fund in repaying its obligations. The main parliamentary opposition party, Nea Demokratia, as well as the smaller parties, opposed the MoU reached between the Government and the Troika. Apart from them, fractions in PASOK also expressed their discontent. All of these political actors received support from influential trade unions, regional farmer associations, and business associations in Greece. One of the reasons, in our opinion, for this widespread disapproval can be found in the signed MoU, which could have led to small institutional changes in Greek politics, economics, and society. In this way, the trade unions, whose leaders were part of the Greek elite and had helped PASOK in many elections since the 1970s, would lose their grasp on Greek politics.

A series of nationwide strikes, along with the rulings of the Constitutional Court, prevented the enforcement of the agreed-upon institutional changes. These actions resulted in PASOK and PASOK/Nea Demokratia governments' reluctance and delays in the required legal amendments during the first and second programmes for economic adjustment. The Constitutional Court and the court system revoked the planned legal amendments. Hence, we may assess the government’s stance as positive but not decisive regarding institutional changes during the first programme and strongly negative during the second programme. It resulted in the postponement of reforms, while the austerity policies led to both political and economic crises. Politically, the traditional parties were replaced by SIRYZA, while economically, apart from a high percentage of unemployment and mass defaults of SMEs, the crisis evolved into a banking crisis in 2015. We present the positions taken by various actors between 2010 and 2015 when a number of governments (regular and interim) held office. Many strikes, organised by trade unions and various regional and business associations, also put pressure on the delicate political and social relations in the country.

Yannis Varoufakis, a former advisor to Papandreou and Minister of Finance for SYRIZA in 2015, was the chief adversary to the Third Programme for Economic Adjustment. Once Tsipras' government removed him from office, it signed the agreement with the Troika, and soon afterwards, SYRIZA won the next parliamentary snap elections. The Third Programme for Economic Adjustment had clear criteria for government and parliamentary performance in legal matters. The Troika exerted external pressure, linking the close scrutiny of legal reforms to a tight schedule for loan transfers, which enabled Tsipras to push forward with challenging institutional reforms. This programme of restructuring not only reorganised the pension, social, and health systems but also addressed issues related to the labour market and excessive public administration. The government laid down solid foundations with its taxation reforms, which enabled its successive governments to improve the taxation system further. The support of the lead parliamentary opposition party, as well as some minor parties, facilitated the passage of the necessary legal amendments. These were not challenged at the Constitutional Court. At the same time, the trade unions, which had started to lose their social and political value due to the closure of the main industrial plans since the 1990s, could not mobilise as many supporters for their cause, unlike during the first crisis years. The loss of political value was reflected in the ousting of trade union leaders from the inner circle of the Greek elite.

Further developments

The proposed model for assessing public positions taken by various national and international actors, who are in favour of or against the institutional changes imposed upon a developed EU state via an Economic Adjustment Programme by international financial organisations, could signal early in the negotiation phase whether certain Programme will be successful or there will be a need of a future further assistance. The model could be elaborated in at least three directions. Firstly, it could be more sensitive when applied to a single country, and the assessment period could be split into two: a six- to three-month period prior to signing a Memorandum of Understanding (MoU), supplemented by an Economic Adjustment Programme, and the period of the Programme itself. Secondly, the model could be applied to two countries, such as Greece and Portugal, which have already emerged from crisis periods, or Spain and Italy, which barely escaped crisis, or France and Germany, where saving the former may drag the latter under water. Finally, the model could be sophisticated enough to assess any public position prior to the signing of any Programme for institutional changes and

during its implementation in a timely manner by identifying and incorporating public actors who have a stake in it.

Conclusions

The paper aims to survey how the decisions of the political, social, and economic elite determine the success or failure of the Economic Adjustment Programmes agreed upon between the Greek government and the Troika between 2010 and 2018. For this purpose, we have developed a theoretical framework that connects several fields within the economic and social sciences. This endeavour resulted in a model that assessed the public positions of key political, social, and economic actors who collectively exercised power over the Programme's outcomes. It explained the whys and wherefores for Greece's incentives to sign three Economic Adjustment Programmes, enabling the government to implement institutional changes in the fiscal regime, public administration, and other organisations and rules with lesser budgetary impact. At the same time, the government introduced many formal institutional rules and new organisations to enforce the new regulations. Focusing on the elite in the decision-making process for formal institutional changes allows for explaining the removal of PASOK, which had strong connections with the trade unions, thus enabling the new political parties that formed Tsipras's government to introduce the agreed-upon reforms in 2015.

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ANALYZING THE IMPACT OF GEOPOLITICAL RISK AND ECONOMIC POLICY UNCERTAINTY ON GLOBAL SUPPLY CHAIN PRESSURE

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Abstract

The increasing frequency and intensity of geopolitical shocks, along with the increasing uncertainty associated with economic policy, have highlighted the need to understand how these factors affect the global supply chain. In this paper, we analyze the relationship between the Geopolitical Risk (GPR) Index and the Economic Policy Uncertainty (EPU) Index, on the one hand, and the Global Supply Chain Pressure Index (GSCPI), on the other. The methodology relies on a Bayesian Vector Autoregressive (BVAR) model incorporating a combination of informative priors. Empirical results suggest that while both GPR and EPU shocks exert upward pressure on the GSCPI, the effect of EPU is more pronounced. Historical decomposition shows that GSCPI dynamics are primarily driven by its own shocks, though EPU contributes during periods of heightened volatility. Scenario-based forecasting suggests that persistent high levels of geopolitical or policy uncertainty are likely to amplify future supply chain stress. These findings emphasize the importance of incorporating political and geopolitical factors into the analysis and management of global supply chains.

Keywords: geopolitical risk, economic policy uncertainty, global supply chain, Bayesian, shocks.

JEL classification codes: C32, F44.

1. Introducction

In recent years, the global economy has been increasingly exposed to non-economic shocks, such as geopolitical conflicts, trade tensions, and policy uncertainty. These events have revealed the fragility of global supply chains and highlighted the importance of understanding how political and economic uncertainty shapes international trade and production dynamics. While traditional macroeconomic models often assume stability in the policy and geopolitical environment, recent disruptions — including the COVID-19 pandemic, Brexit, and the war in Ukraine — have shown this is not a realistic assumption.

The literature has responded to these challenges by developing various indices to quantify uncertainty and geopolitical tensions. For example, the Economic Policy Uncertainty (EPU) Index proposed by Baker, Bloom, and Davis (2016) tracks the number of articles about policy news and has been widely used to gauge the impact of policy uncertainty on investment, output, and financial markets. Similarly, Caldara and Iacoviello (2022) propose the Geopolitical Risk (GPR) Index, which aggregates geopolitical tensions based on media coverage of adverse events such as wars, terrorism, and diplomatic crises.

Several empirical studies investigated the impact of EPU and GPR on macroeconomic variables. For instance, Bloom (2009) shows that uncertainty shocks can lead to significant declines in investment and employment. Recent work by Balcilar et al. (2016) and Antonakakis et al. (2017) explores how geopolitical risk influences oil prices, exchange rates, and stock markets. However, the impact of these uncertainty measures on global supply chain performance is still largely unexplored. More recently, Benigno et al. (2022) introduced the Global Supply Chain Pressure Index (GSCPI), a novel metric designed to assess supply chain stress using a range of transportation and production indicators, that can be used to examine the effects of (geo)political factors on the global supply chain.

This paper contributes to the literature by being the first to apply a hierarchical Bayesian Vector Autoregressive (BVAR) model to examine joint effects of EPU and GPR upon global supply chain pressures as measured by the GSCPI. This modeling method provides a flexible way to integrate prior beliefs yet is robust to uncertainty about the parameters. Our empirical findings reveal that both EPU and GPR shocks exert upward pressure on global supply chain stress, though the effect of EPU is more persistent and pronounced.

By quantifying these relationships and forecasting supply chain pressures under extreme scenarios, we provide novel insights into how uncertainty—whether economic or geopolitical—can propagate through global value chains. These findings are especially relevant to policymakers, firms, and analysts who wish to develop strategies to strengthen supply chain resiliency in an increasingly volatile world.

2. Methodology

In this paper, we estimate Bayesian VAR (BVAR) models to analyze the impact of geopolitical risks and economic policy uncertainty shocks on the global supply chain. Bayesian methods differ from frequentist econometrics in that they combine prior information along with the likelihood function to obtain a posterior distribution for the parameters of interest, using the Bayes theorem. In this case, we use hierarchical priors.

The VAR model is given in a reduced form by:

$$y_t = c + \sum_{j=1}^{p} A_j y_{t-j} + u_t, \quad u_t \sim N(0, \Sigma)$$

where y_t collects our variables in time t, c is a vector of constants and A_j are parameter matrices for each of the respective p lags of the variables.

Frequentists VAR models lead to estimation problems because they generate a large number of parameters. In order to solve this situation, the Bayesian approach is used because it enables to impose a less dense parameter structure by using information previously provided by the data, the so-called prior information in Bayesian jargon.

However, the specific choice and definition of the priors is always a relevant mathematical challenge. In order to overcome it, the idea of hierarchical modeling has been shown as useful because alleviates the otherwise mandatory subjectivity of setting prior parameters. Hierarchical prior selection introduces hyperparameters that govern the prior distributions, allowing the data to inform the degree of prior informativeness. This method enhances model flexibility and can improve forecasting accuracy. In mathematical terms, the fact that prior hyperparameters are assigned their own hyperpriors is expressed as follows by using the Bayes' theorem:

$$p(\gamma|y) \propto p(y|\theta,\gamma)p(\theta|\gamma)p(\gamma) \quad (1)$$
$$p(y|\gamma) = \int p(y|\theta,\gamma)p(\theta|\gamma)d\theta \quad (2)$$

where $y = (y_{p+1},\ldots,y_T)^T$, θ denotes the autoregressive and variance parameters of the VAR model and γ denotes the set of hyperparameters. The part (1) of the equation is marginalized with respect to the parameters θ in the part (2). This gives a density of the data as a function of the hyperparameters p(y|γ), also called marginal likelihood (ML). ML is marginal with respect to the parameters θ, but conditional on the hyperparameters γ. Then, it can be used as a decision criterion for the hyperparameter choice. In the Bayesian hierarchical approach, the ML is used to explore the full posterior hyperparameter space, acknowledging uncertainty surrounding them. This yields robust inference, is theoretically grounded, and can be programmed in an efficient manner. We use the Schwarz Information Criterion to specify the lag-length of the VAR model, and 20,000 draws from the posterior distribution.

3. Empirical results

The Geopolitical Risk (GPR) index corresponds to Caldara and Iacoviello (2022), the Economic Policy Uncertainty Index (EPU) has been taken from Baker, Bloom and Davis (2016). The global supply chain is measured using the Global Supply Chain Pressure Index (GSCPI) by the Federal Reserve Bank of New York (Benigno, di Giovanni, Groen, and Noble, 2022). The GSCPI aims to quantify supply chain disruptions in order to assess the extent to which supply constraints influence economic outcomes. The sample runs from January 1998 to December 2024. As with the GSCPI, sample values of both the GPR and EPU indices are converted into Z-scores, which means that each observation is expressed in terms of the number of standard deviations from the sample mean. This allows us to investigate how pressure in geopolitics or economic policy uncertainty translates into pressures in the global supply chain.

Figure 1 presents the evolution of three indices over time. The GSCPI (top panel), shows a significant increase in global supply chain pressures around 2020–2022, capturing the COVID-19 pandemic and subsequent disruptions, followed by a gradual normalization. The GPR (middle panel) presents increases around major global conflicts or events, such as the 9/11 attacks and recent geopolitical instability, whereas the EPU (bottom panel) reflects raising uncertainty in the aftermath of the global financial crisis and again during the COVID-19 pandemic and related economic interventions. Overall, the graph suggests a potential co-movement between geopolitical and economic uncertainty, on the one hand, and global supply chain pressures, on the other, particularly during major global events. In what follows, we investigate whether this is indeed the case, and consequently, the role and importance of considering (geo)political factors, and the uncertainty associated with them, when analyzing supply chain dynamics.

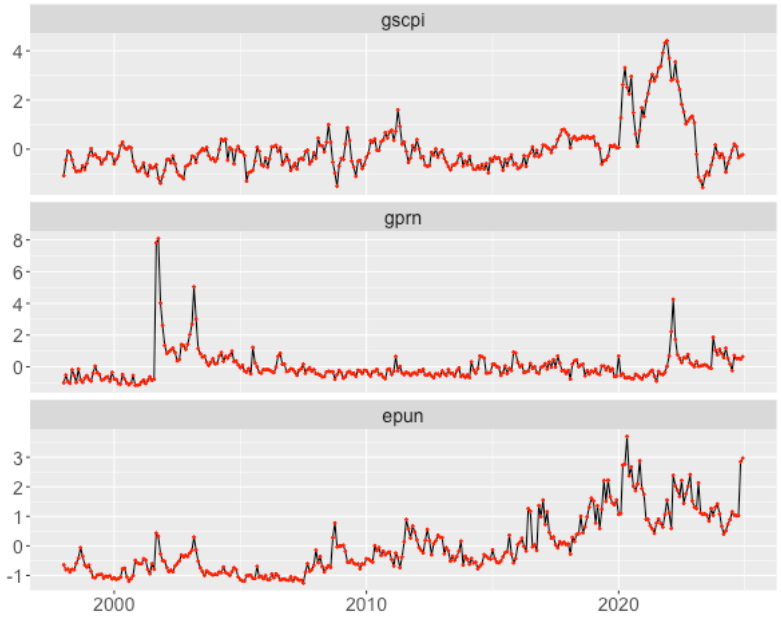


Figure 1: GPR, EPU, and GSCPI indices.

A hierarchical Bayesian VAR (BVAR) is estimated. This type of Bayesian model treats the prior hyperparameters, such as the tightness or variance of priors, not as fixed values but as random variables estimated from the data. This hierarchical structure allows the model to adaptively learn the degree of prior influence, rather than relying on subjective or arbitrary settings. The main advantage over non-hierarchical models is that it offers greater flexibility and data-driven regularization, often leading to better forecasting accuracy and more robust inference, especially when prior information is uncertain.

The priors are selected as a combination of the Minnesota, sum-of-coefficients (SOC), and single-unit-root (SUR) priors, this choice allows Bayesian VAR models provides greater flexibility and improved performance. Each prior captures different features of macroeconomic time series: the Minnesota prior handles short-term dynamics, SOC addresses initial condition biases, and SUR accounts for unit roots and possible cointegration. Combining them allows for better calibration, reduces overfitting, and enhances forecast accuracy, especially in high-dimensional settings. This approach has been shown to perform well empirically, offering a more robust and interpretable modeling framework.

The lag length was selected using the Akaike Information Criterion (AIC) and set to two lags. The BVAR model is identified using a combination of sign and zero-restriction scheme, with the variables ordered as EPU, GPR, and GSCPI. The identification is achieved through a Cholesky decomposition, further imposing the restriction that the response of GSCPI to GPR and EPU shocks are contemporaneously positive.

Figure 2 displays the trace plots and posterior density distributions of the hyperparameters from the estimated BVAR. The trace plots on the left side indicate good mixing and convergence of the Markov Chain Monte Carlo (MCMC) simulations for each hyperparameter (ml, lambda, soc, and sur), as they fluctuate around a stable mean without apparent trends. On the right, the density plots show the posterior distributions: the marginal likelihood (ml) is concentrated around -650, lambda (which controls overall shrinkage) has most of its mass around 0.2, suggesting moderate shrinkage; soc (likely related to the stochastic volatility or variance of the coefficients) centers around 1.5, and sur (possibly reflecting residual variance) peaks around 0.5 with a long right tail, indicating some uncertainty but generally concentrated mass. These results suggest well-behaved posterior distributions and stable inference for the BVAR model's hyperparameters.

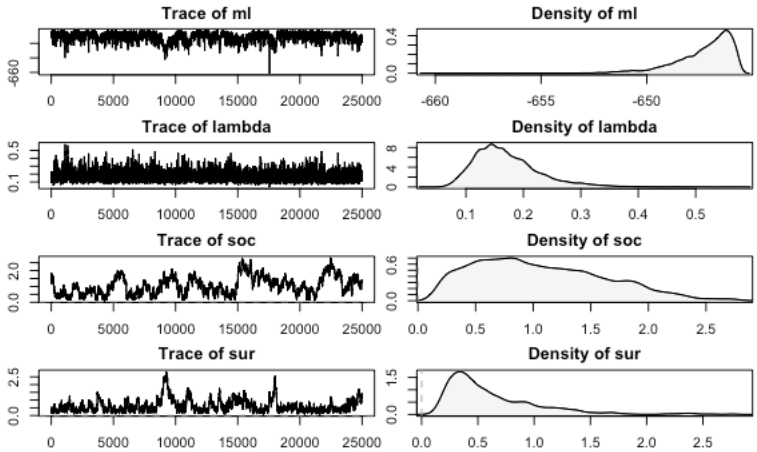


Figure 2: Trace and density.

Figure 3 shows the posterior density distribution of the autoregressive coefficient for the first lag of the Global Supply Chain Pressure Index (GSCPI) in the BVAR model, labeled as "gscpi_gscpi-lag1." The density is sharply peaked around the value of 1, with most of the distribution concentrated between approximately 0.9 and 1.05. This suggests strong persistence in the GSCPI series, meaning that past values of the index are highly predictive of its current value. The tight concentration of the distribution also indicates low uncertainty around this estimate.

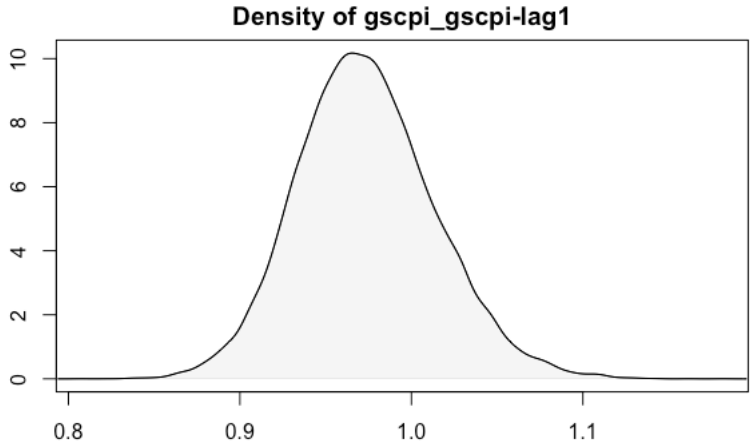


Figure 3: GSCPI density.

Finally, figure 4 shows the residual plots for the three variables included in the BVAR model. For GSCPI and EPU, the residuals are generally centered around zero and exhibit a relatively constant variance over time, suggesting that the model captures the dynamics of these series reasonably well. However, there are a few outliers, particularly in the later observations of both series. In the case of GPR, the residuals also close to zero, but with a few significant spikes, especially early and late in the sample. Overall, the residuals show no strong signs of autocorrelation or heteroscedasticity, indicating that the model's specification is broadly appropriate.

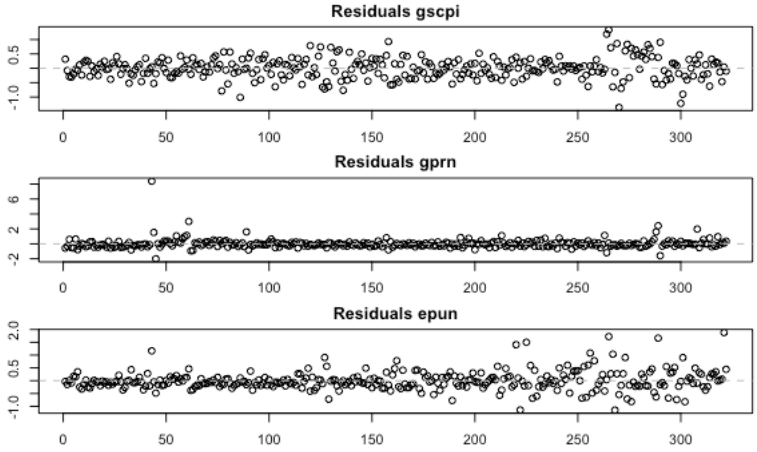


Figure 4: Residual plots.

Figure 5 shows the impulse-response analysis. A shock to EPU leads to an immediate and positive increase in the GSCPI, suggesting that heightened uncertainty around economic policy can disrupt supply chains, potentially through delayed investment decisions, shifts in trade policy expectations, or cautionary behavior by firms anticipating regulatory changes. Similarly, a shock to GPR also exerts upward pressure on the GSCPI, albeit to a lesser extent. This aligns with the notion that geopolitical tensions, such as conflicts, sanctions, or diplomatic instability, can directly affect international logistics, trade routes, or global coordination of production processes. In both cases, the impulse responses decline gradually over time, indicating that while the effects are not permanent, they exhibit some persistence. The third plot shows the response of the GSCPI to its own innovations, which also decays over time, reflecting the intrinsic dynamics and inertia in global supply chain disruptions.

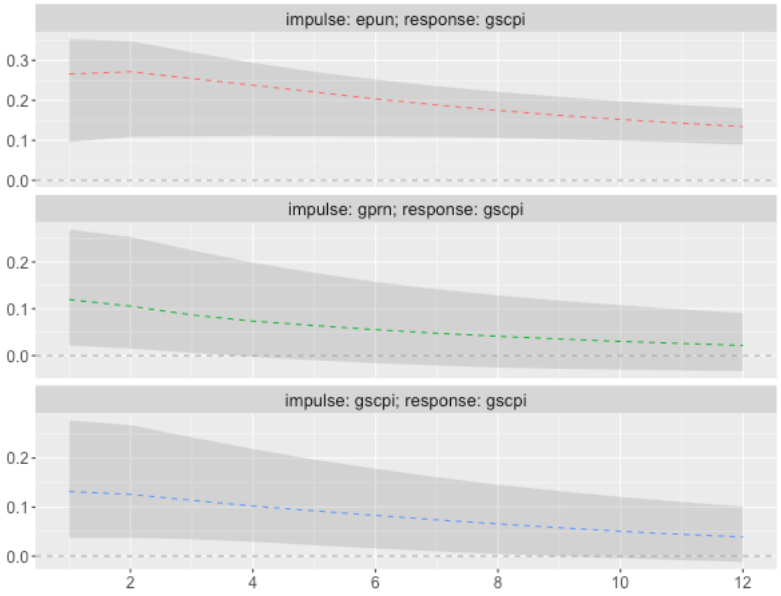


Figure 5: Impulse-response analysis, GSCPI response.

The historical decomposition is shown in Figure 6. This decomposition shows how individual structural shocks have contributed to the evolution of GSCPI over time. Each panel isolates the effect of a single shock (i.e., EPU, GPR, and GSCPI itself) on the observed movements of GSCPI. The blue line represents the actual observed values of the GSCPI, while the red dashed line shows the simulated path of the GSCPI that would result if only one specific shock had occurred, holding all others constant. In the top panel, we observe that shocks to EPU have contributed, although rather modestly, to GSCPI fluctuations only during episodes of heightened volatility, especially during recent spikes. This suggests that uncertainty in policy environments may amplify, to some limited extent, supply chain pressures during turbulent economic periods. The middle panel indicates that GPR shocks have not contributed to explaining GSCPI fluctuations. In the bottom panel, the GSCPI's own shocks capture much of the short-term variation, especially during periods of pronounced supply chain stress.

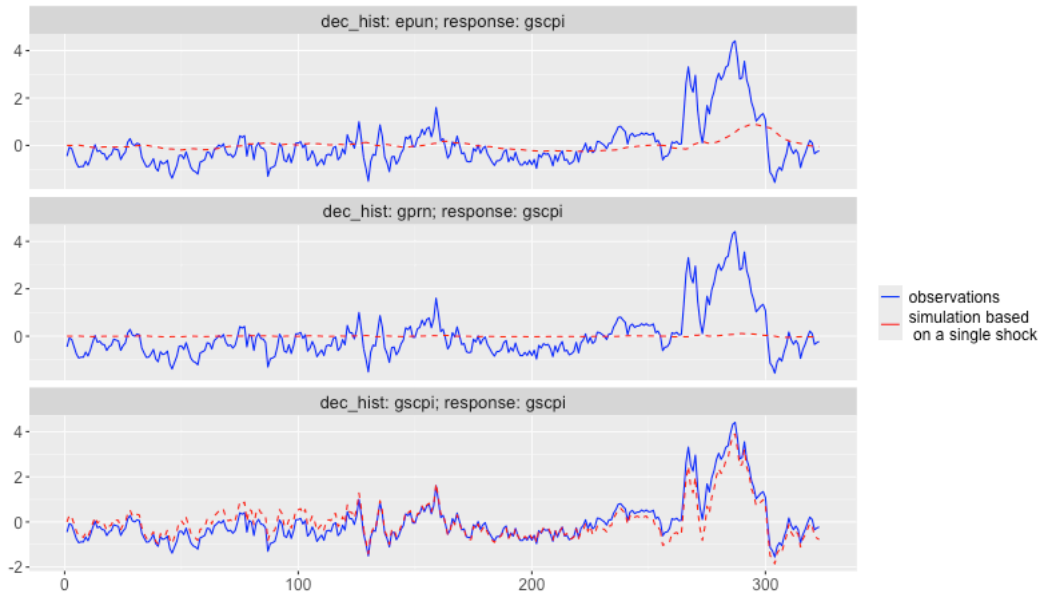
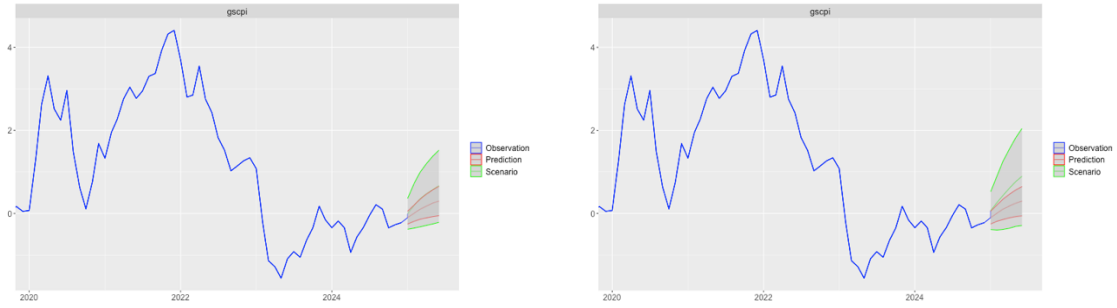


Figure 6: Historical decomposition, GSCPI.

Next, we estimate conditional forecasts under two different scenarios. First, the prediction is made under the assumption that, for six months, the EPU index reaches and maintains its maximum historical value, corresponding to May 2020. The result is displayed in Figure 7, panel (a). Second, we assume that the GPR index also reaches its maximum historical value, corresponding to September 2001. In Figure 7, panel (b), the blue line represents observed values of the GSCPI, while the red lines show the baseline forecast (unconditional prediction), and the green lines represent the conditional forecast under the different scenarios. In both cases, the results clearly show that the conditional forecast diverges upward from the baseline. Under both scenarios, the GSCPI is projected to rise significantly more than in the baseline case. This suggests that a sustained period of heightened economic policy uncertainty or geopolitical risks would exert considerable upward pressure on global supply chain stress. The forecast horizon reflects the accumulating impact of persistent uncertainty on supply chain conditions, meaning that if policymakers or firms are confronted with prolonged uncertainty, it can lead to disruptions such as delays, increased costs, or risk aversion in global production and logistics networks. The shaded area around the predictions represents Bayesian credible intervals, indicating the range of plausible outcomes given model uncertainty. The conditional and unconditional credible sets overlap. Even within that uncertainty, the scenario projection remains consistently above the baseline, reinforcing the notion that such shocks could significantly amplify future supply chain pressures.



(a) EPU scenario (b) GRP scenario

Figure 7: Conditional forecasting.

4. Concluding remarks

This study examined the effects of Geopolitical Risk (GPR) and Economic Policy Uncertainty (EPU) on Global Supply Chain Pressure (GSCPI) in a hierarchical Bayesian Vector Autoregressive (BVAR) model. Impulse-response functions show that the EPU and GPR shocks have positive and significant effects on the GSCPI, with economic policy uncertainty having a relatively stronger effect. Although these effects are temporary, they exhibit persistence, reflecting the inertia of global supply chains and their vulnerability to external disturbances.

Using historical decomposition allows to show that the largest part of the GSCPI fluctuations are driven by its own shocks and particularly during periods of large disruptions such as COVID-19 pandemic. None of the cited individual predictors correlate strongly with outputs, but EPU offers small contributions to higher-level formulas during periods of economic turbulence while GPR have played almost no role.

The historical decomposition analysis indicates that EPU shocks have made a limited contribution to GSCPI fluctuations, with effects being especially significant during periods of increased volatility, while GPR shocks have played almost no role. However, conditional forecasts under extreme scenarios, by assuming persistently elevated levels of EPU or GPR, show a strong increase in supply chain pressures. This highlights that geopolitical and policy-related uncertainty can place considerable stress on global supply chains.

Overall, this research provides evidence of the importance of incorporating political and geopolitical risk factors into supply chain management due to the uncertainty that these types of shocks can cause regarding the future development of the global supply chain.

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ANALYSIS OF CARBON EMISSIONS AND ENVIRONMENTAL QUALITY SCORES OF COMMERCIAL LOANS: A CASE STUDY OF A PARTICIPATION BANK

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Abstract

In today's world, the concept of sustainability holds great importance across all sectors, including the financial sector. In particular, the latest regulation issued by the Banking Regulation and Supervision Agency (BRSA) requires banks to calculate their Green Asset Ratio (GAR), which represents the proportion of total assets allocated to sustainable activities by financial institutions. This ratio serves as a critical indicator for measuring the contribution of the banking sector to environmental sustainability. In this study, commercial loans provided by a participation bank were analyzed on a sectoral basis, carbon emissions were calculated with the PCAF (Partnership for Carbon Accounting Financials) Methodology and quality scores were evaluated. Full Factorial Design was used to explain the relationship between dependent and independent factors. The purpose of this study is to analyze the environmental impacts of commercial loans and to establish a basis for determining sustainable financial activities.

Keywords: Sustainability, Environmental Quality, Banking Sector, Carbon emissions First Section

1 INTRODUCTION

As global issues like resource depletion, climate change, and environmental degradation continue to worsen, sustainability has emerged as a crucial pillar of economic and societal development. Banks and other financial institutions are essential to this shift because they allocate funds to investments that are environmentally friendly. By using green financing techniques, banks help to promote sustainable economic growth in addition to reducing environmental risks. Aligning banking operations with the Sustainable Development Goals (SDGs) is a crucial tactic in this endeavor, as noted by Avrampou et al. (2019). Furthermore, frameworks like the European Union's Taxonomy for Sustainable Activities highlight the importance of accountability and transparency, highlighting the banking industry's top priority of incorporating sustainability into financial decision-making.

Commercial loans contribute significantly to the expansion of carbon-intensive industries and raise awareness of the connection between financial activity and carbon emissions. As Nelson (2022) points out, banks' lending practices indirectly increase greenhouse gas emissions. Financial institutions can now measure and report emissions associated with their operations thanks to standardized frameworks like the Partnership for Carbon Accounting Financials (PCAF), which was created to address this problem. Studies like Bashir et al. (2024) further highlight the significance of transparent carbon accounting systems for coordinating financial portfolios with global climate objectives.

As evidenced by regulatory developments such as Turkey's Green Asset Ratio (GAR), which was introduced by the Banking Regulation and Supervision Agency (BRSA), sustainability has grown in significance within the financial sector. Financial institutions must determine the percentage of their assets devoted to sustainable economic activities in accordance with these new guidelines. These rules are in line with international programs like the Green Deal and the Sustainable Finance Disclosure Regulation (SFDR) of the European Union. Regulatory frameworks are crucial in encouraging banks to implement sustainable practices, which in turn promotes greater environmental sustainability, as Samour et al. (2023) point out.

This study focuses on the environmental impact of commercial loans issued by a participation bank over a defined period. Using the PCAF methodology, sectoral carbon emissions were calculated, and quality scores were evaluated to assess the sustainability of financial activities. Building on the approaches of Imran et al. (2024) and Khan et al. (2022), which explored the complex relationship between financial development and environmental outcomes, this research offers a sector-specific perspective. By highlighting the carbon footprint of financed activities, the study provides a foundation for aligning banking operations with broader sustainability goals.

2 LITERATURE REVIEW

This section reviews relevant studies that provide a theoretical basis for analyzing commercial lending, its environmental impact, and sustainable financial activities. The reviewed literature is categorized into three primary themes: the role of financial development, the impact of renewable energy consumption, and the integration of sustainability into banking practices. These categories are explored through key contributions from recent research.

2.1 The Role of Financial Development

The 2024 study by Bashir et al. examined the relationship between financial development, renewable energy consumption, and environmental quality in BRICS countries.

It emphasized how banking development and industrial activities contribute to carbon emissions. It also highlighted the importance of renewable energy as a mitigating factor (Bashir et al., 2024).

In 2023 by Wang et al. Focusing on Germany, this study uses time series analysis to examine how banking development supports environmental sustainability. The results show a significant relationship between renewable energy consumption and reduced emissions (Wang et al., 2023).

A 2022 multidimensional assessment study by Khan et al. examines the dual role of financial development in both stimulating growth and contributing to environmental degradation. Statistical modeling is used to uncover the trade-offs involved in these activities (Khan et al., 2022).

2.2 The Impact of Renewable Energy Consumption

This study, conducted by Samour et al. in 2022, examined the countries with the highest emissions and used econometric modeling to reveal the critical role of renewable energy shocks and financial systems in improving environmental quality. (Samour et al., 2023).

This study examines the relationship between financial development and renewable energy consumption in the BRICS economies. The findings highlight how economic openness, and technological advances facilitate sustainable energy transitions (Athari, 2024).

This study provides valuable insights into sustainable development by assessing the linkages between renewable energy use in the economy, environmental footprint, and financial stability of South Asian countries using dynamic panel data analysis (Imran et al., 2024).

2.3 Integration of Sustainability in Banking Practices

The case study analysis by Avrampou et al. examines European banks' efforts to achieve the SDGs through green financing and emissions reduction strategies, with a focus on the increasing integration of sustainability into banking practices (Avrampou et al., 2019).

By highlighting the application of the PCAF methodology in this study by Nelson in 2022, it highlights the importance of standardized carbon accounting frameworks for

financial institutions and directly contributes to the methodological framework of this study (Nelson, 2022).

This research by Pang et al. used hypothesis testing and regression analysis to assess how green energy transitions and banking sector growth affect environmental outcomes in the United States (Pang et al., 2024).

This study builds a strong theoretical framework for examining the environmental effects of commercial loans and how well they align with sustainability objectives by utilizing insights from literature.

While previous studies have generally focused on the environmental impacts of financial development and renewable energy consumption (e.g., Bashir et al., 2024; Samour et al., 2023), this study examines in detail the impacts of credit limit categories on sectoral carbon emissions.

3 METHODOLOGY

3.1 Dataset Preparation

In this study, the data of loans disbursed by a specific participation bank between January and November 2024 was analyzed. A total of 43,218 commercial loan records were obtained for this period. To enable more accurate and specific analysis of the data, several filters were applied.

First, the "offer type" option was examined, where a variety of extensive options exist. This study focused solely on "initial offers" to evaluate the creation of credit limits for new customers. The reason for selecting initial offers is that the environmental impact of new loans provides more meaningful data and better reflects their environmental effects. In future studies, the "limit increase" filter could also be included. Since additional financing requests indicate growth activities in the sector, they could contribute to emission increases. Thus, the scope of future studies can be expanded accordingly.

In the "business line" column, the filter for "COMMERCIAL" was applied. This choice was made because the study focuses on analyzing commercial loans.

In the "credit result" column, only those with "Approval" status were selected. This study only focuses on loans that were actually disbursed.

The "company type" was filtered to include only "corporate customers," as this type is more suitable for the study’s focus. Corporate customers are business entities that contribute to economic activities through their institutional structures. They typically request larger-scale loans, making it easier to detect their environmental impacts.

The "currency code" was filtered to "TRY" (Turkish Lira). By focusing on loans disbursed in Turkish Lira, the study aimed to analyze a more specific dataset. Loans in different currencies may have varying impacts, and future studies could consider loans in other currencies as well.

To make the dataset even more meaningful, the "segment" column was also filtered to include only the "Commercial Segment." This aligns with the study's focus on larger and more impactful projects.

During data cleaning, rows where the "active size" valued for later calculations in the formula—were missing were also excluded. After applying these filters, the dataset was reduced to 159 records.

Before starting the analysis, carbon emission rates were calculated based on the dataset. For this calculation, the PCAF (Partnership for Carbon Accounting Financials) methodology, a standard approach used in the financial sector, was employed.

3.2 PCAF (Partnership for Carbon Accounting Financials) Methodology

The PCAF methodology is widely acknowledged as a global standard for calculating and reporting f inanced emissions across different asset classes. It offers financial institutions a transparent framework for evaluating and disclosing the emissions tied to their financing activities, ensuring alignment with the goals of the Paris Agreement. According to Nelson (2022), PCAF "enables the attribution of a portion of a company's total emissions to the financial support provided by a specific institution" (p. 32).

The PCAF methodology, widely adopted by financial institutions globally, offers a consistent framework for calculating financed emissions by integrating sector-specific methodologies, ensuring transparency through a data quality scoring system, and enabling accurate attribution of emissions across various asset classes (Nelson, 2022, pp. 32-34).

Other commonly used methodologies for calculating financed emissions include top-down approaches, which rely on industry averages or geographic emission factors, offering quick implementation but often lacking the precision needed for portfolio alignment with climate goals. In contrast, bottom-up approaches leverage company-specific emissions data, providing greater accuracy and granularity despite being resource-intensive. Hybrid models, such as ASN Bank's Carbon Profit & Loss framework, combine elements of both methods to deliver a balanced analysis. Another method, PACTA (Paris Agreement Capital Transition Assessment), focuses on forward-looking alignment by evaluating portfolio exposure to high-emission sectors, though it may not fully capture current emissions intensity (Nelson, 2022, pp. 35-40).

This study utilized the PCAF framework due to its robust and transparent structure tailored for the f inancial sector. It ensures consistency and global applicability while aligning with the study's objectives. Nelson (2022) emphasizes that "PCAF offers the essential tools for evaluating financed emissions transparently and systematically, making it a vital framework for institutions aiming to achieve net-zero goals" (p. 43).

The following formula was applied for commercial loans in this study:

Financed Emissions = (Outstanding amount / Total equity + Debt) x Company Emissions

where: Outstanding amount: Retrieved from the "Limit" column in the dataset.

Total Equity + Debt: Since this data was unavailable, the most recent asset size information (approximately the sum of equity and debt) was used.

Company Emissions: As the specific company emission factor was not known, sector-based estimated emission factors were utilized.

To calculate sector-based estimated emission factors, the study published by TÜİK on March 29, 2023, was used as a reference (TÜİK, 2023). This study provided total emission rates by sector. Based on this work, which focused on four sectors (energy, agriculture, waste, and industrial processes and product use), a predictive model was developed using Python.

```python
import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression
import matplotlib.pyplot as plt

# Create dataset
data = {
    "Years": [1990, 2000, 2010, 2020, 2021],
    "Energy": [139.5, 216.0, 287.9, 366.6, 402.5],
    "Agricultural": [46.1, 42.3, 44.4, 73.2, 72.1],
}

df = pd.DataFrame(data)

# Train models and predict 2024 emissions
sectors = ["Energy", "Agricultural"]
predictions = {}

for sector in sectors:
    X = df["Years"].values.reshape(-1, 1)
    y = df[sector].values

    model = LinearRegression()
    model.fit(X, y)

    year_2024 = np.array([[2024]])
    prediction = model.predict(year_2024)
    predictions[sector] = prediction[0]


print("2024 Predictions:", predictions)
```

```
2024 Predictions: {'Energy': 409.96708286038483, 'Agricultural': 70.87928490351874}
```

Fig. 1. Python Code for Predicting 2024 Sectoral Emissions and Results.

For sectors without historical data, estimated values were manually determined. For instance, the manufacturing sector, being energy-intensive, was assigned a value close to but lower than that of the energy sector. The service sector was considered the least carbon-intensive sector. The trade sector, due to its association with logistics, was assigned a moderate value. The transportation and logistics sector was deemed a high carbon-intensive sector. The "Others" category was given a more general value.

Table 1. Sectoral Carbon Emission Estimates for 2024

Sector	**Estimated Emissions in 2024 (kg CO_2)**
Agricultural	70.88 (from regression analysis)
Construction	280.00
Energy and Mining	409.97 (from regression analysis)
Manufacturing	250.00
Others	100.00
Service	50.00
Trade	120.00

After estimating the emission factors, the emission rates were calculated using the formula:

Outstanding Amount / Total Equity + Debt) × Company Emissions.

From the calculated values, a quality score was derived. This score classifies each sector and limit category by interpreting the calculated emission rates. Lower emission rates indicate higher quality (more environmentally friendly), while higher emission rates suggest lower quality.

Since the calculated emission rates were clustered within a narrow range, the quality scores were normalized. To normalize the emission rates, the following formula was used:

Quality Score = 1 – (Emission Rate – Min) / (Max – Min)

This method normalizes the quality scores to a scale between 0 and 1.

After completing the necessary calculations, the dataset was prepared for the application of the **Full Factorial Design** methodology.

3.3 Full Factorial Design

In this study, the **full factorial design** methodology was employed to analyze the effects of multiple independent variables (e.g., sector, credit limit category) dependent variables (environmental quality score). As Montgomery (2017) explains, "full factorial design systematically examines all possible combinations of factors, allowing researchers to understand both the main effects and interactions between variables" (p. 45). This makes it a powerful tool for investigating complex relationships.

A full factorial design involves studying every possible combination of factor levels to evaluate their individual and combined effects. Montgomery (2017) emphasizes that "this approach is comprehensive, capturing the intricate interplay of factors that simpler designs may overlook" (p. 47).

Its applicability is especially significant in fields requiring detailed interaction analyses, such as environmental and financial research.

Many studies have shown the efficacy of full factorial design in examining environmental and financial data. Montgomery (2017) claims that "this approach continues to be a fundamental element for strong experimental design across various disciplines" (p. Sure, please provide the text that you would like me to paraphrase. In the same vein, Gupta and Kapoor (2020) utilized this methodology in their examination of sustainable finance, discovering it "essential for analyzing the intricate connections between emissions and financial choices" (p. 92).

The use of full factorial design in this study allowed for a detailed and comprehensive analysis of the variables influencing environmental quality scores. By capturing both the main effects and interactions, this approach provided nuanced insights into the environmental impacts of commercial loans, thereby contributing significantly to the understanding of sustainable finance practices.

Independent Variables (Factors):

1. Sector

In this study there are 8 sector categories which are agricultural, construction, energy and mining, manufacturing, service, trade and others.

2. Credit Limit Category

There are 3 different limit categories in this study.

Table 2. Limit Categories in the Dataset

700,000-50,000,000	Low Limit
50,000,001-120,000,000	Medium Limit
120,000,001- 190,000,000	High Limit.

Dependent Variable:
Environmental Quality Score is chosen as a dependent variable.

3.4 ANOVA Analysis

In this research, Analysis of Variance (ANOVA) was utilized to assess the impacts of several independent variables—including sector and credit limit category —on the dependent variable, the environmental quality score. ANOVA is a strong statistical technique frequently utilized to assess if significant differences are present among the group means in a dataset (Montgomery, 2017).

ANOVA aims to assess the null hypothesis that all group means are identical, while determining if any factors or their interactions significantly affect the dependent variable. According to Montgomery (2017), "ANOVA is especially valuable in factorial experiments, where several factors and their interactions are analyzed at the same time" (p. 215)

The full factorial design involves multiple factors (e.g., sector and credit limit category) and their levels. ANOVA was chosen as it effectively analyzes both main effects and interaction effects, which are critical in understanding the combined influence of independent variables on environmental quality scores.

The analysis was conducted using Minitab software, where factors were input as independent variables, and the environmental quality score was used as the dependent variable.

4 RESULTS

4.1 Sector-Based Distribution of Emission Rates

The Agricultural**,** Energy and Mining**,** Trade, and Transportation and Logistics sectors appear to have the highest average quality scores.

The Service and Others categories have relatively lower scores but still maintain notably high values.

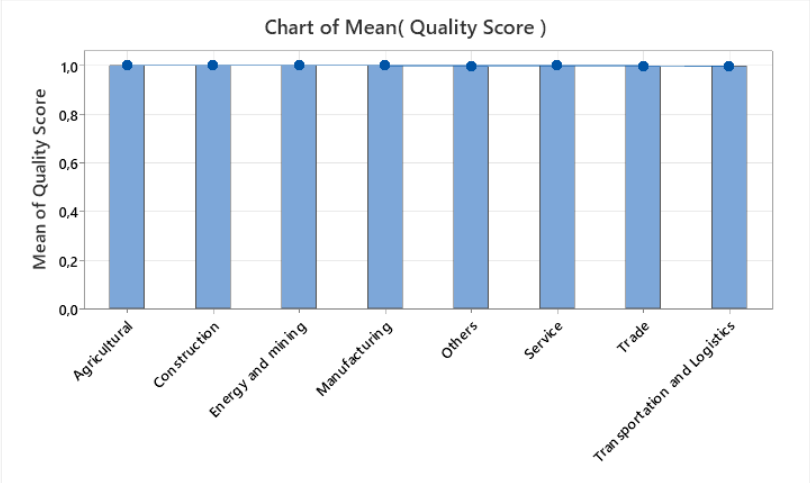

Fig. 2. Quality Scores by Sectors

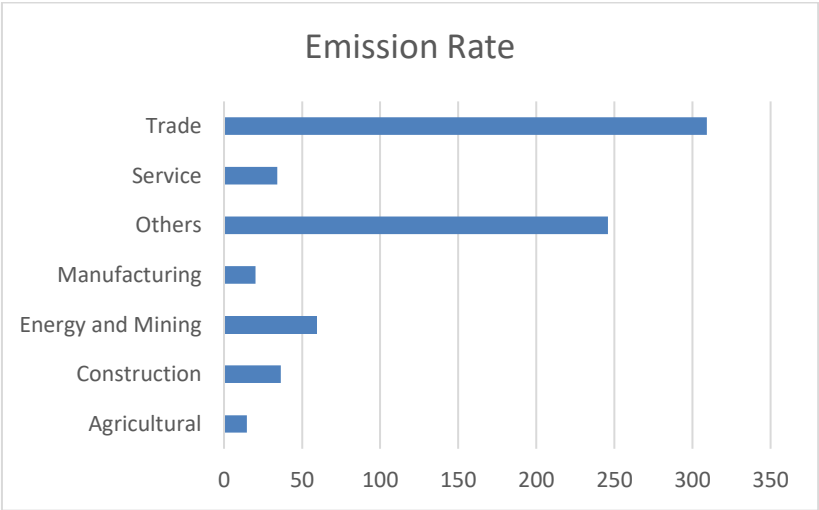

Fig. 3. Emission Rates by Sectors

The Trade and Others sectors show high emission rates, likely due to extensive activities such as logistics and transportation, which are energy-intensive. In contrast, low-emission sectors like Agriculture and Services likely require less energy and produce lower carbon emissions. The Energy and Mining sector, being inherently energy-intensive, contributes significantly to emissions. These findings suggest that credit policies for high-emission sectors should be reconsidered to align with

environmental sustainability goals, while Agriculture, Services, and Construction could be supported for developing greener and more sustainable projects.

4.2 ANOVA and Regression Findings

General Linear Model: Quality Score versus Limit Category; Sector; Quality

Method

Factor coding (-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Limit Category	Fixed	3	High Limit; Low Limit; Middle Limit
Sector	Fixed	8	Agricultural; Construction; Energy and mining; Manufacturing; Others; Service; Trade; Transportation and Logistics
Quality	Fixed	2	High Quality; Low Quality

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Limit Category	2	0,000010	0,000005	4,48	0,013
Sector	7	0,000012	0,000002	1,60	0,140
Quality	1	0,000639	0,000639	587,96	0,000
Error	148	0,000161	0,000001		
Lack-of-Fit	8	0,000039	0,000005	5,63	0,000
Pure Error	140	0,000122	0,000001		
Total	158	0,000822			

Fig. 4: General Linear Model for Quality Score vs. Limit Category, Sector, and Quality.

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0,0010428	80,41%	79,09%	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0,986816	0,000554	1780,68	0,000	
Limit Category					
High Limit	0,000225	0,000251	0,90	0,372	1,73
Low Limit	0,000251	0,000155	1,62	0,107	1,75
Sector					
Agricultural	0,000119	0,000467	0,26	0,799	4,00
Construction	0,000238	0,000225	1,06	0,291	1,85
Energy and mining	0,000031	0,000421	0,07	0,941	3,44
Manufacturing	0,000204	0,000185	1,10	0,273	1,67
Others	-0,000278	0,000278	-1,00	0,320	2,13
Service	0,000153	0,000308	0,50	0,620	2,33
Trade	0,000176	0,000175	1,01	0,316	1,67
Quality					
High Quality	0,012785	0,000527	24,25	0,000	1,02

Fig. 5. Summary of Model Performance and Coefficient Estimates.

Regression Equation

Quality Score = 0,986816 + 0,000225 Limit Category_High Limit + 0,000251 Limit Category_Low Limit - 0,000476 Limit Category_Middle Limit + 0,000119 Sector_Agricultural + 0,000238 Sector_Construction + 0,000031 Sector_Energy and mining + 0,000204 Sector_Manufacturing - 0,000278 Sector_Others + 0,000153 Sector_Service + 0,000176 Sector_Trade - 0,000644 Sector_Transportation and Logistics + 0,012785 Quality_High Quality - 0,012785 Quality_Low Quality

Fits and Diagnostics for Unusual Observations

Obs	Quality Score	Fit	Resid	Std Resid		
23	0,99999	0,99997	0,00002	0,02		X
30	0,99999	0,99997	0,00002	0,02		X
108	0,99995	0,99997	-0,00002	-0,02		X
111	0,99995	0,99997	-0,00002	-0,02		X
157	0,99537	0,99957	-0,00420	-4,21	R	
158	0,98726	0,99848	-0,01122	-11,31	R	
159	0,97446	0,97446	0,00000	*		X

R Large residual
X Unusual X

Fig. 6: Regression Equation and Diagnostic Results for Quality Score

Limit Category (p-value:0.013)
The limit category has a statistically significant effect on the quality score, indicating that different loan limit categories (high, medium, low) contribute meaningfully to variations in the environmental quality score.

Sector (p-value:0.140)
The sector does not exhibit a statistically significant influence on the quality score at a 5% significance level. However, some sector-specific trends may still be explored qualitatively or with additional data.

Quality Classification (High vs. Low): (p-value:0.000)
The quality classification is highly significant, underscoring that high-quality loans (as per your threshold) differ substantially in their environmental impacts compared to low-quality loans.

Model Summary (R-Squared (Adjusted): 79.09%)

Approximately 79.09% of the variance in quality scores can be explained by the model, which includes limit category, sector, and quality classification. This indicates a robust model with good explanatory power.

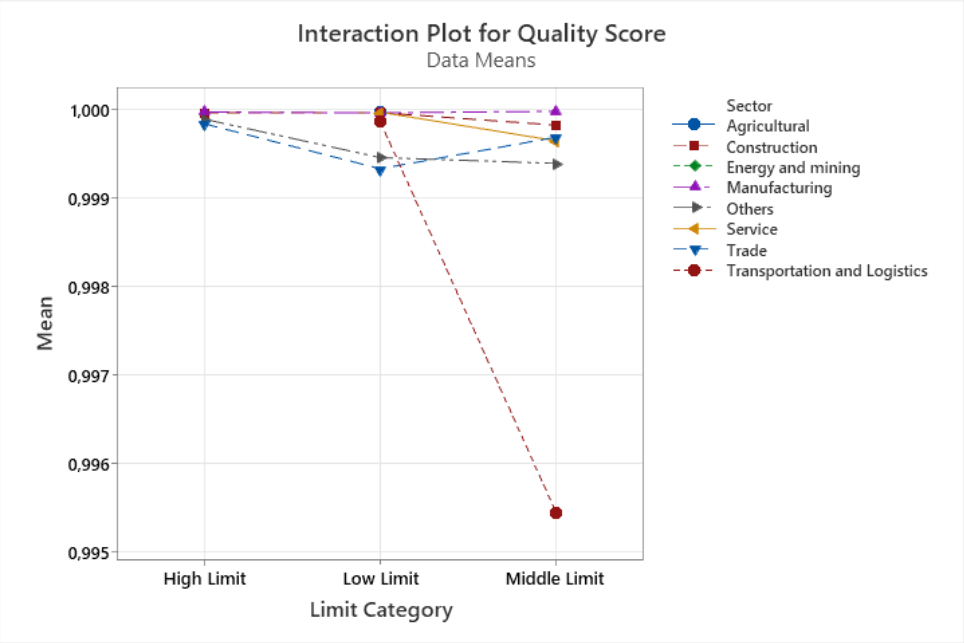

Fig. 7. Interaction Plot for Quality Score Across Limit Categories and Sectors.

The chart illustrates how limit categories (high, medium, low) and sectors influence environmental quality scores. It reveals that some sectors experience a significant drop in quality scores within the low limit category. Notably, the "Transportation and Logistics" sector stands out with a pronounced decrease in the low limit category. This is a key finding for understanding the relationship between sector-based emission impacts and credit limits on quality scores.

The findings indicate that the 'low limit' category in particular causes a decrease in environmental quality scores in some sectors. This result is consistent with the finding by Bashir et al. (2024) and Khan et al. (2022) that financial development can create environmental risks.

5 CONCLUSION

This study aimed to analyze the impact of commercial loans provided in a participation bank on the environmental quality score on a sector basis. The obtained data set was analyzed with Anova after various filtering. In the findings obtained as a result of

Anova, it was determined that the limit categories had a significant impact on the environmental quality score, while no significant result was found in sector-based effects. In addition, quality classification was analyzed in Anova. It was also seen that this had a strong impact.

This study also emphasized the importance of Green Asset Ratio (GAR), which is stated to be mandatory by the Banking Regulation and Supervision Agency (BRSA), on financial impacts. It was stated that it is important for banks to include environmental quality as a metric in their credit evaluation processes. It also contributes to the literature by presenting a model on the environmental impacts of commercial loans.

The study largely fulfilled the determined aim by analyzing the impacts of credit classification on environmental quality. However, more data and detailed analyses are required to explain the variations on a sector basis. In particular, by accessing data such as the maturity period of the loans used in the PCAF method, the remaining debt amount, and the size of the company, a more accurate analysis of the calculations will increase the reliability of the study.

In future studies, the effects of sectors on environmental quality can be examined in detail by focusing on more sectoral variables. A wider data set can be used to improve the model. Sectoral emission factors can be taken from company-based reports for more accurate estimation of carbon emissions. This study focused more on environmental quality, and future studies can also focus on financial quality.

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Appendix

The dataset includes 159 entries detailing the loan amounts, sectors, and calculated carbon emissions.

For full access to the dataset analyzed in this study, please refer to the following link: [https://docs.google.com/spreadsheets/d/1nh1m4W9pdidX0FHQ5DxXRJtvflOBM9Ps/edit?usp=sharing&ouid=104325492325579495122&rtpof=true&sd=true]. This dataset contains anonymized records of commercial loans and their associated environmental impact scores.

Evaluating the Quality Performance of E-commerce Platforms in Turkey

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Abstract

Quality is a concept that has been present in our lives since before the Common Era. In recent years, quality has become a significant fact for organizations in acquiring competitive advantage besides economic concerns. Many studies have been published to determine factors influencing quality. These factors play key role in this study, which aims to measure the performance of the 12 most used e-commerce websites in Turkey. It is decided to use the Data Envelopment Analysis (DEA) model for performance measures. To conduct this measurement, input and output factors that influence and are influenced by quality are first identified. The inputs include the monthly average number of non-member and non-shopping visitors on the sites. The output includes the number of shopping visitors, net earnings, and the average time visitors spend on the site. A publicly available open-source data library is used for these 12 e-commerce websites in Turkey that are Decision-Making Units (DMUs). Using the collected data, performance measurement is conducted through the Improved Common Weight DEA model which is developed by Karsak and Goker (2020). The greatest advantage of this model is that it is designed to determine the most efficient DMU. The model is solved using CPLEX through GAMS tools. The results of the model show that mavi.com.tr emerges as the most efficient among the e-commerce websites. This assessment can serve as a valuable reference for e-commerce websites in Turkey that want to evaluate their quality in comparison to competitors. Additionally, it provides guidance for newly established websites. Beyond these advantages, the study also presents evidence that quality performance is influenced by factors beyond economic considerations.

Keywords: Quality, Performance Measurement, Common Weight DEA

1 INTRODUCTION

Quality has been important for centuries, as seen in the pyramids built by the ancient Egyptians. The Greeks began to apply independent artistic and architectural ideas that is, their art began to show what we term artistic personality or freedom. This is roughly the equivalent between a scientific discovery and its use with greater mechanical ease in daily life. In addition to these vast achievements, the Romans had quality in mind

when building their cities [1]. Quality has since contributed in no small measures to human advances, affecting many facets of contemporary life.

Quality serves as a key indicator of performance across a wide range of sectors, from manufacturing to services. In manufacturing, quality assessments typically focus on the end product, and research in this area often explores how tools like ISO certifications or Six Sigma practices influence final product quality [2] [3]. In contrast, definitions of quality in the service sector tend to vary. For instance, in a hospital setting, quality might refer to the demeanor of medical staff towards patients or the effectiveness of sterilization procedures [4] [5].

The rise of the internet in the 1990s, followed by the surge in e-commerce in the early 2000s, has made performance measurement in this domain a prominent topic in academic literature [6]. Numerous studies have identified factors that influence the perceived quality of e-commerce platforms. These include the site's visual appeal, clarity of layout, and the accuracy of the information provided [7] [8]. However, trustworthiness has emerged as one of the most critical elements [9], driven by aspects such as data security and legal credibility [10]. In addition to site quality, the quality of the purchased product and its delivery process also shape users' overall perception of the platform [11].

Taking these elements into account, this study seeks to evaluate the quality performance of the most frequently used e-commerce platforms in Turkey. The assessment is conducted through Data Envelopment Analysis (DEA). Inputs for the analysis include the average monthly number of non-registered visitors and the number of registered users who only browse. Outputs are defined as the conversion rate, net revenue, and average time users spend on the site.

The remaining portion of the research is structured as outlined below. Section 2 provides a review of the literature about quality studies on e-commerce websites. Section 3 presents the methodology used in this study. Section 4 presents the pertinent datasets and their computational outcomes. Lastly, a summary of the conclusions and future research directions are offered in section 5.

2 LITERATURE REVIEW

In the previous section, various factors influencing the quality of e-commerce websites were discussed. After identifying the factors that influence quality, numerous studies have been conducted in the literature to measure the performance among these sites. Barnes & Vidgen created a survey based on the identified factors and administered it to individuals using the three selected sites [12]. They attempted to measure performance based on the survey results. The results of these surveys can be analyzed in various ways. [13] completed performance measurements from surveys using fuzzy hierarchical TOPSIS. Many other researchers have also attempted to measure quality through surveys [14] [15]. However, these studies have limitations. Respondents to surveys may be unwilling to participate, and another issue is that survey

responses can vary from person to person. Even if a large number of people respond, it may not provide access to all users of the site.

In the literature, various methods have been employed as alternatives to subjective quality measurement. One of these methods is the Data Envelopment Analysis (DEA). DEA is a method used to compare the efficiencies of entities with similar characteristics by utilizing inputs and outputs [16]. Yang and his friens used this method to measure performance among the most widely used e-commerce sites globally [17]. Differently, studies conducted with surveys, economic metrics are considered as a factor influencing quality in this approach. DEA conducts measurements metrics such as total assets, unique vistors etc. [18] but survey results can also be used as inputs and outputs. While Wen and his colleagues conducting performance measurements of websites, requested evaluations from web design experts based on factors such as usability and service quality. They asked experts to provide ratings on a scale of 1 to 7. Subsequently, these ratings have been utilized as a form of output in the model [19].

While there have been numerous studies in the literature, there is a notable absence of research on the quality performance measurement of Turkish e-commerce websites. Hence, the primary contributions of this study can be outlined as follows:

1. Identifying the indicators that significantly affect and are significantly affected by the quality of e-commerce websites.
2. Providing a performance evaluation of e-commerce websites relative to each other using these indicators.
3. It provides strategic directions for managers and employees who aim to improve the quality of e-commerce websites.

3 METHODOLOGY

DEA is a nonparametric approach utilized for assessing the relative efficiency of performance metrics among a group of homogeneous decision-making units (DMUs) with specified inputs and outputs [20]. In these models, the primary objective is to minimize inputs and maximize outputs. The primary DEA model, known as CCR (Charnes, Cooper, and Rhodes), was formulated [16]. Two variations of the CCR DEA model exist based on changes in objective functions, specifically, input-oriented and output-oriented models, which involve desirable inputs and outputs. The input-oriented CCR-DEA model assesses the relative efficiency of Decision Making Units (DMUs) by maximizing the ratio of the total weighted output to the total weighted input. The constraint of this model requires that the output-to-input ratio of each DMU should be less than or equal to one.

The CCR-DEA model can be expressed as follows:

$$\max E_{jo} = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

subject to

$$\begin{aligned} \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} &\leq 1\,, \\ u_r\,, v_i \quad &\geq \varepsilon\,, \qquad \forall\, r, i\,. \end{aligned} \tag{3.1}$$

where E_{j0} represens the efficiency score of the assesed DMUj. The weight of output r is denoted as u_r while v_i represents the weight of input i. The yield of output r produced by DMUj is given by y_{rj}, and x_{ij} represents the amount of input i consumed by DMUj. Addionally, ε is a small positive scalar.

$$\max E_{jo} \;=\; \sum_{r=1}^{s} u_r y_{rj0}$$

subject to

$$\begin{aligned} \sum_{i=1}^{m} v_i x_{ij0} \;&=\; 1\,, \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \;&\leq\; 0\,, \qquad \forall j, \\ u_r\,, v_i \quad &\geq\; \varepsilon\,, \qquad \forall\, r, i\,. \end{aligned} \tag{2.2}$$

Although the CCR model is an effective tool for performance measurement, its low discriminating power has led to the need for the development of other models. One of the models developed in response to this need is the common-weight DEA model. Unlike conventional DEA models, the common-weight DEA models use a set of unique weights for evaluating all the DMUs [21]. One of common weight model was proposed for identifying efficient DMUs using multiple inputs and outputs [22]. The model aims to minimize the maximum deviation from ideal efficiency, which indicates its minimax efficiency model. The model is structured in two stages. In case the first stage results in identifying the one efficient DMU, the model then proceeds to the second stage. The first stage of the model is presented as follows:

$$\min\ \theta$$

subject to

$$\begin{aligned} \theta - d_j &\geq 0, \qquad \forall j\,, \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + d_j &= 0, \qquad \forall j\,, \\ \sum_{r=1}^{s} u_r + \sum_{i=1}^{m} v_i &= 1, \\ u_r\,, v_i &\geq \varepsilon\,, \qquad \forall\, r, i, \\ d_j &\geq 0\,, \qquad \forall\, j\,. \end{aligned} \tag{2.4}$$

where d_j indicates the deviation of jth DMU from efficiency score of 1 (d_j =1-E_j, where E_j represents the efficiency of DMUj), θ is the maximum deviation and ε is a small positive scalar.

If the first stage results in more than one efficient DMU, the model proceeds to the second stage for all DMUs. The second stage is outlined below:

min θ

subject to

$$\begin{aligned}
&\theta - d_j \geq 0, && \forall j, \\
&\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + d_j = 0, && \forall j, \\
&\sum_{r=1}^{s} u_r + \sum_{i=1}^{m} v_i = 1, && \\
&d_j + Mz_j \geq \varepsilon, && j \in EF, \\
&\sum_{j \in EF} z_j = 1, && \\
&z_j \in \{0,1\}, && j \in EF, \\
&u_r, v_i \geq \varepsilon, && \forall r, i, \\
&d_j \geq 0, && \forall j.
\end{aligned} \tag{2.5}$$

where M represents a significantly large positive value, z_j is a binary variable that takes the value of 1 exclusively for the most efficient DMU and EF demonstrates the set of efficient DMUs identified according to the results of the first stage of the model.

4 RESULTS

4.1 Design of Experiment

Firstly, input and output indicators are chosen to design numerical experiments. The primary goal in these studies is to minimize inputs and maximize outputs, and therefore, the choices are made in this direction. In the DEA literature, employee number, expenses are frequently used as input [23] [18] [19]. However, [24] mentioned that many visitors browse e-commerce websites throughout the day without becoming members or making any purchases, and this contributes to server slowdowns. Slowness of these sites reduces quality. Therefore, the inputs are defined as the average monthly number of visitors who enter the site without becoming members (A) and the average monthly number of users who become members but only visit the site (B). Economic metrics and conversion rates are frequently used as output [25] [23]. Economic metrics and conversion rates are directly influenced by quality. Organizations perceived as high

quality tend to have higher economic metrics [26]. The outputs are determined as the conversion rate (C), which represents the monthly average number of users who become members and make purchases, net earnings (D), and the average time users spend on the site (E). In literature, the average time spent on the site has not been used as an output. However, it is added, taking into consideration that users find the site of higher quality when they spend a long time on it, and therefore, they do not exit immediately.

Subsequently, the 12 most widely used e-commerce sites in Turkey is selected as DMUs. The average monthly number of visitors who enter the site without becoming members in 2022 (A), the average monthly number of users who become members but only visit the site in 2022 (B), and the conversion rate in 2022 (C) for e-commerce websites in 2022 are obtained from publicly available data sources on the Guesswork website. The net earnings in 2022 are found by publicly available data sources on the ecommercedb. The average time users spend on the site in 2022 are obtained from publicly available data sources on the similarweb website. Table 1 represents the input and output values in 2022 for these 12 DMUs.

Table 1. e-Commerce Websites Input and Output Data in 2022

e-commerce websites / Data	A (million)	B (thousand)	C (thousand)	D ($ million)	E (second)
adidas.com.tr (1)	1.6	96.9	56.1	57.7	240
Beymen.com (2)	1.3	67.2	25.2	53.6	194
Boyner.com.tr (3)	4.3	305.9	193.2	110.0	276
dr.com.tr (4)	10.1	508.8	169.6	69.6	160
decathlon.com.tr (5)	2.6	269.7	324.8	51.5	120
defacto.com.tr (6)	5.9	359.1	207.9	110.4	107
hepsiburada.com (7)	59.5	4865.4	4347.8	768.7	383
mavi.com (8)	1.5	158.1	202.3	68.2	294
mediamarkt.com.tr (9)	8.1	325.9	60.5	154.4	195
morhipo.com (10)	9.5	774.6	692.2	98.7	114
teknosa.com (11)	8.9	451.2	150.4	118.9	216
trendyol.com (12)	20.8	1699.5	1518.7	3864.6	512

To obtain more accurate results, each input and output is normalized separately using linear normalization. (i.e. x_{ij}/x_i^* , where $x_i^* = max_j(x_{ij})$ for all inputs and y_{rj}/y_r^* , where $y_r^* = max_j(y_{rj})$ for all outpus)[27]. The normalized data is represented in Table 2.

Table 2. e-Commerce Websites Input and Output Normalized Data

e-commerce websites / Data	A	B	C	D	E
adidas.com.tr (1)	0.026891	0.019916	0.012903	0.014930	0.468750
Beymen.com (2)	0.021849	0.013812	0.005796	0.013869	0.378906

Boyner.com.tr (3)	0.072269	0.062873	0.044436	0.028463	0.539063
dr.com.tr (4)	0.169748	0.104575	0.039008	0.018010	0.312500
decathlon.com.tr (5)	0.043697	0.055432	0.074704	0.013326	0.234375
defacto.com.tr (6)	0.099160	0.073807	0.047817	0.028567	0.208984
hepsiburada.com (7)	1.000000	1.000000	1.000000	0.198908	0.748047
mavi.com (8)	0.025210	0.032495	0.046529	0.017647	0.574219
mediamarkt.com.tr (9)	0.136134	0.066983	0.013915	0.039952	0.380859
morhipo.com (10)	0.159664	0.159206	0.159207	0.025540	0.222656
teknosa.com (11)	0.149580	0.092736	0.034592	0.030766	0.421875
trendyol.com (12)	0.349580	0.349303	0.349303	1.000000	1.000000

4.2 Model Results and Discussions

The model is solved using the CPLEX v.22.1.0.0 solver through GAMS v.41.5.0. The model results are presented in Table 3.

Table 3. e-Commerce Websites Model Results

e-commerce websites / Data	Result	Ranking
adidas.com.tr (1)	0.9936	4
Beymen.com (2)	0.9943	3
Boyner.com.tr (3)	0.9813	5
dr.com.tr (4)	0.9545	10
decathlon.com.tr (5)	0.9981	2
defacto.com.tr (6)	0.9762	6
hepsiburada.com (7)	0.8224	12
mavi.com (8)	1.0000	1
mediamarkt.com.tr (9)	0.9663	8
morhipo.com (10)	0.9717	7
teknosa.com (11)	0.9596	9
trendyol.com (12)	0.9380	11

Based on the results of the three models, mavi.com.tr is identified as an efficient among e-commerce websites. According to the Karsak & Goker's model, if multiple efficient websites are identified in the first step, the analysis proceeds to a second step.

However, since only one efficient website is identified in the first step, there was no need for further analysis.

Karsak & Goker's common weight DEA models identify hepsiburada.com and trendyol.com as the worst-performing website in comparison. Although trendyol.com has the highest net earnings compared to other e-commerce websites, the high average monthly number of visitors who enter the site without becoming members, as well as the high average monthly number of users who become members but only visit the site, have made it inefficient. In other words, the e-commerce website with the highest net earnings performs worse compared to other e-commerce websites based on this study's quality metrics.

CONCLUSION

Quality, a concept that has been part of our lives for thousands of years, has become a significant concern for organizations in the face of increasing competition. With the development of the internet since the 1990s, e-commerce websites have also been competing in terms of quality. In this study, a quality performance measurement is conducted using the DEA (Data Envelopment Analysis) method for the 12 most widely used e-commerce websites in Turkey. The inputs are defined as the average monthly number of visitors who enter the site without becoming members and the average monthly number of users who become members but only visit the site. The outputs are determined as the conversion rate, net earnings, and the average time users spend on the site. These input and output data for 12 e-commerce websites for the year 2022 were collected from publicly available online data sources. One of the common-weight DEA model is selected to assess the performance of e-commerce websites relative to each other. These models are solved using the CPLEX solver within the GAMS tool. According to the results of the linear CCR DEA model, Beymen.com, mavi.com, and trendyol.com are identified as efficient among DMUs. In contrast, the common weight DEA models identified only mavi.com as an efficient among the e-commerce websites. This demonstrates the strong discriminating power of the common weight DEA models. Another finding is that measuring quality solely based on economic factors is inadequate. When other quality metrics are considered, e-commerce websites with high net earnings are found to be inefficient.

This study focuses exclusively on e-commerce websites in Turkey. In future research, quality performance measurement could be extended to frequently used e-commerce websites in other countries. Additionally, this study only considered desirable outputs. Future studies could also consider undesirable outputs, such as bounce rate, which indicates the percentage of visitors who leave the site after viewing only one page.

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Strategic Backlog Prioritization: A Management Framework Using the Weighted Sum Model

Abstract

Objectives: This study aims to enhance agile product backlog prioritization in dynamic and resource-constrained environments, with a specific focus on the cybersecurity sector. The Weighted Sum Model (WSM) is applied as a decision-support framework to optimize decision-making processes, integrating business impact, customer value, technical feasibility, security implications, and time sensitivity as key criteria.

Data and Methods: The research adopts a mixed-method approach, combining qualitative insights from expert interviews with quantitative analysis to establish a robust weighting system for prioritization. Criteria were identified and validated through semi-structured interviews, while their relative importance was determined using a Likert scale and normalized for integration into the WSM framework.

Results: The findings reveal that business impact and customer value are the primary drivers of prioritization decisions, significantly influencing backlog ranking. Security implications and time sensitivity were also identified as critical factors, reflecting the need for responsiveness and risk management in cybersecurity contexts. Technical feasibility, while relevant, assumes a secondary role, aligning the decision process with strategic value optimization.

Conclusions: The application of WSM provides a transparent, adaptable, and methodologically sound approach to backlog prioritization, aligning agile development efforts with strategic objectives. Its structured framework enhances decision-making clarity, stakeholder engagement, and cross-functional alignment, making it a valuable tool for agile product management in high-stakes environments like cybersecurity. Future research should explore dynamic criteria adjustments and hybrid decision-support methodologies to further optimize backlog management.

JEL Classification: C61, D81, L86, M15, O32

Keywords: Product Backlog Prioritization, Cybersecurity, Weighted Sum Model, Agile Product Management, Decision-Support Systems, Strategic Alignment

1. Introduction

The strategic prioritization of product backlogs, particularly within industries characterized by high dynamism and rapid technological evolution, such as cybersecurity, is increasingly recognized as a cornerstone of agile product management. The effective alignment of operational activities with overarching strategic objectives is not merely an operational concern but a fundamental business imperative that directly impacts organizational competitiveness, resource efficiency, and stakeholder satisfaction. Within this context, the present study addresses the urgent need for a structured framework to optimize decision-making in product backlog prioritization, a critical process that ensures development teams focus their limited resources on the most valuable and impactful initiatives.

The concept of product backlog prioritization involves systematically ranking tasks, features, or enhancements to deliver maximum value, achieve customer satisfaction, and support long-term organizational objectives. However, traditional approaches to backlog prioritization, often relying on ad hoc or simplistic frameworks, have proven insufficient in addressing the multifaceted challenges of modern development environments. These methods frequently fail to incorporate the complex interplay of criteria such as business impact, customer value, technical feasibility, security implications, and time sensitivity, leading to inefficiencies, misaligned priorities, and suboptimal resource allocation. This research introduces the Weighted Sum Model (WSM) as a robust, transparent, and adaptable decision-support tool to overcome these limitations and enhance the prioritization process within agile frameworks.

Contextualization and Relevance of the Research Topic

In industries such as cybersecurity, where threats evolve rapidly and organizational resilience depends on the ability to adapt swiftly, the prioritization of development efforts becomes particularly critical. Cybersecurity companies must navigate an environment where customer expectations for reliability and innovation intersect with the need to counter emerging vulnerabilities and regulatory demands. As emphasized in the literature (e.g., Fowler, 2018; Ionita et al., 2019), effective backlog prioritization is not only an operational challenge but a strategic necessity for maintaining competitive advantage and safeguarding organizational reputation.

The limitations of existing prioritization frameworks further underscore the importance of this research. Approaches such as *Must Have; Should Have; Could Have; Won't Have* (MoSCoW) method (Leffingwell, 2011) and *Reach; Impact; Confidence; Effort* (RICE) scoring model (Cagan, 2017), while valuable in certain contexts, often lack the methodological rigor to evaluate competing demands within resource-constrained and high-stakes environments like cybersecurity. Multi-Criteria Decision-Making (MCDM) methodologies, including WSM, provide a structured alternative that integrates quantitative and qualitative factors into a coherent decision-making process. This research builds upon prior work in MCDM (Hwang & Yoon, 1981; Belton & Stewart, 2002) and applies WSM within the specific operational context of cybersecurity backlog prioritization, addressing an identified gap in both academic literature and practical applications.

Research Questions and Objectives

This study seeks to answer the overarching question: *How can the Weighted Sum Model (WSM) be applied to optimize product backlog prioritization in the context of a cybersecurity organization?* This primary question is further supported by the following sub-questions:

1. What criteria are most relevant to the prioritization of product backlogs in a cybersecurity context?
2. How can these criteria be systematically weighted and integrated into a decision-making framework?
3. What is the practical impact of implementing WSM on resource allocation, operational efficiency, and strategic alignment?

The primary objective of this research is to develop and validate a WSM framework tailored to the specific needs of cybersecurity companies thereby enabling a transparent and data-driven approach to backlog prioritization. This objective is operationalized through several key goals: first, to identify and define the prioritization criteria through expert consultation; second, to establish a rigorous weighting system that reflects the relative importance of each criterion; and third, to demonstrate the applicability and effectiveness of the WSM framework through a practical case study.

Motivation and Problem Statement

The motivation for this study arises from the inherent complexities of managing product backlogs in cybersecurity, a field where the rapid pace of technological change, the unpredictability of threat landscapes, and the need for compliance with evolving regulations converge to create a uniquely challenging operational environment. As highlighted by Ionita et al. (2019) and Springer & Miler (2022), traditional backlog management approaches struggle to accommodate these dynamic factors, often resulting in reactive rather than proactive decision-making processes. Moreover, the lack of a standardized framework for incorporating security considerations into prioritization decisions exacerbates the risk of misaligned development efforts and resource wastage.

This research directly addresses these challenges by leveraging the WSM framework to provide a structured methodology for evaluating and ranking backlog items. By systematically integrating diverse criteria such as business impact, customer value, technical feasibility, security implications, and time sensitivity, the WSM not only ensures alignment with strategic objectives but also enhances the agility and responsiveness of development teams. Furthermore, the transparent nature of the framework facilitates stakeholder engagement, accountability, and cross-functional collaboration, all of which are critical for successful implementation in complex organizational settings.

Structure of the Article

The structure of this article is designed to provide a logical and comprehensive exploration of the research topic. Following this introduction, the Literature Review synthesizes existing knowledge on backlog prioritization, MCDM methodologies, and the application of WSM, establishing the theoretical foundation for the study. The Methodology section details the research design, including the processes for identifying and weighting prioritization criteria through expert interviews and the development of the WSM framework. In the Results and Analysis, the empirical findings are presented, highlighting the finalized

criteria, their weights, and the practical application of WSM in prioritizing backlog items. The Discussion contextualizes these findings within the broader literature, evaluates the strengths and limitations of the framework, and explores its implications for agile management and strategic decision-making. Finally, the Conclusion summarizes the key contributions of the study, reflects on its limitations, and outlines recommendations for future research.

By addressing a critical gap in both academic literature and industry practice, this study contributes to the ongoing evolution of agile methodologies and decision-making frameworks, offering actionable insights for organizations navigating the complexities of modern cybersecurity operations.

2. Literature Review

The review of the literature constitutes a critical foundation for situating the present study within the broader academic discourse on agile product management, decision-making frameworks, and the specific challenges associated with product backlog prioritization. This section explores the evolution of prioritization methodologies, analyzes the theoretical underpinnings of Multi-Criteria Decision-Making (MCDM) frameworks, and systematically justifies the selection of the Weighted Sum Model (WSM) as an appropriate methodology to address the research problem.

Overview of Prioritization Methodologies

Product backlog prioritization, a fundamental component of agile product management, has been the focus of extensive research aimed at enhancing decision-making processes. Traditional approaches such as the MoSCoW method (Leffingwell, 2011) and the RICE scoring model (Cagan, 2017) prioritize simplicity and accessibility, offering structured techniques for ranking tasks based on predefined criteria. However, these methodologies often fall short in addressing the complexities of modern industries characterized by competing priorities and resource constraints (Dalton, 2018).

MCDM frameworks, grounded in decision theory, offer systematic tools for evaluating alternatives based on multiple, often conflicting criteria. Prominent methodologies include the Analytical Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and *ELimination Et Choix Traduisant la REalite* (ELECTRE). Recent studies (Zavadskas et al., 2022; Thokala et al., 2021) highlight the versatility of these frameworks in integrating both quantitative and qualitative factors, making them particularly suitable for complex decision-making scenarios.

Recent Developments in Agile Prioritization

In recent years there have been significant advancements in backlog prioritization methodologies, with a growing emphasis on integrating advanced technologies and stakeholder-centric approaches. Notably, research by Kravchenko et al. (2020) underscores the importance of aligning prioritization frameworks with organizational strategies to enhance market competitiveness. Similarly, Ionita et al. (2019) emphasize the role of cybersecurity considerations in backlog management, particularly in sectors where risk management is critical.

Emerging studies have also explored the application of machine learning techniques to backlog prioritization. For example, Nguyen et al. (2023) demonstrate the potential of predictive analytics to optimize prioritization decisions by analyzing historical project data. This approach not only enhances

decision-making accuracy but also aligns with agile principles by enabling iterative adjustments based on evolving priorities.

Justification for the Weighted Sum Model (WSM)

Among the various MCDM methodologies, the WSM stands out for its simplicity, transparency, and adaptability. Introduced by Hwang & Yoon (1981), the WSM evaluates alternatives by assigning weights to criteria and aggregating scores to derive a ranking, offering a straightforward yet robust approach to decision-making. Recent studies (Hazelrigg, 2019; Springer & Miler, 2022) affirm the continued relevance of WSM in agile environments, particularly for its computational efficiency and ease of implementation.

The selection of WSM for this study is further justified by its alignment with the specific requirements of product backlog prioritization. WSM is a multi-criteria decision-making framework applied in many contexts and has been used namely for: material selection in biomedical applications (Pesode et al., 2022); robot selection (Goh et al., 1996); query optimization in mobile-cloud database environments (Helff et al., 2016); and urban agriculture farm evaluation (Sathiyaraj et al., 2022). WSM has also been used to determine recipients of community health insurance (Mesran et al., 2017) and special allocation funds (Handoko et al., 2017) and to evaluate location alternatives for manufacturing plants (Suryadi et al., 2023) and this framework has also been combined with entropy technique to evaluate cybersecurity metrics under uncertainty, where it shows its ability to handle complex and uncertain environment (Mohamed et al., 2024). WSM is simple and effective for multi-criteria decision-making. Researchers have proposed modifications to the traditional WSM such as a revised model that reduces the impact of extreme opinions (Goh et al., 1996) and a dynamic version that includes time (Abdullah et al., 2013) and across these various applications WSM always provides an objective and systematic approach to decision-making by allowing the weighting of multiple criteria, it's a valuable tool to generate ranking and recommendations in complex selection process. WSM's ability to systematically integrate and evaluate different criteria underscores its suitability for addressing the complexities of agile product management.

Synthesis of Methodologies and Criteria

The synthesis of the reviewed methodologies and criteria underscores the unique advantages of WSM in addressing the challenges of product backlog prioritization. By providing a transparent, adaptable, and systematic approach, WSM facilitates the integration of diverse criteria into a cohesive decision-making framework. Recent studies, including Nguyen et al. (2023) and Zavadskas et al. (2022), emphasize the relevance of WSM in dynamic environments, where flexibility and stakeholder engagement are critical.

The review of the literature highlights the critical importance of structured decision-making frameworks, such as WSM, in optimizing product backlog prioritization. By synthesizing recent advancements and integrating insights from theoretical and empirical studies, this section establishes the theoretical and practical foundations for the research. The findings underscore the suitability of WSM as a robust and adaptable tool for addressing the complexities of prioritization in dynamic and high-stakes environments. Subsequent sections of this study will detail the methodology employed to develop and validate the WSM framework, present the empirical findings, and discuss their implications for agile project management and strategic decision-making

3. Methodology

This study employed a structured methodology to develop and validate a WSM framework for product backlog prioritization. The approach was designed to ensure rigor, transparency, and applicability to

dynamic organizational contexts. By integrating qualitative insights with quantitative analysis, the research aimed to create a scalable decision-making tool that aligns operational activities with strategic goals.

The research design was anchored in a qualitative framework, leveraging expert interviews to capture domain-specific knowledge and refine the prioritization criteria. This approach ensured that the WSM was tailored to the unique challenges of managing backlogs in fast-paced and resource-constrained environments.

The process unfolded in three distinct phases. The first phase involved identifying and defining the criteria relevant to product backlog prioritization. To achieve this, a preliminary list of key criteria was derived from existing literature and best practices in agile product management. The list was then presented to subject matter experts through semi-structured interviews to refine and validate its relevance. This phase ensured that the final chosen key criteria were both comprehensive and specific to the organizational context.

The semi-structured interview format was chosen for its ability to balance structure with flexibility, allowing experts to elaborate on their perspectives while ensuring that key topics were consistently addressed. The interviews were conducted individually to avoid group thinking and encourage candid responses. Each session lasted between 60 and 90 minutes and was guided by a predefined protocol that included open-ended questions and prompts for clarification.

Thematic analysis was employed to analyze the qualitative data from the interviews. This approach involved coding the transcripts to identify recurring themes and patterns, which were then synthesized into a final set of prioritization criteria. The analysis revealed five primary criteria: business impact, customer value, technical feasibility, security implications, and time sensitivity. These criteria were the basis of the tailored WSM framework.

The second phase focused on weighting the criteria to reflect their relative importance in the decision-making process. Experts were asked to rate each criterion on a Likert scale ranging from 1 (least important) to 10 (most important). To mitigate bias, the ratings were collected independently, and each expert was also asked to rank the criteria in order of importance. This dual approach provided both numerical and ordinal data, enhancing the robustness of the weighting process.

The collected data were analyzed using statistical measures such as mean, median, and standard deviation to assess the level of agreement among experts. The median was selected as the primary statistic for determining the final weights, as it is less influenced by outliers and provides a more stable measure of central tendency in small sample sizes. The weights were then normalized to ensure they summed to one, making them directly comparable and suitable for integration into the WSM.

The third phase involved designing the WSM framework and demonstrating its application through a hypothetical scenario. The framework calculates a weighted score for each backlog item based on its performance across the defined criteria.

A hypothetical example was used to illustrate the framework's application. Two backlog items were evaluated based on their scores across the five criteria, and the resulting weighted scores determined their relative priorities. This demonstration validated the framework's utility in providing clear and actionable insights for prioritization decisions.

Throughout the research process, ethical considerations were paramount. Participants were informed about the study's objectives and provided consent to participate. Confidentiality was maintained, and the data were anonymized to protect the identity of the experts. Additionally, measures were taken to minimize bias,

such as conducting individual interviews and employing structured protocols for data collection and analysis.

The methodology adopted in this study aligns with best practices in multi-criteria decision-making research. By integrating qualitative insights with quantitative analysis, the research ensures that the WSM framework is both contextually relevant and methodologically robust. The iterative process of criteria refinement, weighting, and validation reflects the principles of transparency and adaptability, which are critical for decision-making in dynamic environments.

The methodology employed in this study provides a solid foundation for the development and application of the WSM in backlog prioritization. By engaging experts, leveraging structured analytical techniques, and adhering to ethical standards, the research delivers a framework that is both theoretically sound and practically applicable. The next sections of this article will present the results of applying this methodology and discuss its implications for agile project management and strategic decision-making.

Data Collection Through Semi-Structured Interviews

The semi-structured interview format was chosen for its flexibility and ability to capture nuanced insights, balancing a guided approach with the opportunity for participants to elaborate on their perspectives. A predefined interview protocol was developed to ensure consistency across sessions while allowing for the exploration of emergent themes. The protocol included questions designed to:

1. Identify the key criteria for evaluating product backlog items in a cybersecurity context;
2. Explore the relative importance and weighting of each criterion.

The expert panel consisted of key stakeholders from product management, engineering, and user experience teams, ensuring a holistic perspective on backlog prioritization. Each interview lasted between 60 and 90 minutes and was conducted individually to avoid groupthink and encourage candid responses. The qualitative data obtained from these interviews were analyzed using thematic analysis, which involved coding the transcripts to identify recurring patterns and themes.

Weighting and Aggregation of Criteria

Once the final set of criteria was established, the next phase focused on assigning weights to reflect their relative importance. This step was critical to ensuring that the WSM framework accurately represented the priorities and strategic objectives of the organization. The weighting process combined quantitative and qualitative techniques to enhance robustness as follows:

1. Rating Scale: Each criterion was rated on a scale of 1 to 10, where 1 represented minimal importance and 10 represented critical importance. Ratings were collected independently from each expert to minimize bias;
2. Ranking Exercise: Experts were also asked to rank the criteria in order of importance, providing ordinal data to complement the numerical ratings;
3. Normalization: The ratings were normalized to ensure that the weights summed to one, making them directly comparable and suitable for integration into the WSM framework.

The aggregated data from the rating and ranking exercises were analyzed using statistical measures, including mean, median, and standard deviation, to assess the level of agreement among experts. The median was selected as the primary statistic for determining the final weights, as it is less influenced by outliers and provides a stable measure of central tendency.

Development of the WSM Framework

The WSM framework was constructed by combining the weighted criteria with scores assigned to individual backlog items based on their alignment with each criterion. The total score for each backlog item was calculated using the total score for backlog item, the weight assigned to criterion and the score of backlog item for criterion. The weighted scores for each criterion were aggregated to generate a final ranking of backlog items, providing a clear and actionable prioritization framework. Table 1 presents the final criteria and their respective weights.

Table 1. Final Criteria and Weights

Criterion	Weight
Business Impact	0.26
Customer Value	0.26
Technical Feasibility	0.08
Security Implications	0.18
Time Sensitivity	0.22

The methodology employed in this study integrates rigorous academic principles with practical insights, ensuring the relevance and robustness of the WSM framework. By systematically identifying and weighting key criteria, the research provides a transparent and adaptable approach to product backlog prioritization in a cybersecurity context. The inclusion of tables and figures enhances the comprehensibility of the methodology, aligning with best practices in academic reporting. Subsequent sections will detail the application of the WSM framework and analyze its implications for agile project management and strategic decision-making.

4. Results and Analysis

The application of the WSM framework to product backlog prioritization provided a comprehensive understanding of the interrelationship between strategic objectives and operational demands. This section presents the findings of the study, detailing the finalized criteria and their weights, alongside the results of applying the framework to a hypothetical scenario. Additionally, the implications of these results are discussed, highlighting their relevance to agile project management.

Criteria and Weights

Through a rigorous process involving a literature review and semi-structured interviews, five key criteria were finalized for the WSM framework: business impact, customer value, technical feasibility, security

implications, and time sensitivity. The process ensured these criteria reflected both theoretical insights and practical needs, aligning with best practices and operational priorities.

To determine the relative importance of these criteria, domain experts rated and ranked them using a predefined protocol. The results were analyzed statistically, with the median selected as the primary measure to minimize the influence of outliers. The normalized weights derived from this process are shown in Table 2.

Table 2. Criteria and Weights

Criterion	Normalized Weight
Business Impact	0.263
Customer Value	0.263
Time Sensitivity	0.211
Security Implications	0.184
Technical Feasibility	0.079

The relative importance of business impact and customer value underscores their critical role in driving prioritization decisions, as these criteria directly influence organizational growth, market competitiveness, and customer satisfaction.

Application of the WSM Framework

To demonstrate the utility of the WSM framework, a hypothetical scenario was constructed, involving the prioritization of two backlog items—Feature A and Feature B. Each feature was scored against the five criteria using a scale of 1 to 10, with higher scores indicating stronger alignment with the criterion. The criteria weights were applied to calculate a weighted score for each feature, as illustrated in Table 3.

Table 3. Feature Evaluation and Weighted Scores

Criterion	Weight	Feature A	Feature B
Business Impact	0.263	8	5
Customer Value	0.263	7	9
Technical Feasibility	0.079	6	7
Security Implications	0.184	9	6
Time Sensitivity	0.211	8	7

Feature A achieved a higher weighted score, indicating its stronger alignment with strategic objectives. This result emphasizes the utility of the WSM framework in systematically evaluating and prioritizing tasks based on diverse criteria.

Analysis of Results

The findings highlight the pivotal role of business impact and customer value in backlog prioritization, as evidenced by their high weights and influence on decision-making outcomes. Backlog items with significant potential to enhance revenue, market differentiation, or customer satisfaction were consistently prioritized, aligning with organizational strategic goals. This aligns with the literature, which underscores the necessity of aligning operational activities with broader objectives (Fowler, 2018; Springer & Miler, 2022).

Time sensitivity emerged as another critical factor, particularly in dynamic environments where addressing urgent issues such as regulatory compliance or emerging threats is paramount. This criterion's weight reflects the need for agility and responsiveness in decision-making, ensuring that immediate challenges are effectively managed without compromising long-term priorities.

Security implications, while assigned a slightly lower weight, remain essential in scenarios where neglecting security considerations could result in significant reputational or financial risks. This finding is consistent with the recommendations of frameworks such as the Secure by Design framework (CISA, 2023) and the Secure Software Development Framework (NIST, 2022), which advocate for integrating security into development workflows.

Technical feasibility, though weighted lower, was not disregarded in decision-making. Instead, it played a secondary role, allowing tasks with higher complexity to be prioritized when their strategic value justified the resource investment. This reflects a deliberate focus on achieving high-impact outcomes and fostering innovation, even in challenging operational contexts.

Implications and Relevance

The application of the WSM framework revealed several strengths. Its transparency facilitates stakeholder engagement and accountability, as decisions are based on clearly defined and documented criteria. The adaptability of the framework ensures its relevance in evolving environments, allowing recalibration of criteria and weights as organizational priorities shift. Additionally, the model balances strategic and operational considerations, providing decision-makers with a holistic tool for backlog prioritization.

By systematically integrating diverse criteria into a coherent decision-making process, the WSM framework enhances resource allocation, accelerates responsiveness, and aligns development efforts with strategic objectives. These findings have practical implications for managers seeking to optimize backlog prioritization in dynamic industries, offering a structured and data-driven approach to addressing complex challenges.

Subsequent sections will further discuss the broader implications of these findings, addressing limitations and proposing directions for future research.

5. Discussion

The application of the WSM to backlog prioritization offers valuable insights into the integration of operational decision-making with strategic objectives, particularly in dynamic and resource-constrained environments. This section critically examines the findings of this study in the context of existing

management literature, situating the results within broader theoretical and practical frameworks while evaluating their strengths, implications, and limitations.

Alignment with Strategic and Operational Priorities

One of the most significant contributions of this study is the identification and systematic weighting of five core criteria—business impact, customer value, technical feasibility, security implications, and time sensitivity—which collectively encapsulate the essential dimensions of product backlog prioritization in agile settings. These criteria reflect a holistic approach to balancing competing demands and ensuring that resource allocation aligns with organizational priorities. Business impact and customer value emerged as the most heavily weighted criteria, underscoring their pivotal role in driving outcomes that enhance market competitiveness and customer satisfaction. This prioritization aligns with established research emphasizing the importance of these factors in strategic decision-making.

The inclusion of time sensitivity highlights the framework's capacity to address immediate operational challenges while maintaining a focus on long-term objectives. For instance, backlog items with tight regulatory deadlines or urgent risk mitigation requirements received higher priority, demonstrating the framework's adaptability in dynamic contexts. This finding aligns with studies on agile management that stress the importance of flexibility and responsiveness in decision-making processes.

Security implications, although moderately weighted, remain integral to backlog prioritization, particularly in sectors where risk management and compliance are critical. The results reinforce the necessity of embedding security considerations into development workflows, consistent with best practices recommended by frameworks such as Secure by Design (CISA, 2023) and the Secure Software Development Framework (NIST, 2022). By addressing vulnerabilities and regulatory requirements, organizations can enhance their resilience and safeguard stakeholder trust.

Practical Implications of the WSM Framework

The WSM framework's transparency and adaptability emerged as key strengths, fostering stakeholder engagement and ensuring accountability in the prioritization process. By relying on clearly defined and systematically weighted criteria, the model provides a common language for evaluating trade-offs and aligning cross-functional efforts. This feature is particularly relevant in agile environments, where collaboration across diverse teams is essential for achieving organizational goals.

Moreover, the adaptability of the framework enhances its applicability in evolving operational contexts. The ability to recalibrate weights and criteria in response to shifts in market dynamics or organizational priorities ensures the model's continued relevance. For example, organizations can increase the weight of time sensitivity during periods of heightened regulatory scrutiny or adjust the emphasis on customer value to align with shifting consumer preferences.

The results also underscore the importance of prioritizing tasks based on their potential strategic value rather than their ease of implementation. Technical feasibility, the lowest-weighted criterion, reflects a deliberate focus on high-impact outcomes, fostering innovation and long-term growth. This finding aligns

with research advocating for resource allocation that prioritizes strategic contributions over operational convenience (Pichler, 2010).

Strengths and Limitations

While the WSM framework demonstrates significant strengths, including its transparency and systematic approach, certain limitations warrant consideration. One notable challenge lies in ensuring the accuracy and consistency of input data, as biases in expert assessments or inconsistencies in scoring criteria can compromise the reliability of the results. To mitigate this issue, rigorous training for participants involved in the weighting process and clear, standardized definitions for each criterion are essential. Additionally, employing iterative scoring rounds with feedback mechanisms could enhance the robustness and reliability of the results.

Another limitation is the framework's assumption of additive relationships among criteria. This linear approach may oversimplify the interdependencies between factors, such as the interaction between time sensitivity and security implications, which could amplify the prioritization of certain tasks under specific conditions. Addressing this limitation may require exploring hybrid models that integrate WSM with complementary decision-making methodologies to better capture complex prioritization dynamics.

Integration with Existing Literature

The findings of this study align with and extend the existing body of literature on agile project management and decision-making frameworks. By providing a structured and transparent methodology for backlog prioritization, the WSM framework addresses key challenges identified in previous research, including the need for adaptability, stakeholder engagement, and alignment with strategic objectives (Dalton, 2018; Fowler, 2018). Additionally, the study's emphasis on integrating diverse criteria into a cohesive decision-making process reinforces the value of multi-criteria approaches in dynamic organizational environments (Belton & Stewart, 2002).

The inclusion of security considerations within the WSM framework is particularly noteworthy, given the growing emphasis on risk management and regulatory compliance in contemporary management literature (CISA, 2023; NIST, 2022). This integration highlights the relevance of the model in addressing emerging challenges in agile software development and cybersecurity.

The application of the WSM framework to product backlog prioritization demonstrates its utility as a practical and effective tool for aligning operational activities with strategic objectives. By systematically integrating diverse criteria and providing a transparent, adaptable approach to decision-making, the framework addresses many of the complexities inherent in agile management. While certain limitations, such as the assumption of additive relationships and the potential for input biases, warrant further investigation, the strengths of the model underscore its potential for enhancing prioritization processes in dynamic environments. Future research could explore the development of hybrid methodologies, the automation of the framework for scalability, and its application across diverse industry contexts, thereby solidifying its role as a cornerstone of effective product backlog prioritization.

6. Conclusion

This study has demonstrated the applicability and effectiveness of the WSM as a structured and transparent decision-making framework for product backlog prioritization in agile product management. By addressing the complexities of balancing strategic objectives with operational demands, the WSM framework has provided a systematic approach to evaluating and ranking backlog items based on clearly defined and weighted criteria. These criteria—business impact, customer value, technical feasibility, security implications, and time sensitivity—were identified as central to prioritization processes, ensuring alignment with both immediate operational needs and long-term strategic goals.

Findings of the Study

The findings underscore the critical importance of prioritizing tasks that deliver measurable value, with business impact and customer value emerging as the most influential criteria. This prioritization not only supports organizational success and stakeholder satisfaction but also reflects the necessity of aligning development efforts with overarching business strategies. The inclusion of time sensitivity and security implications highlights the need for responsiveness and risk management in environments characterized by rapid change, regulatory pressures, and technological advancements in a cybersecurity context. Although technical feasibility was assigned a lower weight, it remains a crucial consideration for ensuring the practical implementation of prioritized tasks without undermining strategic imperatives.

A key strength of the WSM framework lies in its adaptability. Organizations can recalibrate the weights of criteria or introduce new criteria as priorities evolve, making the model highly suitable for dynamic industries where market conditions and technological progress necessitate continuous reassessment. The framework's transparency further fosters stakeholder engagement and accountability, promoting collaboration across teams and enhancing the legitimacy of prioritization decisions. These characteristics make the WSM framework a robust tool for addressing inefficiencies and misalignments in traditional product backlog management practices.

The study has effectively addressed the research question posed in the introduction: *How can the Weighted Sum Model (WSM) be applied to optimize product backlog prioritization in agile environments?* By demonstrating the integration of structured decision-making with agile principles, the study has achieved its objectives, validating the WSM framework as a practical solution for aligning operational activities with strategic objectives. This alignment ensures that resources are allocated to tasks with the highest potential impact, thereby fostering operational efficiency and long-term competitiveness.

Limitations of the Study

Despite its strengths, the study is not without limitations. The accuracy and reliability of the WSM framework are heavily dependent on the quality and consistency of input data, including the ratings and rankings provided by domain experts. Variability in expert assessments or insufficiently defined criteria could compromise the validity of the results. To mitigate these issues, it is essential to implement rigorous training for participants involved in the weighting and scoring processes and to establish clear, standardized definitions for each criterion.

Another limitation of the WSM framework is its assumption of additive relationships among criteria. This linear approach may not fully capture the complex interdependencies between factors, such as the interaction between time sensitivity and security implications, which could amplify the importance of certain tasks in specific contexts. While the framework provides a strong foundation for prioritization, its robustness could be enhanced by integrating complementary decision-making tools that account for these interdependencies.

Additionally, the study's focus on a hypothetical scenario limits its generalizability. While the findings demonstrate the potential of the WSM framework, its application to real-world case studies would provide more comprehensive insights into its effectiveness and adaptability in diverse organizational contexts. Furthermore, the scalability of the framework in larger organizations or more complex environments remains an area for further exploration.

Future Research

Building on the findings of this study, future research could explore several avenues to enhance the utility and robustness of the WSM framework as follows:

1. Conducting empirical studies that apply the WSM framework to product backlog in a cybersecurity context would validate its practical relevance and identify potential refinements.
2. Integration with Hybrid Methodologies: Incorporating complementary decision-making tools, such as multi-attribute utility theory or entropy-based techniques, could address the limitations of additive relationships and provide a more nuanced understanding of prioritization dynamics.
3. Dynamic Criteria Adjustments: Investigating mechanisms for real-time recalibration of criteria and weights in response to changing priorities or external pressures would enhance the framework's adaptability.
4. Cross-Cultural and Sectoral Analysis: Exploring the application of the WSM framework across different cultural and organizational contexts could reveal variations in prioritization practices and inform the development of more universally applicable models.

By addressing these areas, future research could extend the contributions of this study, ensuring that the WSM framework continues to evolve as a cornerstone of effective product backlog prioritization in agile management. Its capacity to integrate strategic and operational considerations, foster collaboration, and adapt to dynamic environments positions it as a valuable tool for organizations striving to maintain competitiveness in an ever-changing landscape.

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Does Corporate Waste Management Enhance Firms' Access to Trade Credit? International Evidence

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Abstract

This study examines how corporate waste management practices influence firms' access to trade credit, using a comprehensive international sample across 42 countries from 2002 to 2022. Motivated by the growing global focus on climate change, environmental degradation, and sustainable business practices, we explore how suppliers perceive and respond to firms' environmental efforts, particularly waste recycling. Our findings reveal that firms with higher levels of recycling secure more favorable trade credit terms, especially in environmentally sensitive industries where such practices face greater scrutiny. These results are robust across various sensitivity tests, including alternative model specifications, subsample analyses, and after addressing potential endogeneity using two-stage least squares (2SLS), Heckman's selection model, propensity score matching (PSM), and entropy balancing. Our channel analysis indicates that engaging in waste management reduces operational expenses and enhances company value and performance, which in turn leads to increased trade credit. This study provides insights into how corporate environmental strategies influence business relationships and promote sustainable economic practices, advancing the understanding of how green strategies drive business success.

Keywords: Waste management; Trade Credit; Firm Value and performance; Environmentally Sensitive Industries.

JEL classifications: G30, G32, D25, Q53, Q56.

1. Introduction

This paper investigates the extent to which suppliers value corporate environmental strategies, particularly focusing on waste recycling practices, and examines the subsequent impact on firms' access to trade credit. The study is motivated by the urgent and escalating issue of climate change, fueled by greenhouse gas emissions and solid waste generation (Intergovernmental Panel on Climate Change (IPCC), 2007; Prado-Lorenzo et al., 2009). Firms significantly contribute to solid waste generation due to their extensive manufacturing activities, which, in turn, lead to severe environmental degradation. For example, waste production is expected to increase from approximately two billion tons in 2016 to 3.40 billion tons by 2050 (Kaza et al., 2018). This growing scale and complexity of waste from the industrialized economy threatens our ecosystem, detrimentally affecting climate change, biodiversity, pollution, and human health (Hantoko et al., 2021; Parte & Alberca, 2024).

Concerns about the increase in waste and its environmental consequences have placed pressure on firms as their production processes inevitably generate large amounts of waste (Saeed et al., 2024). This, in turn, has prompted firms to adopt sustainable practices, such as waste minimization and recycling (Eccles et al., 2014; Gull et al., 2024). These practices are essential components of sustainable development strategies and are increasingly emphasized in global sustainability frameworks, including the Sustainable Development Goals (SDGs). However, despite the clear evidence of the detrimental impact of waste on the environment, many firms remain reluctant to invest in sustainable waste management practices due to the perceived high costs and long-term nature of these initiatives (King & Lenox, 2002; Seadon, 2010).

Waste management refers to the organized approach of gathering, transporting, treating, and disposing of waste materials in a manner that minimizes environmental harm and ensures adherence to legal requirements. This process often involves the separation of materials,

recycling, and the implementation of appropriate disposal methods (Batista et al., 2021; Das et al., 2019; Pluskal et al., 2021). However, these environmental initiatives often face criticism, owing to their high costs and delayed financial returns. Moreover, they necessitate significant managerial effort, technological innovation, and process redesign (Bao & Lu, 2020; Hart & Ahuja, 1996; Johnstone & Hallberg, 2020; King & Lenox, 2002; Seadon, 2010). Previous research suggests that when companies divert resources from their core operations, they may underfund essential activities, potentially harming financial performance and disrupting operations. Telle (2006), for example, identified a negative relationship between a firm's environmental initiatives and its financial outcomes. More recently, Bao and Lu (2020) indicated that recycling firms encounter difficulties in sustaining long-term operations without government subsidies, which poses risks to both their capital structure and overall viability (Walls et al., 2012).

Conversely, stakeholder-agency theory suggests that companies should focus on generating value for all stakeholders within their long-term strategies and business policies (Clarkson, 1995; Donaldson & Preston, 1995). This prioritization would, in turn, enhance shareholder value (Eccles et al., 2014). Implementing policies that minimize waste and boost recycling provides an opportunity to align a firm's competitive edge with its long-term financial success. Additionally, it allows firms to improve societal well-being and meet the expectations of various stakeholders. Prior literature concludes that firms attentive to stakeholders' environmental concerns achieve better outcomes, such as lower cost of capital (El Ghoul et al., 2011), better financial performance (Gull et al., 2022), reduced risks (Atif & Ali, 2021; Bruno & Henisz, 2024), lower stock price crash risk (Zaman et al., 2021), enhanced brand value and reputation (Fernández-Kranz & Santaló, 2010; Flammer, 2015b; Gangi et al., 2020), boost firm value (Dechezleprêtre et al., 2021; Gallego-Álvarez et al., 2015; Matsumura et al., 2014), and better operating performance (Awaysheh et al., 2020; Gull et al., 2022). Based

on the potential increase in firm value and enhanced of performance documented by these studies, we hypothesize a negative association between corporate waste generation and trade credit and a positive association between waste recycling and trade credit.

We examine these conflicting arguments using an international sample of firms across 42 countries from 2002 to 2022. Our findings reveal a negative relationship between corporate waste production and trade credit and a positive relationship between corporate recycling efforts and trade credit. These results support our hypothesis that suppliers value corporate waste management and incentivize them to extend more favorable credit terms. Our findings remain consistent after (1) accounting for various firm-specific attributes and incorporating fixed effects for year, industry, and country; (2) using alternative samples that exclude periods of financial crisis, the COVID-19 pandemic, and firms from the USA and the UK; (3) using alternative measures of waste generation to ensure the robustness of our findings. Moreover, our results are robust to address potential endogeneity issues using multiple tests such as two-stage least squares estimation (2SLS), Heckman's selection equation, propensity score matching (PSM), and entropy balancing. In an additional test, we find that the mechanisms by which corporate waste generation and recycling affect trade credit are through their effects on operating expenses and firm value. Our final analysis reveals that the impact of waste recycling on trade credit is more significant in environmentally sensitive industries.

We contribute to the growing literature on waste management (Ahsan et al., 2024; Benjamin et al., 2020; Gull et al., 2024; Gull, Atif, et al., 2023; Gull, Luong, et al., 2023; Shahab et al., 2022), which mainly focuses on the determinants of waste management. We contribute to these studies by focusing on the economic consequences of engaging in waste recycling, and how such engagement improves firms' access to trade credit. Consequently, our research enhances the understanding of the economic impact of corporate waste management practices.

Second, our study contributes to research on firms' access to trade credit by examining suppliers' perspectives on their clients' adoption of environmentally friendly practices (Xu et al., 2020; Yang et al., 2019; Zhang, 2020). We extend the literature by introducing a unique dimension: the impact of waste management, as a critical factor in trade credit decisions. Additionally, we demonstrate that reductions in operating costs and improved overall value and performance are the key channels driving these results.

Lastly, our study has an important implication, as it provides a compelling incentive for firms to adopt and enhance their environmental management practices, benefiting not only the firms themselves but also contributing positively to broader environmental goals.

2. Hypothesis development

Economic agents have long begun to adopt green initiatives to mitigate the exploitation of natural resources or the environment, which otherwise produce negative externalities (Farooq et al., 2022; Zhang, 2022). Integrating such green initiatives in a firm's business indicates a good market reputation, which reduces a firm's default risk and enhances its profitability (Atif & Ali, 2021; Gangi et al., 2020). Consistently, Klassen and McLaughlin (1996) observe that environmental management is associated with increased reputation, profitability, growth, market value, and financial performance. Gangi et al. (2020) find similar evidence using a recent international sample.

Prior studies examining the determinants of trade credit have analyzed the association between several sustainable practices. For instance, studies have documented that trade credit is affected by corporate philanthropy (Yang et al., 2019), corporate social responsibility (Cheung & Pok, 2019; Zhang et al., 2020), environmental regulation (Farooq et al., 2022), green credit financing (Gao, 2022), and green innovation (Deng et al., 2023). However, the waste management aspect of green initiatives remains unknown and has not yet been explored.

Understanding the role of waste management in trade credit demands significant attention as it potentially caters to the interests of important stakeholders, leading to enhanced shareholder value.

The alarming and worsening climate issues caused by greenhouse gas emissions and solid waste generation have called for effective climate protection mechanisms, including waste management (Ahsan et al., 2024).[1] In fact, waste management has become an important concern in tackling climate change, as improper waste management enhances pollution, public health hazards, and the deconstruction of habitation (Atawnah et al., 2024). This is partly because generating waste at high levels doubles the use of raw materials during production. Moreover, it causes high energy consumption and carbon emissions, leading to higher production costs and degenerating environmental quality (Alam et al., 2019). Waste management or recycling include the collection, transport, processing, and disposal of waste materials to enhance environmental well-being (Batista et al., 2021; Das et al., 2019; Pluskal et al., 2021). Structural and product reengineering incorporating effective waste management brings about multiple opportunities to integrate firms' competitive strategies, focusing on long-term financial and operational performance, by ensuring that their business activities remain socially responsible for minimizing adverse environmental impact (Ahsan et al., 2024; Atawnah et al., 2024; Gull et al., 2022).

Environmental initiatives (i.e., waste management) entail extensive investment and impact long-term business strategies (Hart & Ahuja, 1996). However, the traditional viewpoint of a firm's profitability suggests that the prime motive of a business must be profit-making while fulfilling the agendas of shareholders' wealth maximization (Friedman, 1970). Hence, when firms prioritize the allocation of cash flows and resources for activities other than core

[1] In fact, the pressure on firms to provide more information related to their policies to their environmental policies have increased rapidly over the years (Gerged et al., 2021).

business operations, they may encounter a shortage of funds for essential primary projects, which adversely affects firm performance. Furthermore, prior studies suggest that the effective implementation of waste management projects requires considerable managerial effort, technological sophistication, and process reengineering (Bao et al., 2020; Bao & Lu, 2021; Johnstone & Hallberg, 2020). For instance, Johnstone and Hallberg (2020) suggest that waste management imposes forced process restructuring, potentially changing how business operations are carried out and possibly creating an excessive cost burden. Additionally, Bao and Lu (2021) argue that recycling companies struggle to sustain long-term operations without government subsidies, which threatens their optimal capital structure and long-term viability (Walls et al., 2012).

In contrast, the prominent argument in line with stakeholder-agency theory contends that companies must prioritize generating value for all stakeholders when devising their long-term strategies (Clarkson, 1995; Donaldson & Preston, 1995). Environmentally degenerating actions, including increased waste generation and insufficient recycling at the firm level, may invite stakeholders' wrath and dissent, leading to several corrective actions such as boycotting firms' products and campaigns to discourage purchases, legal suits against the firm (Bogojević, 2023), reduced employee productivity (Baron, 2001), and circulating unfavorable information about the firm's practices (Branco & Rodrigues, 2006). Furthermore, the functional requirements at the global level and the coexistence of firms' businesses in society make it appealing for firms to undertake projects that are not value-destroying for society, enabling them to widen people's trust (Joyner & Payne, 2002). As a result, firms also need to cater stakeholders' expectations regarding to the effective execution of waste management at the firm level, leading to reduced long-term operation costs and enhanced shareholder value (Eccles et al., 2014).

The superior firm value and enhanced performance achieved through corporate waste management could enable firms to secure better trade credit. Suppliers benefit from extending trade credit to profitable and growing firms in anticipation of capturing promising future businesses (Petersen & Rajan, 1997). Consistently, several studies report that firms' attentiveness to stakeholders' environmental concerns leads to better outcomes, such as lower cost of capital, minimum default risks, higher competitive edge, enhanced brand value, and better operating and financial performance (Atif & Ali, 2021; El Ghoul et al., 2011; Fernández-Kranz & Santaló, 2010; Flammer, 2015a; Gull et al., 2022). Similarly, Mishra and Suar (2010) and Gallego-Álvarez et al. (2015) argue that the incorporation of innovations and engagements to address climate change (i.e., waste generation and recycling) in business practices opens up new opportunities for firms, thus attaining financial competitiveness. Specific to waste recycling, Gull et al. (2022) find that effective waste management enhances operating and financial performance by reducing operation costs.

Waste management also necessitates firms to integrate innovative methods and technologies, enabling them to reduce operational costs, which helps firms secure increased trade credit. For example, large firms striving to improve their environmental management are encouraged to adopt new technologies and update programs and systems to enhance their environmental performance (Darnall et al., 2010; Worthington & Patton, 2005). In line with this argument, several studies have reported that environmental management systems lead to enhanced competitive advantages through reduced operation costs, capturing higher market share, or increased access to capital (Ambec & Lanoie, 2008; Porter & Van Der Linde, 2017). In particular, Gull et al.(2022) find that waste recycling (generation) reduces (increases) operation costs, leading to enhanced financial performance. Reduced operational costs improve profit margins and increase firms' cash flow, enabling them to obtain higher trade credit. For

instance, Peura et al. (2017) argue that increased demand for products will upsurge firms' trade credit financing by improving their profit margins.

Based on the above discussions, we posit that effective waste management fulfills the expectations of important stakeholders like governments and the public, reducing long-term operational costs and increasing firm performance. This will likely help firms improve their business opportunities and cash availability, securing higher and better trade credit financing. Therefore, we hypothesize a positive association between waste recycling and trade credit and a negative association between waste generation and trade credit. Hence, we develop the following hypothesis:

H1: *Waste management is positively associated with higher trade credit.*

3. Research Design

3.1 Data and Sample

To assess the impact of waste management on trade credit, we utilize data from the Thomson Reuters Asset4 database, which offers waste generation and recycling metrics for an international sample of firms (Nadeem et al., 2020). This dataset is combined with the Compustat Global database to gather trade credit and firm-specific details. In line with previous research, countries with fewer than ten firm-year observations are excluded. Additionally, we exclude companies in the utilities (SIC codes 7000–7577) and financial sectors (SIC codes 8000–8995) from our international sample, in line with prior studies. Furthermore, we remove firm-year observations with incomplete data on any variables necessary for the analysis. Our final sample comprises 13,083 firm-year observations over the period between 2002 and 2022, across 42 countries.[2]

[2] The use of international sample overcomes the limitation of existing research and allows for a comprehensive examination of the effect of waste management on trade credit. For example, as noted by (Karaman et al., 2024, p. 2) "existing research exhibits notable limitations, primarily in its focus on single-country contexts or small sample sizes".

3.2 Trade Credit Measures

Following prior studies on trade credit (e.g., Al-Hadi & Hussain, 2025; Hasan & Habib, 2019; Levine et al., 2018; Li et al., 2024; Li et al., 2020; Luo et al., 2023; Ouyang et al., 2024), we rely on four widely used measures of firms' access to trade credit. These are the proportion of accounts payable to the cost of goods sold ($Trade\ Credit_{(AP/COGS)}$); the proportion of accounts payable to firms' purchases ($Trade\ Credit_{(AP/Purchase)}$); the sum of accounts payable, notes payable, and customer deposits divided by the cost of goods sold ($Trade\ Credit_{((AP+NP+DPTC)COGS)}$); and the sum of accounts payable, notes payable, and customer deposits divided by firms' purchases ($Trade\ Credit_{((AP+NP+DPTC)/Purchase)}$).

3.3 Waste Management

Following prior studies (Atawnah et al., 2024; Gull, Atif, et al., 2023; Gull, Luong, et al., 2023; Saeed et al., 2024; Shahab et al., 2022), we use multiple proxies for waste management. Specifically, our first measure is the natural logarithm of the total amount of waste (both hazardous and non-hazardous) generated in tons (*Log(Waste)*). Our second measure is the total amount of waste generated divided by the total assets (*Waste_Assets*). Our third measure captures firms' efforts to manage the waste generated, which is waste recycling (*Recycle_Waste*). It is measured as the proportion of recycled waste to the total waste generated. We also test the sensitivity of our results to relying on the total amount of waste generated divided by total sales as an alternative measure of waste.

3.4 Regression Model

To examine the effect of waste management on trade credit, we rely on the following model specification:

$$Trade\ Credit_{i,t} = \beta_0 + \beta_1\, Waste_{i,t-1} + \beta_2 \chi_{i,t-1} + \beta_{ind} + \beta_t + \beta_{Country} + \varepsilon_{i,t}, \quad (1)$$

Where, trade credit represents one of the four measures of trade credit (*Trade Credit*$_{(AP/COGS)}$, *Trade Credit*$_{(AP/Purchase)}$, *Trade Credit*$_{((AP+NP+DPTC)COGS)}$, and *Trade Credit*$_{((AP+NP+DPTC)/Purchase)}$). Waste presents one of the three measures of waste/waste management (*Log(Waste)*, *Waste_Assets*, and *Recycle_Waste*). χ is a vector of firm-level control variables. Specifically, similar to prior studies, we control for firm size (*Log(Size)*), *Life Cycle*, *Sales Growth*, , corporate cash holding (*Cash*), research and development (*RD*), *Leverage*, the cost of financing (*Finance Cost*), the Altman (1968) Z-score (*Z-Score*), firm age (*Log(Age)*), profitability (*ROA* and *Loss dummy*), and firm mergers and acquisitions (*Log(M&A Cost)).* The Appendix offers a comprehensive explanation of all variables. Lastly, to account for differences in trade credit across countries, industries, and over time, we include year, industry (Fama French 12 industrial classification), and country fixed effects. To minimize the impact of outliers, we winsorize the continuous variables at the 1st and 99th percentiles. Additionally, the model is estimated using heteroskedasticity-robust (HAC) standard errors, adjusted for correlations within firm and year clusters (Petersen, 2009).

Our main variable of interest in Eq. (1) is *Waste*. If waste affects trade credit, we expect the variables *Log(Waste)*, and *Waste_Assets* to be negatively associated with trade credit, while the variable *Recycle_Waste* to be positively associated with trade credit.

4. Results

4.1 Main Results

Table 1 presents the descriptive statistics for trade credit, waste management, and the control variables among our sample firms. The average *Trade Credit*$_{(AP/COGS)}$ is 0.24, suggesting that suppliers' trade credit accounts for over 24% of the cost of goods sold for firms in our sample. This is consistent with prior studies (Gofman & Wu, 2022; Hasan & Habib, 2019, 2023; X. Li

et al., 2021). The mean values for *Trade Credit*$_{(AP/Purchase)}$, *Trade Credit*$_{((AP+NP+DPTC)COGS)}$, and *Trade Credit*$_{((AP+NP+DPTC)/Purchase)}$ are 23%, 38%, and 38%, respectively. The mean values for waste generation (*Log Waste* and *Waste_Assets*) and waste recycling (*Recycle_Waste*) are 10.92, 12.95, and 0.48, respectively, aligning with those reported by Gull et al. (2023). All other firm-specific control variables are consistent with the previous literature (Hasan & Alam, 2022; Hasan & Habib, 2023; Luo et al., 2023; Zhang, 2020).

[Insert Table 1]

In Panel B of Table 1, we divide the sample into firms with high and low waste management. The mean values of trade credit variables are higher for the high waste management group than for the low waste management group. The trade credit differences between the two groups are also statistically significant at the 1% level, offering preliminary support for our main hypothesis.

Next, we examine the effect of waste management on corporate trade credit using Equation (1) and present the results in Table 2. The results in Table 2 indicate a negative association between corporate waste generation and trade credit, while a positive association between waste recycling and trade credit. Specifically, the coefficient for *Log (Waste)* in column (1) is -0.0035, and it is significant at the 1% level. Additionally, the coefficient for *Waste_Assets* in column 2 is -0.0002, and it is significant at the 5% level. Moreover, the coefficient for waste recycling (*Recycle_Waste*) in column 3 is 0.0137, and it is significant at the 1% level. These effects are also economically meaningful. For instance, a one standard deviation increase in waste generation (recycling) corresponds to a 3.88% decrease (2.2% increase) in trade credit, as shown in columns 1 and 3. Consistent findings are observed across other trade credit measures in columns 4 through 12. The control variables are loaded as expected, aligning with prior research. Overall, the results in Table 2 support our main

hypothesis that firms with higher levels of waste recycling secure greater trade credit and more favorable terms from their suppliers.

[Insert Table 2]

4.2 Robustness Tests

We conduct several robustness tests, with the results displayed in Table 3.[3] First, we exclude the Global Financial Crisis (GFC) and the COVID-19 periods from our analysis. Prior studies have noted changes in the behavior of both suppliers and customers during crisis periods due to either the inability of suppliers to provide credit or the reluctance of customers to take on more credit (Love et al., 2007; Pattnaik et al., 2020; Zaman et al., 2021).[4] It is possible that the GFC or COVID-19 periods may affect the relationship between waste management and trade credit. Following Zaman et al. (2021), we exclude the years 2007–2009 from our sample and report the results in Panel A of Table 3. Similarly, we exclude the years 2020 to 2022 related to the COVID-19 period and report the results in Panel B. The relationship between waste generation (recycling) and trade credit remains consistent after excluding both the GFC and the COVID-19 periods.

[Insert Table 3]

Second, we recognize that our sample contains a significant number of firm-year observations from the U.S. and the U.K., which could indicate that these firms influence the main results and create a potential sample selection bias. To mitigate this issue, we conduct our baseline analysis again, excluding U.S. and U.K. firms. Panel C of Table 3 reports these results. The findings remain quantitatively unchanged, indicating that our main results are not driven by large observations from these countries. Third, we employ an additional measure of waste

[3] For conciseness, the table includes only the coefficients for the variables of interest. The full results of these tests are available from the authors upon request.
[4] See the literature review by Pattnaik et al. (2020) for a comprehensive review of the effect of the financial crisis on firms' access to trade credit.

generation, *Waste_Sales*, computed as the total waste scaled by sales. The results in Panel D of Table 3 show that the coefficient estimates on *Waste_Sales* are positive and statistically significant across columns (1) to (4), indicating that our baseline results are not influenced by how we measure waste generation. Overall, the results of these tests confirm that the baseline results in Table 2 are robust to various factors.

4.3 Endogeneity Tests

We consider that waste management might endogenously been determined by firms, which might bias our main results. Although, in all our regressions, we use lagged independent variables to mitigate the simultaneous or joint determination of waste management and trade credit, we also employ four strategies to address potential endogeneity concerns.

4.3.1 Instrumental variable approach (IV)

First, we utilize the two least squares regression (2SLS) using the industry median of waste generation (*Ind. Waste*) as an instrumental variable (IV) similar to recent studies (Gull et al., 2024; Nadeem, 2021; Shahab et al., 2022). This instrument satisfies the exclusion restriction and relevance conditions. Specifically, a firm's waste generation is anticipated to be directly affected by its peers, as companies compete for market share and share similar investment opportunities within their industries. However, it is unlikely that industry waste generation would affect firms trade credit other than through the firms' waste generation.

We performed the IV regression in two stages. In the first stage, we regress our measures of waste generation (recycling) on our instrumental variable (*Ind. Waste*) and report the results in Panel B of Table 4. In the second stage, we estimate the regression model in Equation (1) using the predicted values from the first stage regression in place of our measures of waste generation. The results for this stage are presented in Panel A of Table 4.

[Insert Table 4]

The first stage results in columns (1), (2), and (3) of Panel B indicate that industry median waste generation (*Ind. Waste*) is significantly positively associated with firm waste generation (*Log (Waste)* and *Waste_Assets*), and negatively associated with waste recycling *(Recycle_Waste*). The Kleibergen-Paap F-statistic and the Kleibergen-Paap rk LM values confirm the relevance and strength of our instrument. Turning to the second-stage results, the coefficients of predicted waste generation in columns (1) and (2) are negatively significant at the 1% level. Conversely, the coefficient of predicted waste recycling in column (3) is positively significant at the 1% level. We find similar inferences in columns (4) to (12). These findings align with our baseline results in Table 2, accounting for endogeneity in our analysis.

3.3.2 Heckman Selection Model

In our study, we acknowledge the potential for sample selection bias arising from our focus on firms engaged in waste management practices, which could introduce non-random selection and endogeneity (Certo et al., 2016). To mitigate these concerns, we apply the Heckman two-step procedure (Heckman, 1979). Following the methodology outlined by Certo et al. (2016), we first estimate a probit model to identify the determinants of waste generation[5] using the full sample of Compustat global firms. We then obtain the Inverse Mills Ratio (IMR) from the selection Equation. The results of this step are presented in Panel D of Table 4. We find that the IMR is significant.

We then estimate a section stage regression (Equation (1)) and integrate the IMR from the selection equation. The second-stage results, reported in Panel C of Table 4. The results show that across all trade credit measures our findings are robust after addressing potential sample selection biases. Specifically, we find that firms' waste (*Log (Waste)* and *Waste_Assets*)

[5] These are firm size, loss dummy, ROA, Cash holding, Tangibility, R&D and leverage.

is negatively associated with trade credit, and while waste recycling *(Recycle_Waste*) is positively associated with trade credit.

3.3.3 Propensity scores matching and entropy balancing

In this section, we utilize propensity score matching (PSM) and entropy balancing to address selection bias stemming from company-specific attributes and potential functional specification errors (Rosenbaum & Rubin, 1983). First, we apply propensity score matching to compare trade credit between a group of firms with high waste/waste management (the treatment group) and a group with low waste/waste management (the control group), based on firm covariates (firm size, loss dummy, ROA, Cash holding, Tangibility, R&D and leverage). We match treatment and control firms within a 0.001 caliper, allowing replacement, using all control variables from the baseline results (Table 2). Next, we re-estimate Equation (1) with the matched sample and present the findings in Panel A of Table 5.

[Insert Table 5]

Panel A of Table 5 shows that waste generation is significantly and negatively associated with trade credit, while waste recycling is significantly and positively associated with trade credit. These findings support our hypothesis that waste management practices influence trade credit terms. Second, we employ an entropy balancing methodology to address selection bias stemming from company-specific attributes and potential functional specification errors (Hainmueller, 2012). We achieve balance between firms with high and low waste management by adjusting the first three moments (mean, variance, and skewness) of all matching variables. The results in Panel B of Table 5 reaffirm that waste generation negatively affects trade credit, whereas recycling positively affects it. These results align with our baseline findings, indicating that firms emphasizing effective waste management tend to receive more favorable trade credit terms from their suppliers.

Overall, the results in Tables 4 and 5 indicate that our main conclusions are less vulnerable to endogeneity concerns.

5. Channel Analysis

Our underlying hypothesis is that firms engaged in waste management enjoy reduced operating expenses and enhanced firm value (Albitar et al., 2020; Awaysheh et al., 2020; Gull et al., 2022), which incentivize suppliers to provide better credit terms. In this section, we consider whether the reduction in operating expenses and enhancement in firm value represent the channel through which waste management affects trade credit, using Baron and Kenny's (1986) causal step regression. The results of this channel analysis are shown in Table 6. (operating expenses in Panel A and firm value in Panel B).

[Insert Table 6]

The results in columns 1, 2, and 3 of Panel A align with our baseline findings, showing that waste generation is negatively associated with trade credit, while recycling has a positive association. Crucially, the results in columns 4, 5, and 6 indicate that waste generation increases a firm's operating expenses, whereas waste recycling decreases them. Furthermore, in column 7, we observe a negative link between operating expenses and trade credit, implying that lower operating expenses are associated with higher trade credit. Lastly, the coefficients in columns 8, 9, and 10 are less significant and of smaller magnitude compared to those in columns 1, 2, and 3, suggesting that operating expenses partially mediate the relationship between waste generation or recycling and trade credit.

In Panel B, we build on the methodology and insights from Panel A to explore the impact of firm value (Tobin's Q) on the relationship between waste generation and trade credit. The results in columns 1, 2, and 3 are consistent with our baseline findings. Most importantly, the results in columns 4, 5, and 6 indicate that waste generation decreases a firm's value, as proxied

by Tobin's Q, whereas waste recycling increases it. Furthermore, we identify a positive connection between firm value (i.e. Tobin's Q) and trade credit in columns 7, suggesting that higher firm values are associated with increased trade credit. Lastly, the coefficients in columns 8, 9, and 10 are less significant and smaller in magnitude compared to those in columns 1, 2, and 3, suggesting that firm value partially mediates the relationship between waste generation or recycling and trade credit.

Overall, the findings in Table 6 support our hypothesis that firms involved in waste recycling experience lower operating expenses and higher firm values, which contribute to increased trade credit.

6. Additional Analysis

In this section, we investigate whether the relationship between waste generation or recycling and trade credit varies across industries. Previous studies indicate that firms operating in environmentally sensitive industries exhibit different behaviors than those in environmentally insensitive sectors. According to the legitimacy theory, investors anticipate that firms with poorer environmental performance will undertake more environmental initiatives, such as waste recycling, to enhance their credibility (King & Lenox, 2002; Zaman et al., 2021). For example, industries such as chemicals or oil and gas, which focus on resource extraction, often face heightened legal and environmental scrutiny owing to potential hazards associated with their operations.

To test this hypothesis, we categorize our sample into firms in environmentally sensitive industries and those in non-sensitive industries, then re-estimate our model (Equation (1)). Consistent with established literature, we classify firms as environmentally sensitive (assigned a value of '1') if they operate in industries such as oil and gas, forestry, pulp and paper, energy, chemicals and drugs, mining and resources, and utilities. Otherwise, firms were classified as

environmentally insensitive (assigned a value of '0') (Aerts et al., 2006; Zaman et al., 2021). We anticipate that firms in environmentally sensitive sectors will engage more in waste management practices and may derive greater benefits from these environmental initiatives. We report the results in Table 7.

[Insert Table 7 here]

Our findings highlight a notably strong negative (positive) association between waste generation (waste recycling) and trade credit within the environmentally sensitive subsample compared to the environmentally insensitive subsample. These results support our hypothesis that the benefits of waste recycling are particularly significant in mitigating the negative environmental impacts in sensitive industries, thereby leading to higher levels of trade credit. This suggests that suppliers in these industries place greater value on environmental initiatives, such as waste recycling, potentially resulting in higher trade credit for firms that actively engage in such practices.

7. Conclusion

This study investigates the relationship between corporate environmental orientation, particularly waste recycling practices, and firms' access to trade credit. By analyzing a comprehensive global sample from 42 countries over the period from 2002 to 2022, we find a negative association between corporate waste generation and trade credit and a positive association between corporate recycling and trade credit, supporting the hypothesis that suppliers value effective waste management. Importantly, these results remain consistent across various firm-specific attributes and are robust to a range of sensitivity tests, including different time periods and the exclusion of firms from major economies. We also address potential endogeneity concerns using rigorous methodologies such as two-stage least squares

estimation, Heckman's selection equation, propensity score matching, and entropy balancing, further affirming the robustness of our findings.

Our channel analysis reveals that firms engaged in waste management enjoy reduced operating expenses and enhanced firm value, which incentivizes suppliers to provide better credit terms. Our final analysis highlights that the impact of waste recycling on trade credit is particularly pronounced in environmentally sensitive industries, underscoring the strategic importance of environmental practices in these sectors.

Our study enriches the growing body of research on waste management by focusing on the economic consequences of recycling practices and their effect on trade credit access, thereby deepening the understanding of the economic implications of corporate waste management. Moreover, it adds to the literature on firms' access to trade credit by introducing waste management as a crucial factor in trade credit decisions. Lastly, it identifies reductions in operating costs and improved firm value as the primary channels through which waste recycling enhances firms' access to trade credit. Our research has an important implication, as it provides a compelling incentive for firms to adopt and enhance their environmental management practices, benefiting not only the firms themselves but also contributing positively to broader environmental goals.

Appendix: Variable Definitions

Variables	Description
Dependent variables	
Trade Credit$_{(AP/COGS)}$	Proportion of accounts payable to the cost of goods sold
Trade Credit$_{(AP/Purchase)}$	Proportion of accounts payable to total purchases. Whereas the purchase is calculated as the COGS and adjusted for year-to-year changes in inventory.
Trade Credit$_{((AP+NP+DPTC)COGS)}$	The sum of accounts payable, notes payable, and customer deposits divided by the cost of goods sold
Trade Credit$_{((AP+NP+DPTC)/Purchase)}$	The sum of accounts payable, notes payable, and customer deposits divided by firms' purchases.
Main independent variables	
Log(Waste)	The total amount of waste (both hazardous and non-hazardous) generated in tons.
Waste_Assets	The total amount of waste generated divided by total assets.
Recycle_Waste	The proportion of the recycled waste to total waste generated.
Control variables	
Log(Size)	The natural logarithm of total assets.
Log(Age)	The natural logarithm of firm age.
Firm Lifecycle	Retained earnings as a proportion of total equity, as in Deangelo et al. (2006)
Leverage	Leverage ratio measured as the sum of short- and long-term debt divided by total assets
Cash	Cash and marketable securities divided by total assets
Sales Growth	Growth in sales over the previous year's sales
RD	Research and development expenses divided by total assets. Missing R&D values are replaced by 0.
Z-Score	Is Altman (1968) Z-score using the following formula: $Z_score = 0.717X1 + 0.847X2 + 3.107X3 + 0.420X4 + 0.998X5$ X1=Working Capital/Total Assets; X2=Retained Earnings/Total Assets; X3=Earnings before Interest and Taxes/Total Assets; X4=Market Value of Equity/Book Value of Total Liabilities; and X5=Sales/Total Assets.
Finance Cost	Cost of financing measured as total interest expenses scaled by total debt as in Zhang, Lara and Tribo (2020)
ROA	Net income divided by total assets
LOSS	An indicator variable that equals 1 if the firm reports a negative net income, and 0 otherwise.
Log(M&A Cost)	The natural logarithm of the merger and acquisition amount.

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Table 1: Summary Statistics

Panel A: Descriptive statistics of full sample

	count	mean	sd	p25	p50	p75
Trade Credit$_{(AP/COGS)}$	13083	0.2408	0.2274	0.1199	0.1815	0.2745
Trade Credit$_{(AP/Purchase)}$	13083	0.2346	0.2756	0.1115	0.1696	0.2574
Trade Credit$_{((AP+NP+DPTC)COGS)}$	13083	0.3752	0.4565	0.1622	0.2565	0.4042
Trade Credit$_{((AP+NP+DPTC)/Purchase)}$	13083	0.3803	0.5455	0.1603	0.2528	0.3972
Log(Waste)	13083	10.9235	2.6750	9.1935	10.7980	12.5776
Waste_Assets	13083	12.9581	27.4834	0.0659	0.8518	8.6402
Recycle_Waste	13083	0.4820	0.3875	0.0000	0.5629	0.8572
Log(Size)	13083	10.7594	2.8908	8.4414	10.1534	13.1611
Life Cycle	13083	0.5323	0.5379	0.2769	0.6248	0.8300
Sales Growth	13083	0.0531	0.1755	-0.0286	0.0406	0.1173
Cash	13083	0.2010	0.2196	0.0700	0.1358	0.2475
RD	13083	0.0171	0.0264	0.0000	0.0037	0.0247
Leverage	13083	0.1872	0.1341	0.0830	0.1712	0.2657
Finance Cost	13083	0.0503	0.0724	0.0180	0.0354	0.0560
Z-score	13083	0.8574	0.5003	0.5282	0.7760	1.0522
Log(Age)	13083	2.5886	0.4102	2.3979	2.7081	2.8904
Loss dummy	13083	0.1219	0.3272	0.0000	0.0000	0.0000
ROA	13083	0.0433	0.0560	0.0167	0.0392	0.0684
Log(M&A Cost)	13083	1.7731	2.6649	0.0000	0.0000	3.6217

Panel B: Descriptive across high and low waste management

	(1) High waste management		(2) Low waste management		(3) Difference in Mean
	count	mean	count	mean	
Trade Credit$_{(AP/COGS)}$	6542	0.2515	6541	0.2301	(5.395)***
Trade Credit$_{(AP/Purchase)}$)	6542	0.2452	6541	0.2240	(4.409)***
Trade Credit$_{((AP+NP+DPTC)COGS)}$	6542	0.3967	6541	0.3536	(5.398)***
Trade Credit$_{((AP+NP+DPTC)/Purchase)}$	6542	0.4007	6541	0.3599	(4.277)***

Panel A presents the descriptive statistics for the full sample, while panel B presents the descriptive across high and low waste management. Appendix A reports the detailed definitions of all variables.

Table 2: Main results

	Trade Credit$_{(AP/COGS)}$			Trade Credit$_{(AP/Purchase)}$			Trade Credit$_{((AP+NP+DPTC)COGS)}$			Trade Credit$_{((AP+NP+DPTC)/Purchase)}$		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Log(Waste)	-0.0035***			-0.0061***			-0.0086***			-0.0127***		
	(-3.666)			(-5.230)			(-4.584)			(-5.646)		
Waste_Assets		-0.0002**			-0.0004***			-0.0010***			-0.0013***	
		(-1.977)			(-3.967)			(-6.449)			(-7.612)	
Recycle_Waste			0.0137***			0.0161**			0.0542***			0.0699***
			(2.783)			(2.490)			(5.284)			(5.420)
Log(Size)	0.0032*	0.0004	0.0004	0.0035*	-0.0015	-0.0014	-0.0048	-0.0123***	-0.0120***	-0.0075**	-0.0185***	-0.0181***
	(1.938)	(0.275)	(0.249)	(1.799)	(-0.816)	(-0.753)	(-1.414)	(-3.682)	(-3.645)	(-1.965)	(-4.642)	(-4.613)
Life Cycle	-0.0070*	-0.0070*	-0.0073**	-0.0082**	-0.0083**	-0.0083**	-0.0117	-0.0130	-0.0133*	-0.0121	-0.0136	-0.0140
	(-1.952)	(-1.943)	(-2.043)	(-2.015)	(-2.053)	(-2.058)	(-1.474)	(-1.633)	(-1.678)	(-1.402)	(-1.584)	(-1.616)
Sales Growth	-0.0241*	-0.0241*	-0.0241*	-0.0098	-0.0096	-0.0101	-0.0896***	-0.0877***	-0.0889***	-0.0987***	-0.0963***	-0.0981***
	(-1.905)	(-1.907)	(-1.911)	(-0.504)	(-0.493)	(-0.523)	(-3.305)	(-3.233)	(-3.291)	(-2.927)	(-2.857)	(-2.916)
Cash	0.1039***	0.1050***	0.1069***	0.1381***	0.1396***	0.1429***	0.2419***	0.2408***	0.2507***	0.3204***	0.3197***	0.3328***
	(6.485)	(6.562)	(6.656)	(5.905)	(5.977)	(6.081)	(6.137)	(6.147)	(6.367)	(6.198)	(6.221)	(6.433)
Leverage	-0.0279	-0.0304	-0.0306	-0.0067	-0.0121	-0.0104	0.2426***	0.2297***	0.2329***	0.3133***	0.2957***	0.3004***
	(-1.473)	(-1.600)	(-1.619)	(-0.272)	(-0.489)	(-0.424)	(5.776)	(5.508)	(5.560)	(6.027)	(5.727)	(5.791)
RD	0.6794***	0.6945***	0.7064***	0.5658***	0.5821***	0.6199***	0.5175***	0.4718***	0.5701***	0.4527**	0.4056**	0.5381***
	(7.664)	(7.879)	(8.090)	(5.458)	(5.648)	(6.094)	(3.184)	(2.918)	(3.549)	(2.466)	(2.230)	(2.980)
Finance Cost	0.0152	0.0126	0.0077	-0.0109	-0.0141	-0.0229	-0.1100*	-0.1056*	-0.1313**	-0.1667***	-0.1628***	-0.1968***
	(0.479)	(0.398)	(0.244)	(-0.305)	(-0.396)	(-0.639)	(-1.841)	(-1.764)	(-2.186)	(-2.793)	(-2.722)	(-3.269)
Z-score	-0.0803***	-0.0789***	-0.0793***	-0.0777***	-0.0750***	-0.0759***	-0.1773***	-0.1723***	-0.1747***	-0.1752***	-0.1682***	-0.1714***
	(-17.231)	(-17.180)	(-17.254)	(-13.416)	(-13.207)	(-13.323)	(-18.492)	(-18.268)	(-18.482)	(-15.228)	(-14.929)	(-15.149)
Log(Age)	-0.0157	-0.0168*	-0.0179*	0.0005	-0.0011	-0.0036	0.0446**	0.0460**	0.0390**	0.0608**	0.0618**	0.0525**
	(-1.599)	(-1.711)	(-1.828)	(0.038)	(-0.087)	(-0.295)	(2.248)	(2.316)	(1.974)	(2.521)	(2.558)	(2.177)
Loss dummy	-0.0134**	-0.0134**	-0.0133**	-0.0087	-0.0087	-0.0086	-0.0161	-0.0161	-0.0157	-0.0241	-0.0240	-0.0235
	(-2.029)	(-2.022)	(-2.008)	(-1.032)	(-1.023)	(-1.008)	(-1.203)	(-1.200)	(-1.170)	(-1.553)	(-1.546)	(-1.513)
ROA	-0.0164	-0.0114	-0.0085	-0.0436	-0.0366	-0.0288	0.1354	0.1322	0.1532*	0.2113**	0.2106**	0.2387**
	(-0.356)	(-0.247)	(-0.185)	(-0.748)	(-0.627)	(-0.493)	(1.494)	(1.461)	(1.686)	(2.087)	(2.083)	(2.347)
Log(M&A Cost)	0.0012	0.0012	0.0012	0.0013	0.0013	0.0014	0.0073***	0.0071***	0.0074***	0.0078***	0.0075***	0.0080***
	(1.285)	(1.279)	(1.333)	(1.173)	(1.138)	(1.244)	(3.998)	(3.884)	(4.065)	(3.546)	(3.427)	(3.626)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083
Adjusted R^2	0.251	0.250	0.250	0.196	0.194	0.194	0.231	0.232	0.231	0.206	0.208	0.206

The table presents the results for Eq. (1). All continuous variables are winsorized at the 1st and 99th percentiles. In parentheses, we report the t-statistics based on firm-year clusters and heteroskedasticity-corrected standard errors. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 3: Sensitivity tests

Panel A: Excluding the financial crisis period

	Trade Credit$_{(AP/COGS)}$			**Trade Credit$_{(AP/Purchase)}$**			**Trade Credit$_{((AP+NP+DPTC)COGS)}$**			**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Log(Waste)	-0.0030***			-0.0057***			-0.0071***			-0.0110***		
	(-3.104)			(-4.696)			(-3.674)			(-4.748)		
Waste_Assets		-0.0001			-0.0003***			-0.0009***			-0.0013***	
		(-1.574)			(-3.595)			(-5.712)			(-6.869)	
Recycle_Waste			0.0149***			0.0161**			0.0562***			0.0718***
			(2.843)			(2.362)			(5.172)			(5.247)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11713	11713	11713	11713	11713	11713	11713	11713	11713	11713	11713	11713
Adjusted R^2	0.245	0.245	0.245	0.191	0.189	0.189	0.230	0.231	0.230	0.205	0.206	0.205

Panel B: Excluding Covid 19 period

	Trade Credit$_{(AP/COGS)}$			**Trade Credit$_{(AP/Purchase)}$**			**Trade Credit$_{((AP+NP+DPTC)COGS)}$**			**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Log(Waste)	-0.0043***			-0.0073***			-0.0098***			-0.0140***		
	(-4.093)			(-5.512)			(-4.625)			(-5.574)		
Waste_Assets		-0.0002***			-0.0004***			-0.0012***			-0.0015***	
		(-2.611)			(-4.362)			(-6.717)			(-7.687)	
Recycle_Waste			0.0123**			0.0154**			0.0460***			0.0606***
			(2.315)			(2.181)			(4.151)			(4.389)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10677	10677	10677	10677	10677	10677	10677	10677	10677	10677	10677	10677
Adjusted R^2	0.256	0.255	0.255	0.201	0.199	0.198	0.238	0.239	0.237	0.212	0.213	0.210

Panel C: Excluding USA & UK firms

	Trade Credit$_{(AP/COGS)}$			**Trade Credit$_{(AP/Purchase)}$**			**Trade Credit$_{((AP+NP+DPTC)COGS)}$**			**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Log(Waste)	-0.0028***			-0.0056***			-0.0078***			-0.0124***		
	(-2.779)			(-4.394)			(-3.881)			(-5.081)		
Waste_Assets		-0.0001			-0.0003***			-0.0010***			-0.0014***	
		(-0.987)			(-2.921)			(-5.786)			(-7.026)	

Table 3 *Continued*

	Trade Credit$_{(AP/COGS)}$			**Trade Credit$_{(AP/Purchase)}$**			**Trade Credit$_{((AP+NP+DPTC)COGS)}$**			**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Recycle_Waste			0.0129**			0.0155**			0.0564***			0.0729***
			(2.503)			(2.273)			(5.259)			(5.362)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12007	12007	12007	12007	12007	12007	12007	12007	12007	12007	12007	12007
Adjusted R^2	0.264	0.263	0.263	0.205	0.204	0.204	0.239	0.240	0.239	0.214	0.215	0.214

Panel D:Alternative measure of waste management

	Trade Credit$_{(AP/COGS)}$	**Trade Credit$_{(AP/Purchase)}$**	**Trade Credit$_{((AP+NP+DPTC)COGS)}$**	**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**
	(1)	**(2)**	**(3)**	**(4)**
Waste_Sales	-0.0000*	-0.0000***	-0.0001***	-0.0001***
	(-1.661)	(-3.199)	(-4.328)	(-6.093)
All Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083
Adjusted R^2	0.253	0.196	0.234	0.209

The table presents the results for the sensitivity tests. Unless otherwise indicated, all control variables are the same as in the main analyses. All continuous variables are winsorized at the 1st and 99th percentiles. In parentheses, we report the t-statistics based on firm clusters and heteroskedasticity-corrected standard errors. ***, ** and * denote significance at the 1, 5 and 10% respectively.

Table 4: Endogeneity tests

Panel A: IV regression- 2nd stage results

	Trade Credit(AP/COGS)			Trade Credit(AP/Purchase)			Trade Credit((AP+NP+DPTC)COGS)			Trade Credit((AP+NP+DPTC)/Purchase)		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Log(Waste)	-0.0093***			-0.0120***			-0.0204***			-0.0239***		
	(-5.212)			(-6.393)			(-5.055)			(-5.912)		
Waste_Assets		-0.0009***			-0.0012***			-0.0021***			-0.0024***	
		(-5.150)			(-6.428)			(-4.879)			(-5.687)	
Recycle_Waste			0.3204***			0.4147***			0.7041***			0.8281***
			(4.481)			(5.253)			(4.346)			(4.785)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083

Panel B: IV regression- 1st stage results

	Log (Waste)	Waste_ Assets	Recycle_ Waste
	(1)	**(2)**	**(3)**
Ind. Waste	0.0000***	0.0000***	-0.0000***
	(7.165)	(7.776)	(-6.563)
Weak instrument- Kleibergen-Paap F-stat	50.8417	59.3765	40.7542
Critical value	16.380	16.380	16.380
Relevant instrument- Kleibergen-Paap rk LM	262.595	194.028	57.561
p-value	0.0000	0.0000	0.0000
Endogeneity test- Durbin-Wu-Hausman test	8.22	14.94	23.45
p-value	0.00	0.00	0.00
Observations	13083	13083	13083

Panel C: Heckman's selection equation-2nd stage results

	Trade Credit(AP/COGS)			Trade Credit(AP/Purchase)			Trade Credit((AP+NP+DPTC)COGS)			Trade Credit((AP+NP+DPTC)/Purchase)		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Log(Waste)	-0.0038***			-0.0066***			-0.0095***			-0.0138***		
	(-4.861)			(-6.646)			(-6.004)			(-7.190)		
Waste_Assets		-0.0001*			-0.0003***			-0.0009***			-0.0013***	
		(-1.945)			(-3.729)			(-6.496)			(-7.154)	
Recycle_Waste			0.0118**			0.0139**			0.0491***			0.0637***
			(2.367)			(2.213)			(4.875)			(5.206)

Table 4 *Continued*

	Trade Credit$_{(AP/COGS)}$			**Trade Credit$_{(AP/Purchase)}$**			**Trade Credit$_{((AP+NP+DPTC)COGS)}$**			**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Inverse Mills Ratio	-0.1450***	-0.1429***	-0.1426***	-0.1703***	-0.1664***	-0.1666***	-0.3829***	-0.3759***	-0.3758***	-0.4626***	-0.4528***	-0.4528***
	(-13.840)	(-13.634)	(-13.607)	(-12.907)	(-12.600)	(-12.610)	(-18.091)	(-17.767)	(-17.751)	(-18.008)	(-17.627)	(-17.612)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083
Panel D: Heckman's selection equation-Selection equation												
	Trade Credit$_{(AP/COGS)}$			**Trade Credit$_{(AP/Purchase)}$**			**Trade Credit$_{((AP+NP+DPTC)COGS)}$**			**Trade Credit$_{((AP+NP+DPTC)/Purchase)}$**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Size	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***	0.5522***
	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)	(144.705)
Loss	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163	0.0163
	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)	(0.786)
ROA	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***	1.1645***
	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)	(11.260)
Cash	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***	-0.2925***
	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)	(-10.443)
Tangibility	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***	0.1908***
	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)	(6.149)
RD	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***	5.3852***
	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)	(23.941)
Leverage	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***	-0.3250***
	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)	(-8.522)
Constant	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***	-9.6542***
	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)	(-35.409)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	489857	489857	489857	489857	489857	489857	489857	489857	489857	489857	489857	489857

The table presents the results for the IV estimation as well as for Heckman's selection equation. All variables are defined in Appendix A. All continuous variables are winsorized at the 1st and 99th percentiles. In parentheses, we report the t-statistics based on firm-year clusters and heteroskedasticity-corrected standard errors. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 5 : Propensity Score Matching and Entropy Balancing

Panel A: PSM

	Trade Credit(AP/COGS)			Trade Credit(AP/Purchase)			Trade Credit((AP+NP+DPTC)COGS)			Trade Credit((AP+NP+DPTC)/Purchase)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log(Waste)	-0.0033***			-0.0064***			-0.0082***			-0.0126***		
	(-4.453)			(-6.780)			(-5.541)			(-7.089)		
Waste_Assets		-0.0003***			-0.0006***			-0.0016***			-0.0020***	
		(-4.063)			(-5.758)			(-8.928)			(-9.229)	
Recycle_Waste			0.0126***			0.0113**			0.0341***			0.0422***
			(2.814)			(2.008)			(3.778)			(3.817)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13066	13078	13064	13066	13078	13064	13066	13078	13064	13066	13078	13064
Adjusted R^2	0.250	0.302	0.261	0.186	0.261	0.199	0.232	0.304	0.238	0.198	0.302	0.209

Panel B: Entropy balancing

	Trade Credit(AP/COGS)			Trade Credit(AP/Purchase)			Trade Credit((AP+NP+DPTC)COGS)			Trade Credit((AP+NP+DPTC)/Purchase)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log(Waste)	-0.0029***			-0.0050***			-0.0069***			-0.0101***		
	(-2.856)			(-3.934)			(-3.582)			(-4.353)		
Waste_Assets		-0.0002**			-0.0006***			-0.0014***			-0.0018***	
		(-2.367)			(-4.232)			(-6.269)			(-6.994)	
Recycle_Waste			0.0130***			0.0135***			0.0371***			0.0464***
			(3.221)			(2.682)			(4.674)			(4.775)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083
Adjusted R^2	0.247	0.278	0.258	0.181	0.232	0.198	0.217	0.277	0.235	0.183	0.269	0.210

Panel A presents the results for the PSM estimation, while Panel B presents the entropy balancing estimation. All variables are defined in Appendix A. All continuous variables are winsorized at the 1st and 99th percentiles. In parentheses, we report the t-statistics based on firm-year clusters and heteroskedasticity-corrected standard errors. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 6 : Channel Analysis

Panel A: *Operating Expenses*

	Trade Credit$_{(AP/COGS)}$			**Operating Exp**			**Trade Credit$_{(AP/COGS)}$**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Log(Waste)	-0.0127***			0.0033***				-0.0044***		
	(-6.436)			(7.322)				(-4.631)		
Waste_Assets		-0.0013***			0.0001***				-0.0002**	
		(-7.377)			(2.855)				(-2.337)	
Recycle_Waste			0.0699***			-0.0078***				0.0115**
			(5.622)			(-3.543)				(2.350)
Operating Exp							-0.2940***	-0.3029***	-0.2955***	-0.2926***
							(-14.982)	(-8.699)	(-8.552)	(-8.512)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083
Adjusted R^2	0.210	0.211	0.210	0.580	0.578	0.578	0.265	0.267	0.266	0.266

Panel B: *Tobin's Q*

	Trade Credit$_{(AP/COGS)}$			**Tobin's Q**			**Trade Credit$_{(AP/COGS)}$**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Log(Waste)	-0.0035***			-0.0019***				-0.0029***		
	(-3.666)			(-3.335)				(-3.183)		
Waste_Assets		-0.0002**			-0.0002***				-0.0001	
		(-1.977)			(-4.983)				(-1.212)	
Recycle_Waste			0.0137***			0.0134***				0.0102**
			(2.783)			(4.327)				(2.092)
Tobin's Q							0.2644***	0.2626***	0.2635***	0.2633***
							(18.671)	(15.666)	(15.691)	(15.661)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13083	13083	13083	13083	13083	13083	13083	13083	13083	13083
Adjusted R^2	0.254	0.253	0.253	0.577	0.577	0.577	0.272	0.273	0.272	0.272

The table presents the results for the channel analysis. All variables are defined in Appendix A. All continuous variables are winsorized at the 1st and 99th percentiles. In parentheses, we report the t-statistics based on firm-year clusters and heteroskedasticity-corrected standard errors. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 7: Additional Analysis: Environmental sensitivity

Panel A: Environmentally sensitive industries

	Trade Credit(AP/COGS)			Trade Credit(AP/Purchase)			Trade Credit((AP+NP+DPTC)COGS)			Trade Credit((AP+NP+DPTC)/Purchase)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log(Waste)	-0.0078***			-0.0132***			-0.0201***			-0.0305***		
	(-5.158)			(-6.291)			(-5.822)			(-6.705)		
Waste_Assets		-0.0008***			-0.0012***			-0.0019***			-0.0028***	
		(-5.788)			(-6.681)			(-6.389)			(-7.229)	
Recycle_Waste			0.0183**			0.0343***			0.0583***			0.0950***
			(2.054)			(2.740)			(2.957)			(3.595)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100	4100
Adjusted R^2	0.398	0.400	0.394	0.342	0.344	0.335	0.351	0.354	0.346	0.326	0.328	0.318

Panel B: Environmentally non-sensitive industries

	Trade Credit(AP/COGS)			Trade Credit(AP/Purchase)			Trade Credit((AP+NP+DPTC)COGS)			Trade Credit((AP+NP+DPTC)/Purchase)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log(Waste)	-0.0053***			-0.0023***			-0.0013			-0.0018		
	(-3.469)			(-4.242)			(-0.495)			(-0.598)		
Waste_Assets		-0.0001			-0.0002*			-0.0006***			-0.0006***	
		(-0.423)			(-1.743)			(-3.343)			(-3.849)	
Recycle_Waste			0.0052*			-0.0005			0.0392***			0.0428***
			(1.876)			(-0.068)			(3.295)			(2.981)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8982	8982	8982	8982	8982	8982	8982	8982	8982	8982	8982	8982
Adjusted R^2	0.233	0.231	0.231	0.357	0.165	0.165	0.213	0.214	0.214	0.184	0.184	0.185

The table presents the results for the additional analysis. All variables are defined in Appendix A. All continuous variables are winsorized at the 1st and 99th percentiles. In parentheses, we report the t-statistics based on firm-year clusters and heteroskedasticity-corrected standard errors. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Exploring Sustainability Reporting Practices in Italian Universities: A Legitimation Approach

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ABSTRACT

Purpose: Universities, due to their position in society, play a key role in the achievement of the SDGs. To reach the SDGs, universities need to rethink how they allocate their resources and report their results in relation to the SDGs. The article aims to understand how the application of the GRI framework by universities helps to report on efforts towards sustainable development and whether this is done in response to societal pressures.

Design/methodology/approach: Employing a longitudinal analysis, this study empirically analyses the relationship between SDGs disclosure and GRI standards in Italian universities through a study of their sustainability and social reports. A qualitative content analysis was carried out to evaluate the information disclosed, and the SRI index was developed to quantify the SDGs disclosure efforts for the years 2017-2024.

Findings: The results highlight that despite the application of the GRI guidelines, the level of information reported on SDGs is still low, with little increase over the years. The results stimulate the international debate on the implementation of a common framework for higher education institutions.

Originality: The paper offers insight into GRI reporting practices by Italian universities. Moreover, this work introduces the SRI, an innovative index used to assess the depth and authenticity of SDG reporting in the academic sector over the years, thereby extending the debate between symbolic and substantive legitimacy.

Keywords: Sustainable Development Goals, content analysis, Sustainability reporting, sustainability accounting, Italian universities, legitimacy theory

1. Introduction

In the wake of the United Nations' adoption of the SDGs (United Nations, 2015), a concerted effort has emerged among organizations of both public and private sectors to harmonize economic aspects with social and environmental ones (Alcántara-Rubio *et al.*, 2022; De Iorio *et al.*, 2022; Silva, 2021).

The implementation of business strategies inspired by sustainability principles necessitates the development of common strategies and synergies with academic institutions. Universities are pivotal in the achievement of the SDGs (Blasco *et al.*, 2020; Leal Filho *et al.*, 2021; Raimo *et al.*, 2024; Vilalta *et al.*, 2018; van Weenen, 2000). They are uniquely positioned to advance sustainability given their broad scope, which includes knowledge generation and dissemination, and their distinctive position in society (Moggi, 2019). Their influence on sustainability is twofold: direct, via education,

research, and knowledge transfer; and indirect, operating through the example set by the university in managing and being accountable for its sustainability performance (Adams, 2013; Blasco *et al.*, 2020; Fuchs *et al.*, 2023). This ensures that the values of the organizations are aligned with those of the community in which they operate, thereby gaining a legitimate standing (Lodhia *et al.*, 2023). However, the extant literature regarding the potential contributions of universities to the achievement of SDGs remains in its infancy and is in need of further development (Alcántara-Rubio *et al.*, 2022; Bebbington and Unerman, 2020).

In recent years, an increasing number of studies have focused on the topic of sustainability disclosure in universities in different contexts (Alonso-Almeida *et al.*, 2015; De Iorio *et al.*, 2022; Larrán Jorge *et al.*, 2019; Lozano, 2011; Moggi, 2023; Romolini *et al.*, 2015; Siboni *et al.*, 2013). Most of them have focused on analyzing the determinants and quality of sustainability disclosure, with studies focusing on annual reports or stand-alone reports. However, a gap in the current literature is the lack of analysis of whether these practices are implemented or merely reported over the years.

The present study, framed in the perspective of legitimacy theory (Deegan, 2002; Suchman, 1995), aims to understand the extent to which Italian universities contribute to the SDGs through sustainability disclosure. To this end, the objective of the paper is to examine the progress towards the achievement of the SDGs and the information communicated through different types of reports. A longitudinal approach is adopted to describe the evolution of sustainability reporting, with the aim of identifying the symbolic or substantive changes adopted by Italian universities. To achieve our goal, a content analysis of the non-financial reports of Italian universities belonging to the RUS network (Universities Network for Sustainable Development) was carried out on 124 reports (i.e. sustainability reports, social reports and integrated reports) along the period 2017-2024.

In addition, the SDGs Reporting Index (SRI) was developed with the aim of quantifying the information disclosed in the reports. The index represents the ratio between the number of GRI indicators disclosed in one report and the total number of indicators outlined in the SDG Compass guidelines (GRI & UN Global Compact, 2017). The selection of the GRI guidelines was made due to the absence of established reporting standards for universities in Italy (Del Sordo *et al.*, 2016; Siboni *et al.*, 2013) and their provision of explicit instructions on the disclosure of sustainability information (Adams, 2013). The SRI score was also employed to assess legitimacy, with low scores indicating symbolic approaches and high scores indicating substantive approaches.

This study contributes to the existing body of literature on the subject. Initially, it enhances extant literature concerning the role of universities in advancing the SDGs, demonstrating the evolution of reporting practices and their informative objective. Furthermore, it employs the principles of legitimacy theory to assess universities' contributions to the SDGs and to broaden the discourse on the utilization of indices to gauge SDGs disclosure information. The results indicate a growing emphasis on incorporating SDGs into Italian university reports. However, the findings reveal that the incorporation of SDGs in university reports is predominantly symbolic, with most cases merely mentioning SDGs, occasionally accompanied by infographics to create a positive impression and enhance legitimacy. This study makes a significant contribution to the ongoing international discourse on the utilization of GRI frameworks in the context of sustainability report practices at universities.

The rest of this work is structured as follows: Section 2 introduces the concept of legitimacy theory background and the research questions development. Section 3 presents an analysis of the extant literature on university social disclosure. Section 4 outlines the research methodology, while section

5 presents the research results. Section 6 discusses the results, their implications and the conclusion of the study.

2. Theoretical lens and research question

This study is grounded in legitimacy theory, which posits that organizations must align their actions with societal expectations to be perceived as legitimate (Dowling and Pfeffer, 1975; Lindblom, 1994; Suchman, 1995). Legitimacy theory can be defined as the general perception or assumption that an organization's activities are desirable, appropriate, or aligned with a socially constructed system of norms, values, and beliefs. In other words, an organization is considered legitimate when it adheres to the implicit terms of the "social contract" it has with the context within it operates (Suchman, 1995). Similarly, institutions are expected to maintain continuous conformity between their operations and the norms and rules of their social environment to retain legitimacy with various stakeholder groups (Guthrie and Abeysekera, 2006). From a sustainability perspective, it is of paramount importance that organizations conduct their activities in a socially and environmentally responsible way (Lodhia *et al.*, 2023).

In instances where there is a discrepancy between the activities of an organization and the expectations of society, it can be concluded that a legitimacy gap exists. It has been observed that there are two forms of organizational legitimation: symbolic and substantive (Savage *et al.*, 2000). Substantive legitimation entails the presentation of more rigorous and verifiable sustainability disclosures, accompanied by tangible modifications to internal management systems. This encompasses an emphasis on policies and sustainability objectives, illustrating how the organization has genuinely revised its internal processes and approach. Conversely, symbolic legitimation entails the disclosure of information designed to influence public perception without necessitating any tangible alterations to management systems or practices. The objective is to enhance the reputation and image of the organization, primarily to influence stakeholder perceptions. In both cases, the objective of disclosure strategies is to address societal expectations in a way that enhances, preserves, or restores legitimacy (Deegan, 2002).

It is commonly argued that companies gain legitimacy when they enter a new field (Deegan, 2002; Suchman, 1995). This can happen, for example, when they begin to integrate the SDGs into their strategies and reporting, and the debate between symbolic and substantive approaches to SDG disclosure has called for more extensive empirical evidence (Heras-Saizarbitoria *et al.*, 2022).

Because of their position in society, universities must honor the "social contract" in order to remain legitimate; they should meet society's expectations by acting in socially desirable ways (Jongbloed *et al.*, 2008; Nicolò *et al.*, 2023; Raimo *et al.*, 2024). Moreover, the 2030 Agenda places additional demands on universities, requiring them to transform their management, governance, and operational systems to address global social and environmental challenges and demonstrate their commitment to the SDGs to their stakeholders (Alcántara-Rubio *et al.*, 2022; Fia *et al.*, 2023).

In accordance with legitimacy theory, universities, as public sector organizations, are obliged to operate in a sustainable way and to communicate their sustainability initiatives and efforts to meet the expectations of various stakeholders and gain legitimacy within local communities (An *et al.*, 2019; Larrán Jorge *et al.*, 2019). The sustainability report enables universities to communicate their current activities, areas of development and future strategies for achieving sustainable progress (Moggi, 2023).

Legitimacy theory and the GRI reporting framework help to interpret how universities are integrating the SDGs into their reporting practices. This study assesses how universities report on their contributions to SDGs. Specifically, the study addresses the research question:

Do these reporting practices reflect symbolic or substantive approaches to sustainability?

3. SDG reporting in universities: A literature review

The lack of accounting-related research on the SDGs has been highlighted by accounting academics, but higher education has demonstrated a remarkable level of commitment to sustainable development (van Weenen, 2000). The SDGs have marked a significant turning point in the field of sustainability, and have become increasingly prominent in academic circles and among scholars analyzing how universities are integrating the 2030 Agenda into their programs and practices (Raimo *et al.*, 2024). However, the adoption of sustainability accounting and accountability is contingent upon the development of concrete metrics to facilitate, promote, and legitimize the implementation of these practices (Ball *et al.*, 2014).

The sustainability report is an indispensable tool for universities to demonstrate their commitment to sustainable development (Moggi, 2023). Nevertheless, the implementation and integration of the SDGs is still evolving (Alonso-Almeida *et al.*, 2015). Indeed, sustainability reporting is still in its infancy and the absence of mandatory requirements or uniform standards for such reporting in universities hinders its development (Fusco and Ricci, 2019; Moggi, 2023).

In light of the substantial discrepancies that have been identified among the various reports issued by these institutions, there is an evident necessity for a unified framework through which to assess the data that has been disclosed by higher education institutions (Lozano, 2006). The GRI guidelines have been identified as the most suitable and relevant disclosure standards, with European institutions being the first to adopt them (Alonso-Almeida *et al.*, 2015; Aversano *et al.*, 2020). However, the necessity to adapt the GRI framework diminishes its efficacy in the academic context (Larrán Jorge *et al.*, 2019), with several academics emphasizing the need for GRI-specific standards for universities (Caputo *et al.*, 2021; Moggi, 2019).

Despite the absence of common guidelines, previous studies have had a focus on sustainability reporting practices and the factors that influence the disclosure of information. The factors influencing the disclosure of information have been identified as including the institutionalization of reporting practices, geographical region, the role of external assurance and leadership, the size of the university in question, its seniority, and the diversity of SDG disclosures (De Iorio *et al.*, 2022; Larrán Jorge *et al.*, 2019).

A body of research has emerged focusing on the measurement of the disclosure of SDGs by universities (Caputo *et al.*, 2021; Fiorani and Di Gerio, 2022). The study by Caputo et al. (2021) reveals that the SDGs most frequently disclosed by universities are SDG4, SDG10, and SDG9, while the least disclosed SDGs are SDG17, SDG3, SDG15, and SDG2. This observation underscores the tendency of universities to disclose more information on topics that are more closely related to their activities. The paper by Fiorani and Di Gerio (2022) identified a highly fragmented landscape of SDG disclosure in the context of universities, which poses a significant challenge in comparing the disclosure of SDGs across different universities.

In Europe, some authors have contextualized their research within the Italian context. Some studies have indicated that the dissemination of sustainability reports does not exhibit a consistent trend (Del

Sordo *et al.*, 2016; Moggi, 2019). Furthermore, Moggi (2019) demonstrates that GRI guidelines have been integrated with national standards by Italian universities, resulting in more comprehensive reports that are challenging to verify and compare. Del Sordo et al. (2016) illustrate that the primary obstacle in report development was the absence of a systematic approach to gathering non-financial data within the university.

It has been demonstrated by scholars that the incorporation of SDGs in universities' reporting practices is of significance (Caputo *et al.*, 2021; De Iorio *et al.*, 2022; Monteiro *et al.*, 2024) as a tool to gain legitimacy from stakeholders. Nevertheless, the current level of SDG disclosure remains inadequate to satisfy stakeholders' expectations (Monteiro *et al.*, 2024). This is because reporting practices are still in their beginning and because there is a tendency to report on environmental performance (Lozano, 2011; Moggi, 2019), as sustainability was initially associated with environmental connotations (Lozano, 2011).

Overall, the literature has mainly focused on the accounting of the SDGs and the factors that influence their reporting. To date, it has not focused on the efforts of universities to achieve the SDGs through the analysis of reporting practices. It is therefore considered appropriate to subject the issue to further analysis to determine whether there has been any evolution in the way universities report on sustainability and whether they adopt a substantive or symbolic approach in reporting on the SDGs in their reports. The originality of this research lies in its use of an index based on the GRI framework to assess whether universities have adopted a substantive or symbolic approach to SDG reporting, and whether SDG disclosure has been a one-time initiative or a sustained effort over time. This study makes a substantial contribution to academic literature.

4. Methods

4.1. Data collection and analysis

As sustainability reports are considered the optimal source for the disclosure of SDGs, the institutional websites of each university were consulted to extract and analyze these reports. Italian universities were chosen for the analysis due to the absence of language barriers, which facilitated the search for data and the understanding of the content of the reports.

Once the sample had been identified, a content analysis of the reports was conducted to determine the level of Italian universities proactively providing information on sustainability. Content analysis is a qualitative research technique which enables the researcher to interpret and draw conclusions in an objective, systematic and quantifiable manner. This is achieved by evaluating textual material, such as reports, against predetermined criteria (Beck *et al.*, 2010). It is one of the most widely used techniques in social and environmental accounting. It is used to review non-financial reports and extract valuable patterns and insights by categorizing quantitative and qualitative data according to predetermined criteria (Beck *et al.*, 2010; Guthrie and Abeysekera, 2006).

The content analysis was carried out to identify and examine sections that provided information relevant to sustainability and SDGs themes.

The subsequent step was the creation of an index, which was employed to quantify the disclosed GRI indicators. This step was structured into three stages. The first stage was the identification of the units of analysis in the sustainability reports. These units were subsequently coded using the SDG Compass as an analytical framework. For each GRI indicator, a dichotomous variable was created to

identify the level of university compliance. Following the assignment of scores, a critical evaluation of the reports was conducted, and the scores were used to assess legitimacy.

In the analysis, a substantive legitimacy approach was associated with a university that had clear evidence of revising its strategy and goals to incorporate the SDGs or implementing actions to achieve the SDGs, which was also associated with a high SRI score. Conversely, a university that stated its commitment to the SDGs but failed to identify relevant SDG targets aligned with its core activities or failed to acknowledge potential risks and opportunities associated with the SDGs and associated with low SRI score, was considered to have a symbolic legitimacy approach. Similarly, universities that referenced the SDGs as part of their strategic framework but failed to back this up with concrete actions were deemed to have a symbolic approach.

The study examines the disclosure of the SDGs published from the year 2017 to 2024, as in previous years, most university reports simply stated their intention to commit to the SDGs without directly mentioning specific goals. The rationale behind this implementation, as well as the exponential growth in the use of SDGs in reporting, is likely to be found in the establishment of the RUS network, the inaugural coordination and exchange initiative between Italian universities committed to environmental sustainability and social responsibility (Fiorani and Di Gerio, 2022). The analysis was conducted on Italian universities that are members of the RUS, of which there are 89, representing 86.9% of all Italian universities. The objective of the paper was to examine SDGs reporting practices. To this end, a rigorous approach was adopted to differentiate between disclosures that may align with GRI reporting indicators and those that explicitly address the SDGs without adhering to GRI standards. It is crucial to highlight that our content analysis was conducted on publicly accessible reports published by universities.

To increase rigor, the analysis was conducted independently by the researchers, whose aim was to define the sections of the reports that contain information on sustainability issues, including sentences, paragraphs, figures or tables. At the end of the process, the results were compared and evaluated (Krippendorff, 2019).

4.2. The SDGs reporting index (SRI)

To enhance the study's reliability and comparability, this paper employs an index to evaluate the content of sustainability reports produced by universities, with a particular focus on the level of information disclosed about the SDGs. This index is based on the GRI standards, which are widely regarded as the most appropriate framework for universities (Adams, 2013; Moggi, 2019). The GRI guidelines also provide a base for developing a longitudinal and comprehensive approach to studying this phenomenon (Alonso-Almeida *et al.*, 2015). The SRI was constructed by calculating the value of dichotomous variables associated with each specific SDG, in accordance with the guidelines set by SDG Compass. The guidelines propose a set of indicators based on the GRI standards, designed to capture aspects related to SDGs 1–16. The absence of any reference to SDG 17 is due to the broad focus on sustainable development and the absence of any specific connections to existing GRI indicators.

Following the examination of the reports, the data was entered into an Excel sheet using a binary coding system. A score of 1 was assigned for each disclosed indicator, while a score of 0 was assigned for each undisclosed indicator. Table 1 illustrates the relation between the SDGs and the GRI standards.

Table 1. Relationships between SDGs and GRI

SDGs	*Description*	*GRI Standards*	*N°*
SDG 1	No poverty	202-1; 203-2; 413-2	3
SDG 2	Zero hunger	413-2; 411-1	2
SDG 3	Good health and well being	401-2; 403-2; 403-3; 203-2; 305-1; 305-2; 305-3; 305-6; 305-7; 306-3; 306-2; 306-4; 306-1	13
SDG 4	Quality education	404-1;	1
SDG 5	Gender equality	202-1; 401-1; 404-3; 405-1; 405-2; 406-1; 401-3; 414-2; 414-1; 203-1; 401-2; 102-24; 102-22	13
SDG 6	Clean water and sanitation	306-1; 306-2; 306-3; 303-1; 303-2; 303-3; 304-1; 304-2; 304-4; 306-5; 304-3	11
SDG 7	Affordable and clean energy	302-1; 302-2; 302-3; 302-4; 302-5;	5
SDG 8	Decent work and economic growth	201-1; 404-2; 404-1; 203-2; 204-1; 302-1; 302-2; 302-3; 302-4; 302-5; 303-3; 301-1; 301-2; 301-3; 401-1; 405-1; 202-2; 102-8; 401-2; 405-2; 202-1; 401-3; 404-3; 408-1; 409-1; 403-2; 403-3; 403-1; 403-4; 406-1; 407-1; 402-1; 414-1; 414-2	34
SDG 9	Industry, innovation and infrastructure	201-1; 203-1; G4-EN31;	3
SDG 10	Reduced inequalities	102-8; 401-1; 405-2; 404-3; 404-1	5
SDG 11	Sustainable cities and communities	203-1	1
SDG 12	Responsible consumption and production	301-1; 301-2; 302-1; 302-2; 302-3; 302-4; 302-5; 303-3; 301-3; 306-1; 306-2; 306-4; 305-1; 305-2; 305-3; 305-6; 305-7; 306-3; G4-EN31; 417-1	20
SDG 13	Climate action	201-2; 305-4; 305-5; 305-1; 305-2; 305-3; 302-1; 302-2; 302-3; 302-4; 302-5; G4-EN31	12
SDG 14	Life below water	306-1; 306-3; G4-EN31; 304-3;304-1; 304-2; 306-5; 304-4; 305-1; 305-2; 305-3; 305-4; 305-5; 305-7	14
SDG 15	Life on land	304-1; 304-2; 306-5; 304-4; 304-3; 306-3; G4-EN31; 305-1; 305-2; 305-3; 305-4; 305-5; 305-7	13
SDG 16	Peace, justice, and strong institutions	410-1; 414-1; 414-2; 408-1; 102-16; 206-1; 307-1; 416-2; 417-2; 417-3; 418-1; 419-1; 102-17; 205-1; 205-2; 205-3; 415-1; 102-23; 102-25; 102-22; 102-24; 102-29; 102-21; 102-37	24
SDG 17	Partnership for the goals	-	0
		Total	174

Source: based on GRI and UN Global Compact (2017)

In developing the SRI Index, the methodological approach was derived from previously used scores applied in other studies on SDGs reporting (Avrampou *et al.*, 2019; Caputo *et al.*, 2021; Nikolaou *et al.*, 2023; Pizzi *et al.*, 2021). The SRI was calculated by subtracting the ratio of reported to total GRI indicators in one period from the ratio in the precedent period, subtracting these differences across all periods, and then dividing by the number of periods minus one to obtain an average. The formula is:

$$SRI = \frac{\sum_{T=2}^{T}\left(\frac{GRI_{reported_T}}{GRI_{required}} - \frac{GRI_{reported_{T-1}}}{GRI_{required}}\right)}{T-1}$$

where:

- $GRI_{reported}$ = number of GRI indicators reported
- $GRI_{required}$ = total number of GRI indicators required
- T = the period

This index provides a summary measure of the evolution over time of a university's performance in GRI reporting for all SDGs. It is designed to indicate whether a university discloses information on each SDG, thus offering insight into the specific contributions universities are making in line with the 2030 Agenda. SRI scores permit a more robust interpretation of these efforts through the lens of legitimacy theory, allowing an assessment of whether universities' approaches are substantive, with higher scores, or symbolic, with lower scores.

5. Results

5.1. Analysis of the reports

This research starts with a comprehensive analysis of the reports published by universities within the RUS network. During the period under review, 37 universities produced at least one non-financial report. It is noteworthy that only 43% of the universities in the network published a report during this period. Table 2 provides an overview of the universities included in the analysis, categorized according to geographical location, the size based on the number of students enrolled, and whether they are public, private, or telematics institutes.

Table 2. Higher education institutes that are included in the analysis.

Institute	Location	Region	Enrolled	Size	Type
LUISS - Free International University of Social Studies Guido Carli of Rome	Centre	Lazio	10087	Medium	Private
Polytechnic University of Marche - Ancona	Centre	Marche	14855	Medium	Public
Polytechnic University of Milan	North	Lombardy	47556	Mega	Public
Polytechnic University of Turin	North	Piedmont	33642	Large	Public
School of Higher Studies and Specialization "S. Anna" of Pisa	Centre	Tuscany	345	Small	Public
Telematic University of Rome "Unitelma Sapienza"	Centre	Lazio	3383	Small	Telematic
University of Bologna	North	Emilia Romagna	84681	Mega	Public
University of Brescia	North	Lombardy	15129	Medium	Public
University of Cagliari	South	Sardinia	23660	Large	Public
University of Chieti - Pescara "Gabriele D'Annunzio"	South	Abruzzo	21097	Large	Public
University of Florence	Centre	Tuscany	53612	Mega	Public
University of Gastronomic Sciences	North	Piedmont	328	Small	Private
University of Genoa	North	Liguria	31307	Large	Public
University of L'Aquila	South	Abruzzo	15982	Medium	Public
University of Messina	South	Sicily	23689	Large	Public
University of Milan	North	Lombardy	58899	Mega	Public
University of Milan "Luigi Bocconi"	North	Lombardy	13655	Medium	Private
University of Milano-Bicocca	North	Lombardy	35569	Large	Public
University of Naples "Federico II"	South	Campania	71799	Mega	Public
University of Padua	North	Veneto	68712	Mega	Public
University of Palermo	South	Sicily	41498	Mega	Public
University of Parma	Centre	Tuscany	29664	Large	Public
University of Pavia	North	Lombardy	25070	Large	Public
University of Perugia	Centre	Umbria	27390	Large	Public
University of Pisa	Centre	Tuscany	42467	Mega	Public
University of Roma Tre	Centre	Lazio	31763	Large	Public
University of Rome "La Sapienza"	Centre	Lazio	108176	Mega	Public
University of Rome "Tor Vergata"	Centre	Lazio	30275	Large	Public
University of Sannio	South	Campania	3623	Small	Public

University of Siena	Centre	Tuscany	15148	Medium	Public
University of Trieste	North	Friuli-Venezia Giulia	16295	Medium	Public
University of Turin	North	Piedmont	78799	Mega	Public
University of Tuscia	Centre	Lazio	7525	Small	Public
University of Udine	North	Friuli-Venezia Giulia	14299	Medium	Public
University of Venice "Ca' Foscari"	North	Veneto	18967	Medium	Public
University of Venice IUAV	North	Veneto	4412	Small	Public
University of Verona	North	Veneto	24897	Large	Public

Source: our elaboration based on https://ustat.mur.gov.it/

The sample under examination revealed that many universities are in Northern Italy (46%), are classified as either mega or large universities (27% and 32% respectively) and they are predominantly public institutions. The reports have been prepared by internal university staff, typically the administrative office staff or the accounting professor. The majority of universities adhere to standards such as GRI and/or GBS (Gruppo Bilanci e Sostenibilità), which ensure the comparability of documents over time and facilitate the comparison of documents published by different universities (Shriberg, 2002). Most of the reports analyzed start with an introductory section, which provides information regarding the composition of the working group, the structure of the document, the standards against which the content is evaluated, and the temporal scope of the activities described. 20 universities begin publication of reports during the period under analysis, while 11 published reports cover multiple years. Table 3 presents publication records and the names of the respective reports.

Table 3. Publication records and names of university reports.

Institute	2017	2018	2019	2020	2021	2022	2023	2024	Tot	Report's name
LUISS - Free International University of Social Studies Guido Carli of Rome				X	X	X	X		4	Integrated report
Polytechnic University of Marche - Ancona	X	X		X	X	X			5	Social report - Integrated reporting (2020)
Polytechnic University of Milan					X	X			2	Environmental sustainability report (2021) - Sustainability report (2022)
Polytechnic University of Turin			X	X	X	X			4	Sustainability report
School of Higher Studies and Specialization "S. Anna" of Pisa				X	X		X*		3	Sustainability report
Telematic University of Rome "Unitelma Sapienza"							X		1	Sustainability report
University of Bologna	X	X	X	X	X	X		X	7	Social report - Sustainability report (2024)
University of Brescia			X*		X*	X			3	Sustainability report
University of Cagliari								X*	1	The University of Cagliari's commitment to sustainable development: Activity Report
University of Chieti and Pescara "Gabriele D'Annunzio"				X					1	Sustainability report
University of Florence	X	X	X	X	X	X	X		7	Social report - Sustainability and social report (2022)
University of Gastronomic Sciences						X	X		2	Sustainability report
University of Genoa	X		X*						2	Sustainability report

University of L'Aquila			**X***		**X***				**2**	Sustainability report - Report on U.N. Sustainable Development Goals (2020)
University of Messina					**X**				**1**	Sustainability report
University of Milan					**X**	**X**	**X**		**3**	Sustainability report
University of Milan "Luigi Bocconi"			**X**	**X**	**X**	**X**	**X**		**5**	Sustainability report
University of Milano-Bicocca		**X**		**X**				**X**	**3**	Sustainability report
University of Naples "Federico II"						**X**			**1**	Sustainability report
University of Padua		**X**	**X**	**X**	**X**	**X**	**X**		**6**	Sustainability report
University of Palermo			**X**	**X***	**X**				**3**	Social report
University of Parma		**X**	**X**		**X**				**3**	Sustainability report
University of Pavia					**X**				**1**	Sustainability report
University of Perugia	**X ***			**X***					**2**	Sustainability report
University of Pisa	**X***			**X***			**X***		**3**	Sustainability report
University of Roma Tre							**X**		**1**	Sustainability report
University of Rome "La Sapienza"	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**7**	Social and sustainability report
University of Rome "Tor Vergata"	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**7**	Sustainability report
University of Sannio		**X**			**X***			**X**	**3**	Social report
University of Siena			**X**			**X***			**2**	Sustainability report
University of Trieste				**X**	**X**		**X***		**3**	Sustainability report - Integrated social report (2021)
University of Turin		**X**	**X**		**X***	**X**			**4**	Sustainability report
University of Tuscia				**X**	**X**	**X**	**X**		**4**	Integrated report
University of Udine		**X**	**X**				**X**		**3**	Social report
University of Venice "Ca' Foscari"	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**7**	Sustainability report
University of Venice IUAV		**X**	**X**	**X**	**X**	**X**	**X**		**6**	Sustainability report
University of Verona						**X**	**X**		**2**	Sustainability report
Total	**9**	**13**	**17**	**19**	**24**	**20**	**18**	**4**	**124**	

Source: Authors' calculations. Asterisks (*) denote universities producing multiannual reports; grey background denotes universities publishing their first report; the year in the brackets indicate when the name changes.

A total of 124 reports were analyzed, revealing a highly fragmented landscape. The first distinction concerns the temporal scope of the reporting periods. While most universities publish annual reports covering the eight-year period, a minority publish documents covering two or more years. Notably, 2021 is the peak year with the highest number of reports published. A second distinction concerns the names of the reports. It is common practice among universities to publish reports named social, sustainability, or integrated report. There has been a noticeable shift in terminology over time. In earlier years, the term "social report" was more prevalent, while the term "sustainability report" has gained prominence in recent years. The third difference concerns the consistency of report publication. Several universities, including Bologna, Ca' Foscari, Sapienza, Tor Vergata and Florence, showed remarkable consistency, each producing seven annual reports over the period. The mean publication rate for universities was 3.4 reports over the period of analysis, of which 62% published more than two reports.

5.2. The SRI index

The SRI is used to assess the evolution of sustainability reporting over time, identifying trends in reporting improvement, stagnation or regression, and providing a comparative overview of Italian universities' sustainability disclosure efforts. Table 4 illustrates the SRI scores.

Table 4. SRI for Universities: total report, mean GRI scores and standard deviation.

University	Report published	Mean GRI (Std. dev.)	SRI
LUISS - Free International University of Social Studies Guido Carli of Rome	4	0,290 (0.137)	0,098
Polytechnic University of Marche - Ancona	5	0,340 (0.124)	0,060
Polytechnic University of Milan	2	0,155 (0.041)	-0,057
Polytechnic University of Turin	4	0,180 (0.120)	0,059
School of Higher Studies and Specialization "S. Anna" of Pisa	3	0,239 (0.017)	0,000
Telematic University of Rome “Unitelma Sapienza”	1	-	-
University of Bologna	7	0,646 (0,107)	0,030
University of Brescia	3	0,330 (0,062)	-0,049
University of Cagliari	1	-	-
University of Chieti and Pescara “Gabriele D'Annunzio”	1	-	-
University of Florence	7	0,496 (0.076)	0,000
University of Gastronomic Sciences	2	0,138 (0.073)	-0,103
University of Genoa	2	0,282 (0.016)	0,023
University of L'Aquila	2	0,345 (0.211)	-0,299
University of Messina	1	-	-
University of Milan	3	0,303 (0.065)	0,020
University of Milan “Luigi Bocconi”	5	0,243 (0,018)	-0,001
University of Milano-Bicocca	3	0,339 (0,101)	0,078
University of Naples “Federico II”	1	-	-
University of Padua	6	0,367 (0.063)	0,031
University of Palermo	3	0,182 (0.061)	0,060
University of Parma	3	0,452 (0.044)	-0,034

University of Pavia	1	-	-
University of Perugia	2	0,276 (0.057)	0,080
University of Pisa	3	0,383 (0.072)	0,072
University of Roma Tre	1	-	-
University of Rome "La Sapienza"	7	0,214 (0.069)	0,008
University of Rome "Tor Vergata"	7	0,458 (0.011)	-0,003
University of Sannio	3	0,310 (0.106)	0,020
University of Siena	2	0,233 (0.069)	0,098
University of Trieste	3	0,142 (0.037)	0,020
University of Turin	4	0,474 (0.039)	0,011
University of Tuscia	4	0,312 (0.045)	0,029
University of Udine	3	0,121 (0.006)	0,006
University of Venice "Ca' Foscari"	7	0,316 (0,036)	0,019
University of Venice "IUAV"	6	0,295 (0.035)	0,007
University of Verona	2	0,290 (0.004)	0,006
		mean SRI (Std. Dev.)	0,010 (0,074)

Source: our elaboration

The mean GRI scores for universities with multiple reports, such as the University of Padua and Ca' Foscari University of Venice, range from 0.121 (University of Udine) to 0.646 (University of Bologna). The standard deviations for these universities reflect varying degrees of consistency, with LUISS (0.137) and the University of Verona (0.004). SRI identifies positive trends for institutions such as LUISS and the University of Siena, with scores increasing by 0.098, respectively. Conversely, the University of Brescia and the Polytechnic University of Milan exhibited negative trends, with scores decreasing by -0.049 and -0.057, respectively. The limited data available for institutions such as the University of Pavia and Unitelma Sapienza highlights the necessity for consistent reporting to facilitate meaningful analysis. On average, universities report an SRI of 0.010, with a standard deviation of 0.074, reflecting a combination of improvements and regressions in their sustainability reporting practices. The findings reveal a predominant prevalence of institutions with a favorable SRI, with approximately 57% exhibiting a positive SRI. In addition, approximately 25% of institutions demonstrate an SRI that is equivalent to zero, while the 19% exhibit a negative score. Figure 1 illustrates the box and whisker plot of the SRI Index.

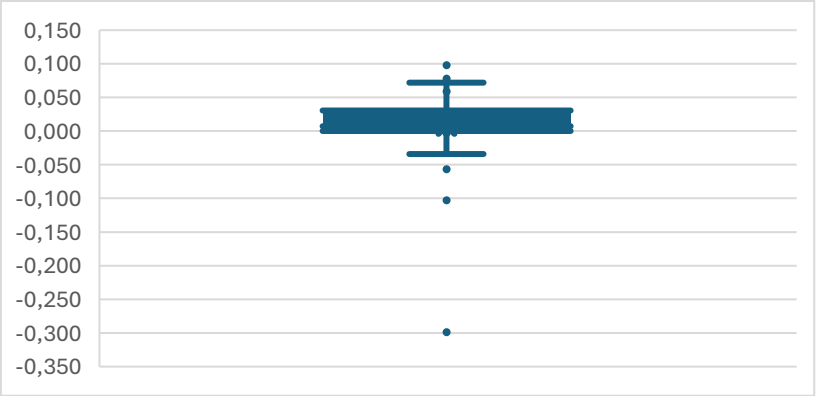

Figure 1. Box plot of the SRI

The box plot of SRI values across the universities demonstrates the considerable variability in reporting trends. The median SRI value, represented by the line within the box, is slightly above zero (0.02), indicating that most universities experienced modest positive trends in their sustainability reporting practices. The interquartile range spans from the first quartile (0) to the third quartile (0.052). The presence of positive outliers, such as LUISS and the University of Siena, is indicative of noteworthy advancements in sustainability reporting. Conversely, the emergence of negative outliers, including the University of L'Aquila, suggests a decline in reporting SDGs. Furthermore, the correlation analysis between SRI, location, enrolled students, size and type shows a positive relationship: the data suggest that size and geographical context are the primary factors associated with enhanced performance in SDG reporting (SRI), while the type of university plays a more marginal role. In conclusion, the relatively low mean SRI demonstrates that universities, which are key actors in the processes of change, have not yet aligned their activities with the goals set by the 2030 Agenda.

5.3. Incorporation of the SDGs in the reports

As previously stated, the UN 2030 Agenda is designed to address the most pressing global challenges affecting all aspects of human life and the planet in a proactive and integrated manner through the 17 SDGs (United Nations, 2015). In this regard, universities are perceived as potential agents of change in the pursuit of sustainability. They are seen as having the capacity to contribute to the realization of the 17 SDGs and the fulfilment of the 2030 Agenda through their educational, research and third mission activities (Paletta and Bonoli, 2019). During the report's analysis, the disclosure of the SDGs is linked to a description of the specific actions or objectives pursued by the university. A common practice is to include images that illustrate the roadmap of the SDGs, accompanied by a declaration of intent to contribute to their achievement.

A dichotomous variable was associated with each GRI, and the ratio between the number of GRI indicators disclosed and the number of indicators required by the SDGs Compass guidelines was calculated using a ponderable mean, taking as a weight, the number of reports published by each institution between 2017 and 2024. The ponderable mean was used in view of the considerable heterogeneity observed in the reports. Table 5 shows the meaning, standard deviation and range of the reported SDGs.

Table 5. Arithmetic means, standard deviation and ponderable means of SDGs.

SDGs	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16
Mean	0,444	0,351	0,401	0,484	0,391	0,258	0,406	0,319	0,535	0,518	0,815	0,305	0,365	0,282	0,266	0,228
Std. Dev.	0,294	0,545	0,209	0,502	0,205	0,205	0,269	0,150	0,207	0,267	0,390	0,169	0,237	0,193	0,193	0,144
P. mean	0,463	0,374	0,385	0,399	0,328	0,264	0,356	0,274	0,478	0,458	0,743	0,288	0,331	0,279	0,254	0,199

Source: our elaboration

The findings indicate that universities tend to report on some SDGs with greater frequency than others. The SDGs most frequently reported were SDG 11 (74%), SDG 9 (48%), SDG 10 (46%) and SDG 1 (46%). Conversely, SDG 16 (20%) was identified as the most challenging to achieve or even to implement active strategies for. The standard deviations for SDGs 2 and 11 are relatively high, indicating significant variability in how universities report on GRI for these SDGs. Conversely, SDGs 6 and 5 exhibit considerably lower standard deviations, indicating that universities reporting on these SDGs tend to do so with greater consistency. These goals are often achieved through teaching and research activities, such as the introduction of degree programs that make explicit reference to sustainability in their curricula, or the provision of extracurricular courses on sustainability that are accessible to both students and staff. Figure 2 shows the trend of reported SDGs.

Figure 2. Radar chart of reported SDGs in hierarchical order.

6. Discussion and conclusions

The analysis is based on the study of sustainability reports, as tools for transparent and effective communication with stakeholders, on the allocation of resources and on the results achieved (An *et al.*, 2019; Arkoh *et al.*, 2024; Larrán Jorge *et al.*, 2019) and to inform about efforts towards the SDGs (Alcántara-Rubio *et al.*, 2022; Fia *et al.*, 2023).

Although sustainability reporting has spread among Italian universities following membership of the RUS network, the reports are oriented towards meeting formal requirements rather than producing substantial organizational changes (Deegan, 2002; Savage *et al.*, 2000; Suchman, 1995). This trend towards symbolic compliance calls into question not only the credibility of the information communicated, but also the actual usefulness of such reports for the measurement of the SDGs.

The results highlight a persistent discrepancy between stated intentions and actual performance in SDG reporting. This difference indicates a challenge in incorporating sustainability into operating practices and also raises questions about the credibility of this information (Heras-Saizarbitoria *et al.*, 2022; Moggi, 2019).

In accordance with the content analysis and the SRI, a clear bifurcation emerges between two groups of institutions. On the one hand, a substantive approach is evident in institutions such as the University of Bologna and Ca' Foscari, which show progress with clear SDG-aligned actions and year-on-year increases in SRI, demonstrating an approach with structured reporting frameworks and well-defined sustainability strategies. In contrast, universities such as the University of L'Aquila, the University of Florence and the Sant'Anna Institute have shown a decline or stagnation in their relations, demonstrating limited institutional capacity and high governance complexity on sustainability issues. In these cases, the prevalence of symbolic reporting indicates the use of sustainability reports and participation in the RUS network as a means to improve one's reputation, rather than as tools to effect a substantial institutional transformation (Lozano, 2011; Raimo *et al.*, 2024).

However, even virtuous cases have room for improvement as the information disclosed is often sectoral and closely linked to specific SDGs (e.g. 11 and 9), as they are closely aligned with the main teaching and research missions. Cross-cutting and governance goals (e.g. SDG 16) remain marginal. In these cases, the sections take the form of a symbolic and rather generic declaration of intent towards one or more priority SDGs, enriched by a colorful infographic, but without inspiring substantial changes in strategies, declaring that they are already aligned with some SDGs. Therefore, it is common to link existing activities to SDG icons to reinforce the sustainability message and make the report more attractive to stakeholders (Heras-Saizarbitoria *et al.*, 2022; Suchman, 1995).

The visual representation of the SDG icons tends to give the impression of active involvement in achieving them. The extensive use of colorful images depicting the SDGs roadmap, often in the introductory section of the report, along with the statement of intent to contribute to their achievement, can be attributed to an empowerment strategy. In this way, organizations project the rhetorical image of socially responsible organizations, careful to do the right thing, masking pre-existing activities (Bebbington and Unerman, 2020; Van Bommel, 2014)

We observe the phenomenon of SDG-washing which highlights an opportunistic approach to reporting, with institutions emphasizing easily communicable metrics, while postponing more challenging or less tangible objectives, reducing accountability and incentivizing opportunistic reporting (Heras-Saizarbitoria *et al.*, 2022). This does not necessarily imply misinformation, but a provision of information not supported by substantive actions because, rather than engaging in costly and in-depth transformations of their business, such organizations seem to find it more convenient and cost-effective to manipulate stakeholder perceptions through symbolic disclosures (Walker and Wan, 2012).

The changes in the name of the reports ("integrated", "social", "sustainability") appear more like a marketing strategy than a sign of substantial change. The temporary increase in SRI after the renaming

testifies to a superficial adjustment rather than a real improvement in practices. In particular, the cases of the Polytechnic University of Milan and L'Aquila indicate how even a change of label can result in a drop in substance, consolidating the hypothesis that labels are not linked to investments in actual performance. This suggests strategic use of labels to indicate alignment with sustainability reporting trends, without ensuring measurable results. These behavior are in line with the theoretical framework of legitimacy, which postulates that organizations can adopt superficial practices to maintain public trust and avoid significant operational changes (An *et al.*, 2019; Deegan, 2002; Suchman, 1995). As a result, there remains a gap between the good intentions declared by these companies to achieve the SDGs and their concrete willingness to translate them into concrete business strategies and operations.

In conclusion, a proactive approach leaves room for a more adaptive approach. In universities, which are key places for a more sustainable future, the SDGs have not inspired structural changes in strategy or business model but represent socially accepted goals to which universities have aligned pre-existing strategies. While they stated that their approach guides their contribution to one or more relevant SDGs, they remained silent about the changes they have undertaken in their business model, strategy, or activities to operationalize them. There is no trace of structural or organizational changes inspired by the same objectives.

These results raise questions about the effectiveness of voluntary and fragmented reporting management. The lack of a mandatory regulatory framework contributes to poor comparability and the risk of erosion of stakeholder trust. The legitimacy theory implies that organizations can leverage symbolic practices to maintain public consensus without changing decision-making processes (Deegan, 2002). Our contribution criticizes the absence of control mechanisms and suggests that, in the lack of consistent regulation, sustainability reports risk remaining mere branding tools.

To bridge the gap between disclosure and action, policymakers and universities should (1) incorporate SDG goals into institutional performance metrics, (2) align budget allocations with sustainability goals, and (3) establish transparent monitoring systems that link disclosure to verifiable outcomes, such as GRI and GBS (GBS, 2024).

The present study contributes to the current body of literature in this field. Firstly, it stresses the importance of concrete actions that effectively integrate the principles of the SDGs into management strategies. Secondly, it increases knowledge about the application of legitimacy theory in the higher education sector. Thirdly, it highlights the link between the use of GRI in reporting and social pressure on sustainability issues.

Limitations and future directions are presented. This work is limited to RUS universities and public reports. Future research should extend the analysis to a wider sample, including qualitative insights and field assessments to measure the true impact of sustainability claims.

In conclusion, the analysis presented highlights that, in the absence of binding regulations and strict controls, there is a considerable risk that sustainability reporting will continue to be a mere branding exercise, thus nullifying the legitimacy and transformative potential of higher education in achieving the 2030 Agenda.

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Modelling Fiscal Drag in a DSGE environment*

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Abstract

In a period of renewed inflationary pressures, understanding how progressive taxation interacts with rising prices is crucial. This paper investigates the macroeconomic effects of fiscal drag - a phenomenon where inflation-induced increases in nominal income push households into higher tax brackets - within a Two-Agent New Keynesian (TANK) DSGE model calibrated to the U.S. economy. We develop a novel piecewise-quadratic tax function to replicate U.S. federal income brackets and simulate a persistent inflationary shock. Our results show that fiscal drag leads to higher tax revenues and passive debt consolidation but imposes asymmetric burdens across households. Forward-looking savers reduce consumption and work more to offset expected taxation, while hand-to-mouth households bear a disproportionate share of the adjustment due to their inability to respond. These findings underscore the redistributive consequences of unindexed tax systems and provide new insights into the role of taxation in inflationary environments.

Body Math *JEL Classification System:* D6, E31, E44, E58, H63

Keywords: Inflation, Fiscal Drag, Tax brackets, Income tax rate, Public debt.

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Key Points

- Define a new technique to model tax brackets creep in a DSGE framework.
- Assess macroeconomic consequences of fiscal drag phenomenon.
- Provide an evaluation of intertemporal choices between consumption and labor.

1 Introduction

In a context like the actual one where inflation raised all over the world, investigate Fiscal Drag phenomenon go back to being relevant. Specifically, fiscal drag occurs within an economy where rising inflation and growth in earnings force consumers into higher tax brackets. This creates a situation where consumers pay more taxes and have less purchasing power, even when earning more. In other words, increase in inflation - acting like a progressive tax - might causes bracket creep that occurs when people are pushed into higher income tax brackets or have reduced value from credits and deductions. In light of that, in US, the Internal Revenue Service (IRS) adjusts more than 60 tax provisions for inflation to prevent this mechanism. Specifically, with the Tax Cuts and Jobs Act of 2017 (TCJA), the IRS now uses the Chained Consumer Price Index (C-CPI) to adjust income thresholds, deduction amounts, and credit values accordingly .

However, according to an analysis prepared for The Post by the Tax Foundation, an average New Yorker making around $80,000 a year will be forced to shell out an extra $225 in taxes in 2023. The reason lies in the fact that the federal government and a group of 13 states that includes New York, New Jersey and Connecticut have failed to fully adjust their tax brackets for inflation, even as the increase in cost of everything .

In light of that, assess Fiscal Drag effects for US economy appears relevant.

This is what we do in this paper. Specifically, it asks: 1) how is possible to model tax "brackets creep" in a DSGE framework? 2) What are macroeconomic effects of a permanent increase in inflation in the presence of progressive taxation? 3) What are economic mechanisms on households and on government budget constraints and how much costly is fiscal drag for agents? To answer these questions, we simulate a permanent increase in inflation target in a Two Agents New Keynesian (TANK) model à la Leeper et al (2017) with monopolistic competition in goods, sticky-price, and distortionary taxation. To measure the effects of fiscal drag we compare results among two different scenarios: one with progressive income taxation and the other with fix tax rate.

This paper provides three main contributions that for different reasons could be difficult to examine in a different framework.

First, this paper introduces a new technique to assess in a DSGE environment, fiscal drag phenomenon implying that taxation rate varies discretely namely is not differentiable. Specifically, we build a polynomial function for income tax rate to model "tax brackets creep" by considering Federal Income Tax Brackets.

Second, this paper is the first attempt to study macroeconomic consequences of fiscal drag in a DSGE model for US economy by considering a determistic environment.

Three, provides an evaluation of how intertemporal choices between consumption and labor of two type of agents - savers and hand to mouth households - in an economic framework with fiscal drag might be affected. Overall, hand to mouth households suffer more the

effects of inflation increase both in the short and in the long run. Indeed, since savers are forward looking agents they expect that permanent increase in inflation might causes tax brakets creep. This, causes that try to prevent these effects by consuming less and working more, entailing lower wages. As consequences, savers' labor income increase less than of hand to mouth households'.

Thus, this paper could represent a potentially important study for different research fields.

First, from theoretical point of view, it provides a useful approach to model labor income tax brackets creep in a DSGE model where everithing is differentiable. Indeed, tax schedules are usually defined in a piecewise manner, which implies non-differentiable and often non-continuous marginal tax rate functions that complicates the computation of an individual's tax liability (Schwarz and Sommer 2018).

Second, from a macro and microeconomic point of view, it allows to analyze tax brackets creep' effect caused by permanent increase in inflation, both for households in terms of income distributions and for the government in terms of fiscal drag. In this regards, progressive taxation acts as authomatic stabilizer that allows increasing government taxation without actually increase taxes. In other words, fiscal drag represents a fiscal policy that results in a fiscal consolidation, namely lower bonds supply. In light of that, this paper tries to provide a descriptive analysis of higher inflation's effects on households' investments in short and long-term bonds. This is the reason why it could represent a potentially research avenue for financial sector as well, specifically for bond markets.

Eventually, we think this is an interesting research question since the impact of inflation on the income distribution in the presence of a progressive tax system is widely unexplored. There are multiple studies using empirical analysis and micro-simulation techniques to assess the effect of bracket creep and tax-policy adjustments on income distribution (Immervoll, 2005; Dorn et al., 2017; Sutherland et al., 2008; Paulus et al., 2020; Fossen et al. 2020). However, there are few empirical studies that quantifies effects of inflation on income distribution dimension in a framework with progressive taxation (Süssmuth and Wieschemeyer, 2022; Hetland and Sabatè, 2021). Instead, as far as we know, there are no theoretical contributions investigating effects of Fiscal Drag phenomenon. Some discussion papers investigate the role of prograssive taxation in a DSGE model in the presence of demand and technology shocks by neglecting the effects of inflation in terms of fiscal drag (Engler and Strehl, 2016; Strehl and Engler, 2015). The only paper that, to our knowledge analyze consequences of progressive taxation for monetary policy is Mattesini and Rossi (2012) by focusing on effects for inflation – output stabilizzation trade off. These papers model progressive taxation as in Guo and Lansing (1999) where tax rate depends from steady-state levels of per capita labor and capital income taking as given by the household. Differently, based on US tax brakets data, we build a specific polynomial function for income tax rate tacking into account a time varing labor income for households.

Main results can be summarized as follows: Rising inflation causes household nominal labor income to rise who, consequently, have to pay higher taxation. However on the one hand, savers, as forward-looking agents, they expect that following rising inflation fiscal drag effects may occur. Therefore, they consume less and work more. As a result, their wages reduce. On the other hand, hand-to-mouth households consume all their income and work less. This causes an increase in their wages. Overall, at the same income tax rate, savers' labor income increase less than hand-to mouth households'. As consequences, the former suffer less than others effects of permanent increase in inflation in terms of bracket creep. As for the government, a permanent increase in inflation in a framework with prograssive taxation entails debt consolidation since fiscal drag effects. The opposite occurs in the model with fix income tax rate.

To our knowledge, this paper is the first attempt to study the effects of permanent inflation target increases in a DSGE model with progressive taxation. However, it would be interesting to investigate how fiscal authorities might keep negative effects of Fiscal Drag under control. Moreover, it would be interesting to compare consequences of an active intervention of monetary and fiscal policy. We leave these for future research.

Now proceeds to the following sections: Sections 2 and 3 describe the model and the calibration of parameters, respectively. Section 4 defines approach to model labor income tax brackets creep in a DSGE model. Sections 5 reports results. Section 6 concludes.

2 Model

The model we use is a Two Agents New Keynesian (TANK) model à la Leeper et al (2017) with monopolistic competition in goods, sticky price and distortionary taxation. The economy includes households, firms, the government and the Central Bank. There are two different type of households: savers who can save, and hand-to-mouth households who can consume their income period by period. Firms convert household labor and capital into the final good and prices are sticky 'a la Calvo (1983) with indexation. The government issues new long-term bonds and levies taxes from households, to finances government expenditures and expiring long-term debt. Eventually, monetary authority follows a Taylor rule in setting the nominal interest rate.

2.1 Households

There is a continuum of households, of which a fraction μ are hand-to-mouth while the remaining fraction $1-\mu$ are savers. The former are indexed by H and savers are indexed by S.

2.1.1 Savers

Savers consume private and public goods and supply labor services. Their utility function is the following:

$$\max E_0 \sum_{t=0}^{\infty} \beta_S^t \left[\log C_{S,t} - \frac{(N_{S,t})^{1+\eta}}{1+\eta} \right],$$

where β_S^t is the discount factor; η represents labor elasticity; $C_{S,t}$ denotes a composite consumption given by the sum of private ($C^*_{S,t}$) and public (G_t) consumption, namely $C_{S,t} = C^*_{S,t} + \alpha_G G_t$; finally, $N_{S,t}$ represents the working hours.

Their budget constraint is:

$$P_t C_{S,t}(1+\tau^C) + P_t^B B_t + \frac{B_{S,t}}{R_{S,t}} = (1+\rho P_t^B) B_{t-1} + B_{S,t-1} + (1-\tau^N) w_{S,t} N_{S,t} + (1-\tau^K) r_t^k K_{S,t}, \tag{1}$$

where B_S are one-period bonds promising a nominal payoff B_S at time t + 1 that can be purchased at the present discounted value $R_{S,t}^{-1} B_{S,t}$; B_t are long-term government bonds that can be purchased at price P_t^B , with a maturity decaying at a constant rate $\rho \in [0,1]$ and duration $(1-\beta\rho)^{-1}$. $w_{S,t}$ and r_t^k represent wages and rental rate of capital, respectively. Nominal consumption is taxed at the rate τ^C; capital and labor incomes are subject to a tax rate τ^K and τ^N, respectively.

The capital stock, $K_{S,t}$, own by savers, evolves according to the following law of motion:

$$K_{S,t+1} = I_{S,t} + (1-\delta) K_{S,t} \tag{2}$$

where δ denotes capital depreciation rate and $I_{S,t}$ represents savers' investments.

The first order conditions to the problem are the following:

$$\frac{1}{C_{S,t}} = \lambda_{S,t} P_t (1+\tau^C) \tag{3}$$

$$(N_{S,t})^{\eta} = \lambda_{S,t} (1-\tau^N) w_{S,t} \tag{4}$$

$$\lambda_{S,t} = \beta_S \lambda_{S,t+1} \left[(1-\tau^K) r_{t+1}^k + (1-\delta) \right] \tag{5}$$

$$\lambda_{S,t} \frac{1}{R_{S,t}} = \beta_S \lambda_{S,t+1} \tag{6}$$

$$\lambda_{S,t} P_t^B = \beta_S \lambda_{S,t+1} (1+\rho P_{t+1}^B) \tag{7}$$

where $\lambda_{S,t}$ denotes the lagrange multiplier. The first three equations represent the first

order conditions respect to consumption, working hours and capital. The last two equations are the inter-temporal conditions for short- and long- term bonds, respectively.

2.1.2 Hand-to-Mouth

As well, hand-to-mouth households maximize the same utility function as savers:

$$\max E_{0}{}_{t=0}^{\infty}\beta_H^t \left[\log C_{H,t} - \frac{(N_{H,t})^{1+\eta}}{1+\eta}\right],$$

where $\beta_H^t = \beta_S^t$ is the discount factor. They consume their after-tax income, period by period and are subject to the following budget constraint:

$$P_t C_{H,t}(1+\tau^C) = (1-\tau^N) w_{H,t} N_{H,t},$$

The first order conditions to the problem are the following:

$$\frac{1}{C_{H,t}} = \lambda_{H,t} P_t (1+\tau^C) \tag{8}$$

$$(N_{H,t})^{\eta} = \lambda_{H,t}(1-\tau^N) w_{H,t} \tag{9}$$

where the first equation represents the first condition respect to the consumption, while the second is the labor supply condition.

2.2 Firms

The final goods firms operate under perfect competition and flexible prices. They aggregate intermediate goods according to the following production function:

$$Y_t = \left[\int_0^1 Y_t\,(z)^{(\varepsilon-1)/\varepsilon}\, dz\right]^{\varepsilon/(\varepsilon-1)},$$

where $\varepsilon > 1$ represents the elasticity of substitution between intermediate goods. The final good firm chooses $Y_t(z)$ to minimize its costs, resulting in demand of intermediate good z:

$$Y_t(z) = \left(\frac{P_t(z)}{P_t}\right)^{-\varepsilon} Y_t.$$

The price index is then given by:

$$P_t = \left[\int_0^1 P_t(z)^{1-\varepsilon} dz\right]^{1/(\varepsilon-1)}$$

where $P_t(z)$ represents price of intermediate goods.

2.3 Intermediate goods producers

We assume that intermediate firms compete monopolistically producing goods according to the following technology:

$$Y_t(z) = (K_t)^{\xi} \left({N_{S,t}}^{\alpha} {N_{H,t}}^{(1-\alpha)} \right)^{1-\xi} \tag{10}$$

where $\xi, \alpha \in [0,1]$ represent elasticities in production function and K_t denotes aggregate capital.

They choose capital and labor services to maximize their expected profits. The first-order conditions of the maximization problem are the following:

$$w_{S,t} = mc_t \left[\alpha(1-\xi)\right] \frac{Y_t(z)}{N_{S,t}} \tag{11}$$

$$w_{H,t} = mc_t \left[(1-\alpha)(1-\xi)\right] \frac{Y_t(z)}{N_{H,t}} \tag{12}$$

$$r_t^k = mc_t \xi \frac{Y_t(z)}{K_t} \tag{13}$$

where mc_t denotes the marginal cost. Equations 11-12 describe the demand for savers' and hand-to-mouth households' labor services, while equation 13 denotes capital demand.

2.4 Price setting equations

The price-setting problem for the intermediate good producers follows the standard Calvo-Yun setting. In each period an intermediate firms sells its good at price $P_t(z)$ and faces a constant probability, $1-\theta \in [0,1]$, of being able to choose the sale price.

The optimal price $P_t^*(z)$ is chosen in order to maximize the discounted value of expected future profits. The firms' maximization problem is the following:

$$\max_{P_t^*(z)} E_t \sum_{s=0}^{\infty} (\theta \beta_S)^s \frac{P_t}{\lambda_t} \frac{\lambda_{t+s}}{P_{t+s}} \left(P_t^*(z) \prod_{k=1}^{s} \pi_{t+k-1}^{\chi} - P_{t+s} mc_{t+s} \right) Y_{t+s}^*(z) = 0$$

subject to:

$$Y_{t+s}^*(z) = \left(\frac{P_t^*(z) \prod_{k=1}^{s} \pi_{t+k-1}^{\chi}}{P_{t+s}} \right)^{-\varepsilon} Y_{t+s}^d$$

where χ represents inflation indexation parameter; $\frac{\lambda_{t+s}}{\lambda_t}$ denotes the stochastic discount factor of savers[1], who own the firms, and Y_t^d represents the aggregate demand.

The first order condition respect to $P_t^*(z)$ is:

[1]Where $\lambda_t = \lambda_{S,t}$ is equal to $\frac{1}{C_{S,t}}$.

$$E_t \sum_{s=0}^{\infty} (\theta\beta_S)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{-\varepsilon} Y_{t+s}^{d} \left(\frac{P_t^*(z)}{P_t} \right)^{-\varepsilon-1}$$
$$\left[\left(\frac{P_t^*(z)}{P_t} \right) \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right) + \frac{\varepsilon}{1-\varepsilon} mc_{t+s} \right]$$

where the term $\frac{\varepsilon}{1-\varepsilon}$ indicates the mark up in the absence of price stickiness. By writing this first-order condition recursively, we can define:

$$x_t^1 = \left(\frac{P_t^*(z)}{P_t} \right)^{-\varepsilon-1} E_t \sum_{s=0}^{\infty} (\theta\beta_S)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{-\varepsilon} Y_{t+s}^{d} mc_{t+s}$$

$$x_t^2 = \left(\frac{P_t^*(z)}{P_t} \right)^{-\varepsilon} E_t \sum_{s=0}^{\infty} (\theta\beta_S)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{1-\varepsilon} Y_{t+s}^{d}.$$

By expressing recursively:

$$x_t^1 = Y_t^d mc_t P_t^*(z)^{-\varepsilon-1} + E_t \left[(\theta\beta_S) \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{P_t^*(z)}{P_{t+1}^*(z)} \right)^{-\varepsilon-1} \left(\frac{\pi_t^{\chi}}{\pi_{t+1}} \right)^{-\varepsilon} x_{t+1}^1 \right] \tag{14}$$

$$x_t^2 = Y_t^d P_t^*(z)^{-\varepsilon} + E_t \left[(\theta\beta_S) \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{P_t^*(z)}{P_{t+1}^*(z)} \right)^{-\varepsilon} \left(\frac{\pi_t^{\chi}}{\pi_{t+1}} \right)^{1-\varepsilon} x_{t+1}^2 \right]. \tag{15}$$

It is possible to rewrite the price setting equation as follows:

$$x_t^1 = \frac{\varepsilon - 1}{\varepsilon} x_t^2. \tag{16}$$

2.5 Aggregation

The market clearing condition for the goods is:

$$Y_t = Y_t^d * \tilde{s}_t \tag{17}$$

where s_t denotes the price dispersion in the Calvo model as follows

$$\tilde{s}_t = (1-\theta) P_t^*(z)^{(-\varepsilon)} + \theta \left(\frac{\pi_t}{\pi_{t-1}^{\chi}} \right)^{\varepsilon} \tilde{s}_{t-1}; \tag{18}$$

P_t^* represents the aggregate price level that satisfies the following equation:

$$1 = \theta \pi_t^{(\varepsilon-1)} \left(\pi_{t-1}^{\chi} \right)^{(1-\varepsilon)} + (1-\theta) P_t^*(z)^{(1-\varepsilon)}. \tag{19}$$

Y_t^d represents the aggregate demand:

$$Y_t^d = C_t + I_t + G_t, \tag{20}$$

where C_t is the aggregate consumption as follows:

$$C_t = \mu C_{H,t} + (1-\mu)C_{S,t}.$$

K_t and I_t denote aggregate capital and investment:

$$K_t = (1-\mu)K_{S,t}, \tag{21}$$

$$I_t = (1-\mu)I_{S,t}. \tag{22}$$

2.6 Fiscal sector

Government issues new long-term debt obligations and accumulates taxes to finances government expenditures and expiring long-term bonds. While considering that short-term bonds are in zero net supply, fiscal authority' nominal budget constraint can be described as follows:

$$(1+\rho P_t^B)B_{t-1} + P_t G_t = P_t^B B_t + (\tau^N) w_{S,t} N_{S,t} + (\tau^N) w_{H,t} N_{H,t} + \tau^K r_t^k K_{S,t} + \tau^C P_t C_t \tag{23}$$

where

$$B_t = b_t Y_t, \tag{24}$$

and

$$G_t = g_t Y_t \tag{25}$$

where b_t represents public debt-to-GDP ratio and g_t denotes public spendig.

2.7 Monetary Policy

We assume that the Central Bank sets the nominal interest rate according to the a standard Taylor rule:

$$\frac{R_t}{R^*} = \left(\frac{\pi_t}{\pi^*}\right)^{\phi_\pi^R} \left(\frac{Y_t}{Y^*}\right)^{\phi_y^R}, \tag{26}$$

where R^*represents the target nominal interest rate; $\pi^*$and y^* denote the steady state

inflation rate and output, respectively[2].

Parameters ϕ_π^R and ϕ_y^R govern the response of nominal interest rate to inflation and output gap, respectively.

3 Calibration

This Section summarizes parameter values. Table 1 shows their description and details. While calibrating structural parameters, we rely largely on the estimates by Leeper et al (2017) which are consistent with the US data.

As for the households, the parameter representing the discount factor is set equal to 0.99 both for savers and for hand-to-mouth households; the inverse Frish elasticity η is set to 1.77 and the parameter denoting the substitutability between private and government consumption α_G is calibrated at -0.24, following Leeper et al (2017). The parameter representing hand-to-mouth households' share is set at 0.11, in line with Kaplan et al (2014). The rate of capital depreciation is set to 0.025 consistently with standard literature. Eventually, in calibrating the decay rate of the maturity of long-term government bonds at 0.9593, we follow Bianchi et al (2020).

As for the firms, parameters denoting elasticity of production function are set to 0.33. The price elasticity of demand ε, is calibrated at 6 as in Cantore and Freund (2021). The Calvo price parameter θ is equal to 0.920 as in Leeper et al (2017) while the price indexation χ to 0.66, as in Smets and Wouters (2007).

With regards to monetary policy, we calibrate first and second steady-state values of inflation at 2% and 5%, respectively.

The parameters denoting the response of nominal interest rate to inflation ϕ_π^R and output ϕ_y^R are set to 1.5 and 0.5 respectively, in line with the classical Taylor rule specification.

With respect to fiscal sector, we follow Leeper et al (2017) in setting tax rates on capital, labor and consumption to 0.218, 0.186 and 0.023, respectively and in setting the public spending to GDP ratio to 0.11.

[2]This Taylor rule defines the Fed's dual mandate pursuing goals of price stability and maximum employment.

Table 1: **Baseline Calibration**

Parameter		Value
Households		
Discount factor	$\beta_S = \beta_H$	0.99
Parameter associated with labor elasticity	η	1.77
Capital depreciation rate	δ	0.025
Maturity of long-term bonds	ρ	0.959
Sustainability of public consumption	α_G	-0.240
Share of hand-to-mouth households	μ	0.11
Firms		
Elasticity in production function	$\alpha = \xi$	0.33
Price elasticity of demand	ε	6
Calvo price	θ	0.920
Price indexation	χ	0.66
Monetary Policy		
Inflation (old target)	π^*_{old}	2%
Inflation (new target)	π^*_{new}	5%
Inflation stabilization	ϕ^R_π	1.5
Output stabilization	ϕ^R_y	0.5
Fiscal sector		
Tax rate on consumption	τ^C	0.023
Tax rate on labor	τ^N	0.186
Tax rate on capital	τ^K	0.218
Public spending to GDP ratio	g	0.11

4 Modelling Fiscal Drag: Spline Vs Polynomial function

Definition.1

A function f: $R \to R$ is a progressive tax rate function, or simply a T-function, if it has the following properties: (0) $0 \leq f(x) < 1$.

(i) $f(x) = 0$ when $x \leq 0$, and $f(x) > 0$ when $x > 0$.

(ii) $f(x)$ is an increasing function when $x > 0$.

(iii) $lim\ f(x) = 1$.

(iv) $f(x)$ is convex when $0 < x < 1$, and $f(x)$ is concave when $x > 1$.

(v) The net income function $g(x) := x(1 - f(x))$ where $(x > 0)$is an increasing function.

Similarly to **Kim (2018),** in the definition of a T-function, the variable x means the total income of a Savers for a certain period. The property (0) follows from other properties (i) (iii). The property (i) says that "No positive income, no tax. Any positive income, some tax". If we want, "Small income, no tax", then we may adjust the property (i) by translating the function $f(x)$. In (ii) and (v), "increasing" means "strictly increasing". The property (iv) fixes the unit $x1 = 1$ as the inflection point of f.

Proposition 1

In our context, the variable x denotes the total labor income earned by households—specifically, the income of savers, who represent the forward-looking agents in the economy and constitute the majority share in the population (as established by our calibration). The function $g(x)$, which we aim to define, is based on empirical U.S. tax data from 2014, obtained from the Internal Revenue Service (IRS).

Each segment corresponds to a fixed marginal tax rate applied within a specific income bracket, introducing points of discontinuity $x1; x2; x3; ...$A progressive tax rate function under this system typically resembles the graph shown in Figure 1.

However, such discontinuous step functions pose certain problems in dynamic macroeconomic modeling—especially within a DSGE (Dynamic Stochastic General Equilibrium) framework—because sudden jumps in tax rates can interfere with the smooth behavior of the model's differential equations and complicate the computation of steady states and dynamics.

To address this issue, and in order to integrate the tax function consistently within our DSGE model, we approximate the progressive tax schedule using a continuous piecewise-linear function. This smoothed functional form eliminates abrupt discontinuities and is more suitable for capturing the behavioral responses of agents over time.

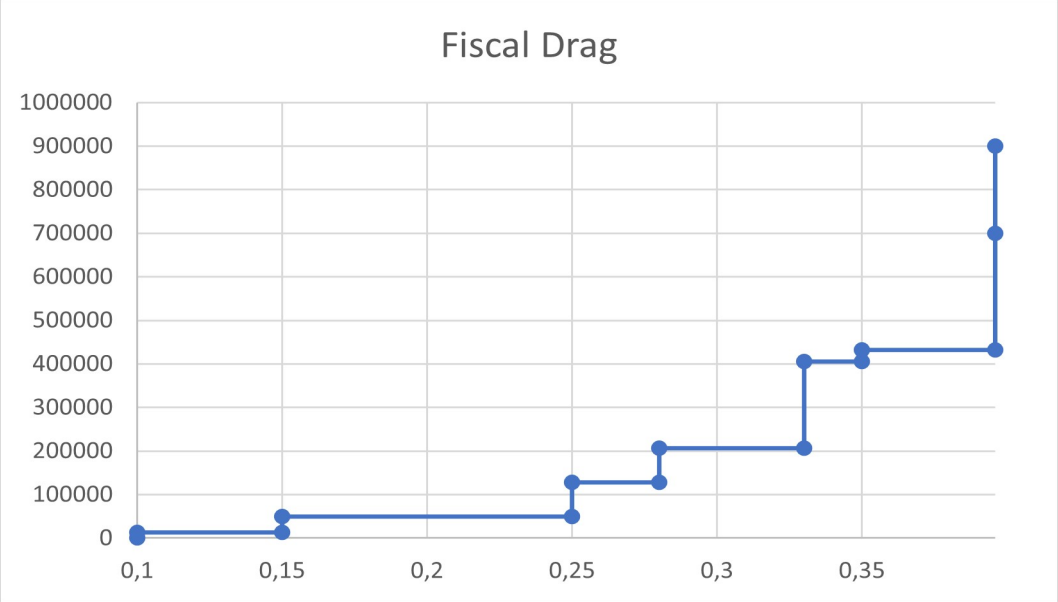

Figure 1: Interpolation function

Definition 2

A piecewise polynomial function $g(x)$ defined on the interval $[a, b]$ is a function such that, on each subinterval $[x_i, +x_{i+1}]$, it coincides with a polynomial $p_i(x)$ of degree k_i.Typically, for simplicity and smoothness, the degree is the same across all segments, i.e. $k_i = k$ for all $i = 0, ..., n-1$. Thus, the function $g(x)$ is expressed in terms of a matrix whose i-th row contains the coefficients of the corresponding polynomial:

$$p_i(x) = a_{i,k}x^k + a_{i,k-1}x^{k-1} + ... + a_{i,0}$$

for each subinterval $[x_i, +x_{i+1}]$. This structure enables the function $g(x)$ to be flexible enough to capture nonlinear relationships while maintaining a manageable analytical form, especially useful in computational frameworks like DSGE models.

Proposition 2

To build a smooth progressive tax rate function aligned with empirical data, we begin by defining the labor income vector for the saver households as:

$$\langle w_s, N_s, \Pi \rangle$$

where w_s is the wage rate for savers, N_s is their labor supply, and Π is the inflation rate.

Given that inflation increases between the first and second steady states of the model, the product $w_s N_s \Pi$, which we denote as wns, also rises. Next, consider a vector y representing marginal income tax rates, and a corresponding vector $g(y)$that captures the U.S. tax brackets (e.g., from IRS 2014 data). To ensure comparability with the modeled economy,

we normalize the observed tax bracket values using the maximum value of the simulated wns vector (obtained from a calibration in which the tax rate on labor τ^N is fixed at 0.186). This yields a rescaled support x, consistent with the scale of labor income in the model.

We then define a polynomial function of degree 2 that provides the best continuous approximation to the observed progressive tax system. This smoothed, piecewise-quadratic tax function eliminates the discontinuities inherent in real-world stepwise brackets, while preserving the key features of progressivity. The choice to focus on savers stems from their forward-looking behavior and dominant share in the population, which makes them the primary channel through which fiscal policy influences the macroeconomic equilibrium in our DSGE framework.

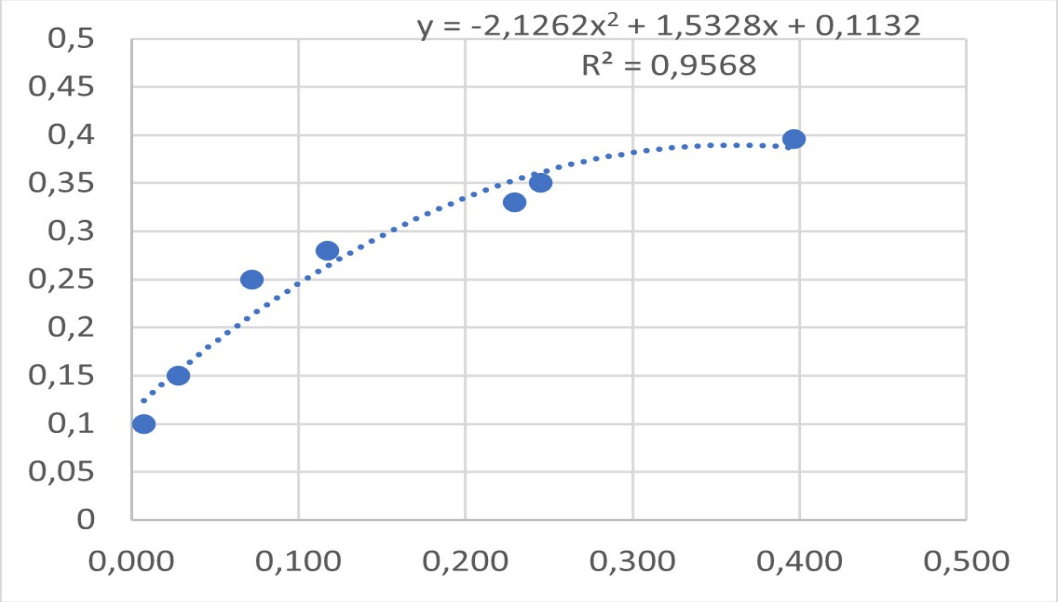

Figure 2: Polynomial function

5 Results

This Section discusses the short-run effects of a permanent increase in inflation on the main macroeconomic variables in a framework with progressive taxation. The aim is to study the impact of persistent inflation rises in terms of tax braxet creep. Moreover, while investigating fiscal drag effects, we compare these results with those entailed from the model with fix income tax rate.

5.1 Short-run results

A permanent increase in the inflation rate induces a downward adjustment in nominal interest rates, particularly if the central bank aims to stabilize real interest rates or follows a

monetary rule with limited responsiveness to inflation. As borrowing becomes less expensive, both households and firms are encouraged to take on more debt, which results in an expansion of the money supply in circulation.

This increase in liquidity contributes to further inflationary pressure, reinforcing the initial price dynamics. At the same time, the inverse relationship between interest rates and bond prices implies that falling interest rates lead to a rise in bond valuations. While this might initially seem beneficial for bondholders, it discourages further investment in government bonds—especially for forward-looking savers—due to reduced returns in future periods.

Consequently, savers adjust their portfolios by reducing their demand for both short- and long-term bonds, reallocating resources toward alternative assets or consumption. This decline in bond holdings reflects a strategic response to the changing macroeconomic environment, where persistent inflation and low interest rates alter the relative attractiveness of fixed-income securities.

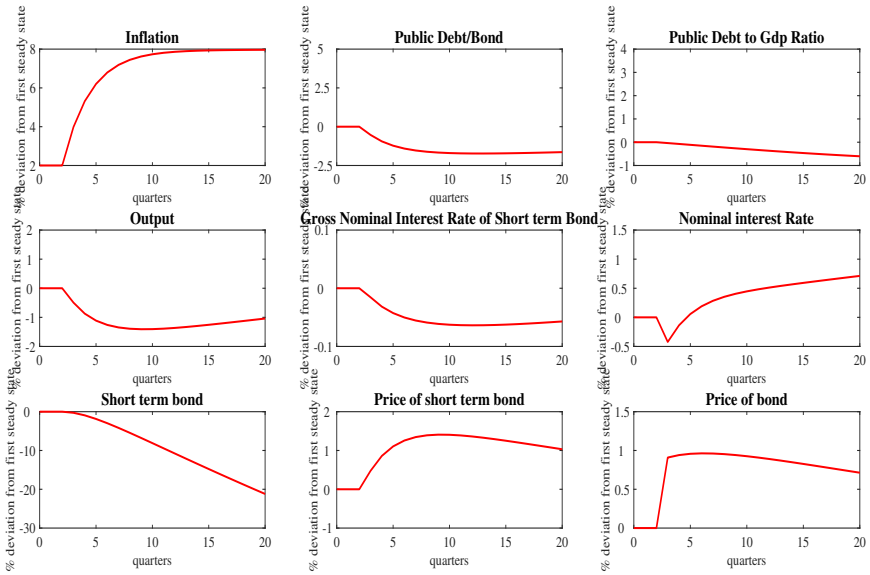

Figure 3: Transition dynamics of main macroeconomic variables

A persistent increase in inflation leads to a rise in household labor income, as illustrated in Figure 4, which details the transmission mechanisms for both savers and hand-to-mouth (HM) households. As nominal labor income increases, a higher tax burden is imposed through the quadratic income tax function. This results in a fiscal drag effect: despite higher nominal income, the increase in taxation reduces disposable income, contributing to a decline in nominal government debt, as shown in Figure 3.

Savers, as forward-looking agents, anticipate both the inflationary consequences (in terms of price increases) and the fiscal drag induced by rising nominal income. In response,

they reduce consumption and increase labor supply. As a result, their gross wage rate falls due to the higher availability of labor. In this case, the observed increase in their nominal labor income is driven primarily by an expansion in working hours rather than wage growth.

In contrast, HM households are non-forward-looking and tend to consume their entire income each period. Unaware of the inflationary dynamics and the associated fiscal implications (such as fiscal drag), they continue to reduce their labor supply while maintaining or even increasing consumption. The reduced labor supply puts upward pressure on wages. Therefore, for HM households, the increase in nominal labor income is primarily driven by rising wage rates rather than changes in labor hours.

Regarding capital, its supply increases when the rental price of capital falls. Anticipating a rise in the cost of capital due to higher prices of new equipment (analogous to the rising prices of short-term bonds, which reflect general price dynamics; see Figure 3), savers increase capital supply in the present. This increase in capital supply leads to a decrease in the actual rental rate for capital (i.e., the cost paid by firms to use capital). On the firm's side, lower rental prices stimulate capital demand.

As the capital stock expands, investment rises. However, the contraction in aggregate consumption—especially among savers—more than offsets the increase in investment. Consequently, aggregate output declines, as depicted in Figure 1.

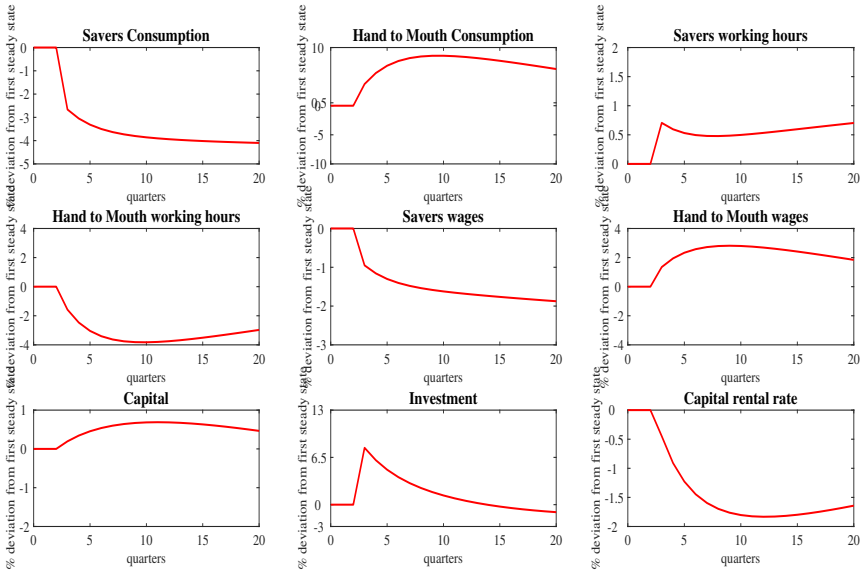

Figure 4: Transition dynamics of main macroeconomic variables

5.2 Measuring Fiscal Drag

Compared to a model with fixed taxation, a progressive tax framework leads to an increase in households' nominal gross labor income, accompanied by a corresponding rise in taxation.

This dynamic is primarily driven by the short-run behavior of savers. In a model with progressive taxation, savers anticipate the effects of fiscal drag and respond by increasing their labor supply (see quantitative results). This heightened labor effort leads to a smaller decline in wage rates compared to the fixed-tax case. As a result, total income rises, and so does the tax burden—since the tax function is increasing in income and applies uniformly to both types of households.

Similarly, hand-to-mouth households also end up working more under progressive taxation: the reduction in their labor hours is smaller relative to the fixed-tax scenario, leading to higher nominal income in the progressive case. The difference in nominal labor income between the progressive tax model (represented by the red line) and the fixed tax model (blue line) illustrates the magnitude of the fiscal drag effect (see Figures 5 and 6).

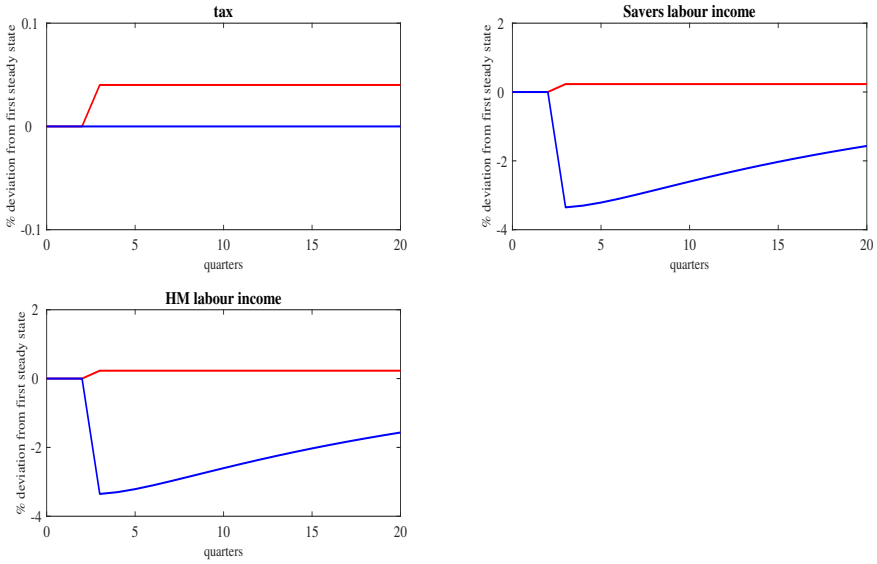

Figure 5: Fiscal drag effects

These dynamics also have direct implications for the government's budget constraint. As shown in the following figure, public debt decreases (red line) in the model with progressive taxation, primarily due to the fiscal drag effect. The higher tax revenues, driven by the increase in nominal income, allow the government to reduce its nominal debt without changing expenditure levels or tax rates explicitly.

In contrast, in the fixed tax model, this automatic stabilization mechanism is absent. The lack of responsiveness of tax revenues to inflation-induced income growth leads to a comparatively smaller fiscal adjustment—or even an increase in debt. This highlights a key difference between progressive taxation and fixed-rate systems in the context of inflation-based fiscal consolidation: while the former facilitates passive debt reduction through automatic stabilizers, the latter relies more heavily on deliberate policy interventions to achieve

similar outcomes.

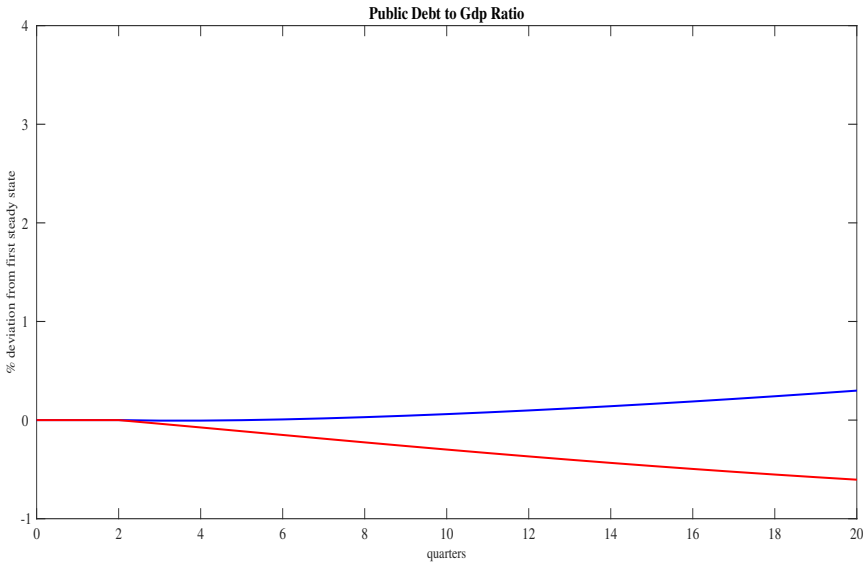

Figure 6: Fiscal drag effects

6 Conclusion

This paper explores the macroeconomic consequences of fiscal drag in the context of rising inflation and progressive income taxation. We show that, in the presence of inflation, nominal labor income increases—pushing households into higher tax brackets—even when real purchasing power remains unchanged. This bracket creep effect acts as an automatic stabilizer: without requiring active fiscal intervention, tax revenues rise and contribute to a reduction in public debt. In other words, progressive taxation under inflationary pressures leads to a form of passive fiscal consolidation.

However, the distributional and behavioral implications of this mechanism are significant. We find that forward-looking savers anticipate the future tax burden associated with fiscal drag and adjust by reducing consumption and increasing labor supply. In contrast, hand-to-mouth households—lacking foresight and liquidity—respond differently, experiencing larger gains in nominal wages and paying more in taxes, despite no conscious behavioral adjustment. As a result, bracket creep imposes asymmetric costs across household types, with vulnerable households potentially bearing a disproportionate share of the fiscal adjustment.

These findings carry important policy implications. In the presence of inflation, failing to index tax brackets adequately can generate unintended redistribution and amplify welfare losses for less sophisticated agents. Policymakers should therefore consider the design

and responsiveness of tax schedules when assessing inflationary environments—not only to protect purchasing power, but also to avoid reinforcing inequalities across household types.

This paper represents a first step toward a more complete understanding of fiscal drag in dynamic macroeconomic models. Future work will focus on simulating a persistent exogenous inflation shock—rather than a permanent change in the central bank's target—allowing us to analyze fiscal drag effects in a more realistic policy-neutral scenario. We will also extend the modeling framework to include the full aggregate labor income from both savers and hand-to-mouth households, thereby capturing broader tax base dynamics. Finally, we aim to recalibrate the model using updated IRS tax brackets, enabling a more accurate and timely assessment of bracket creep effects under current fiscal conditions.

By refining these elements, we hope to deepen our understanding of how inflation interacts with tax systems and to inform the design of fair and efficient fiscal policy responses in inflationary contexts.

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Why employees sometimes voluntarily lose career proactivity: A Japan-US Comparison

Abstract

Objectives

This study compares Japan and the US to investigate why employees sometimes voluntarily lose career proactivity. Career proactivity enhancement has attracted significant academic attention; however, research on career proactivity shrinking remains scarce. To address this issue, the present study assumed that career proactivity has attitudinal and behavioral components, and applied the concepts of career responsibility and career self-management (CSM). Drawing on research pertaining to career and perceived organizational support (POS), the study posits that organizational support may diminish career responsibility, especially in Japan.

Data and Methods

A quantitative online survey was conducted (Japan: n=434, the US: n=381). Multiple Group Confirmatory Factor Analysis (MGCFA) and Structural Equation Modeling (SEM) were performed.

Results

POS was divided into two dimensions: perceived care and perceived safety. Based on the results of MGCFA, measurement equivalence between Japan and the US was confirmed. SEM results showed that the direct effects of POS on CSM were identical in Japan and the US; however, the indirect effects mediated by career responsibility differed between the two countries. In Japan, perceived care improved career responsibility (β=.42, $p<.01$) whereas perceived safety diminished it (β=-.29, $p<.01$). Additionally, career responsibility had a positive effect on CSM within (β=.12, $p<.1$) as well as outside the organization (β=.18, $p<.05$). In the US, perceived care had a positive effect on career responsibility (β=.25, $p<.01$), and career responsibility improved CSM both within (β=.18, $p<.05$) and outside (β=.26, $p<.05$) the organization. However, perceived safety did not significantly affect career responsibility (β=.08, p=n.s.).

Conclusions

This study made theoretical contributions in two research areas. First, in the context of career

proactivity research, it clarified career responsibility and elucidated its usefulness. By using career responsibility, this study revealed the negative effect of POS on career proactivity, which could not be ascertained via CSM alone, and explained the mechanism of career proactivity loss. Second, regarding the cultural perspective of career studies, this research indicated that the relationship between POS and career responsibility differs between Japan and the US. These findings provide valuable insights for practitioners that organizational support can have both beneficial and adverse effects on employees' career and that its effectiveness varies across cultures.

Keywords: career responsibility, career proactivity, perceived organizational support, career self-management, MGCFA

1 INTRODUCTION

In Japan, it has been reported that some employees lose their proactivity toward career development. Kato and Suzuki (2006) defined career drift as when employees lose motivation to develop their careers. These sentiments were clearly expressed by an interviewee, as follows:

> *My organization is not so small, and I had no need to show any intention to make decisions for my career or resist my superiors' decisions for my career. It seemed to be easy to function as a gear in the organization. At that age, I thought that the situation was alright.* (an interview from Kato and Suzuki (2006))

The interview does not indicate that many Japanese think their career within organizations is the norm or that organizations still decide their career in Japan. Economic globalization and technological innovation have continuously changed organizational structures, working environments, and employment relationships. With these changes, careers have become increasingly nonlinear, unstable, and boundaryless (Jiang, Wang, Li, Peng, & Wu, 2022). Consequently, individuals are increasingly expected to actively manage and build their careers, take responsibility for their career development, and take a variety of other proactive actions to build prosperous careers (Arthur, Inkson, & Pringle, 1999; Arthur & Rousseau, 1996; Baruch, Szucs, & Gunz, 2015; Clarke, 2013; Hirschi & Koen, 2021; Jiang et al., 2022; Lee, Felps, & Baruch, 2014; Lips-Wiersma & Hall, 2007; Yan, Zhu & Hall, 2002). These global trends are broadly similar in Japan (Kato & Suzuki, 2006).

Why does the loss of career proactivity occur? Is this phenomenon unique to Japan? Based on the above interview, the prospect of a better career path is determined by the organization an individual works for, which might cause the employee to lose interest in their career. However, the reason why people lose interest when they have good prospects has not been fully explained. Conventional research on career proactivity has studied "how proactivity is increased" (Akkermans & Hirschi, 2023) but has not examined "why proactivity is sometimes lost." This is because traditional career research has uncritically assumed the Western view of the self in which the individual is an independent and autonomous entity (Inkson, Gunz, Ganech, & Roper, 2012; Roper, Ganesh & Inkson, 2010). To address this research gap, this study seeks to answer the questions of why people sometimes lose interest in their careers and whether losing career proactivity occurs only in Japan.

This study sheds light on the new subject of "losing career proactivity," which has been

reported in Japan. Additionally, it explores the concept of "career responsibility," which has not been sufficiently examined despite being a central element of the concept of proactivity, and identifies the characteristic of malleability possessed by career responsibility. Moreover, by comparing the cases of Japan and the US, this study explains cultural differences in career proactivity as differences in the malleability of responsibility rather than conceptual differences in the concept of responsibility itself.

First, based on the literature review, the significance of investigating the concept of responsibility in career proactivity and its nature were deductively derived. Next, research hypotheses using the concept of career responsibility were developed, and the mechanism of losing career proactivity based on survey research in Japan and the US was explored.

2 LITERATURE REVIEW

The current study approaches the loss of career proactivity by referring to studies on career drift. Subsequently, career proactivity studies are reviewed. Through these studies, I show the importance of focusing on the concept of responsibility in the context of career proactivity and explain the concept of career responsibility.

2.1 Losing Career Proactivity

Kato and Suzuki (2006), aware of the lack of an appropriate concept to describe the status of career development in Japan, proposed “career drift” as one of the concepts to explain such a situation. Career drift is defined as a situation in which employees who need to determine their own career orientation have little interest in their careers (Suzuki, 2001). Further, Suzuki (2001, 2002) identified two types of career drift: "floating" and "flowing. On the one hand, the floating type is a state in which an individual is unable to foresee their future and is unsure of their options but is not interested in career development. On the other hand, the flowing type represents a state in which an individual is able to foresee one's future but has no interest in career development. Kato and Suzuki (2006) argued that career decisions are influenced by the process of trying to avoid hopelessness. However, they stated that this is only the case when there is an interest in career development. In the case of no interest in a career, the drift condition is that there is a flowing career drift when the future is uncertain and a floating career drift when the outlook is clear.

Based on career drift studies, the loss of career proactivity is not the same as having a less

proactive personality or not taking proactive actions. Indeed, a less proactive personality is more likely to lead to career drift, which does not lead to proactive actions. However, an important aspect of this phenomenon is that people are no longer interested in career development. Even less aggressive personalities may have an interest in career development, while those with highly proactive personalities may not act because of certain factors (e.g., natural disasters, injuries, or illnesses). Although job-seeking behavior is often considered a sign of career proactivity, it may simply be the result of job loss and does not necessarily indicate career proactivity (Akkermans & Hircshi, 2023).

Kato and Suzuki (2006), based on the interview data presented at the beginning of this paper, noted that interviewees will flow into the expected career situation unless they attempt to control their careers. As expressed in the interviews, the decline in the "attitude of trying to control" is an essential element of losing interest and proactivity. Notably, however, this does not mean that employees are completely relinquishing control over their own career development. Drifting with flow does not necessarily mean taking no action. To drift, one must breathe and float. Similarly, to approach the expected future of one's career, one must fulfill one's daily duties and meet the expectations of one's superiors so that they can drift toward the anticipated future. This indicates that losing career proactivity does not mean having no control, but rather stagnation (i.e., not expanding control) or a reduction in the scope of control over how far one can go.

Hence, I argue that losing career proactivity means stagnation or a reduction of career responsibility and that in the context of career development, responsibility is an attitude that determines the extent to which one has control over one's career. The next subsection discusses the concept of "career responsibility" in detail by reviewing career proactivity studies.

2.2 Career Responsibility

2.2.1 Taking vs. occurring responsibility

Jiang et al. (2022) conducted a systematic review of career proactivity research and defined career proactivity as an individual's self-initiated and future-oriented actions aiming to influence, change, and improve career circumstances, including the situation and the self. Career proactivity is a mechanism that enables individuals to build career competencies, enabling them to succeed and thrive in vocational environments through various actions. Various studies have investigated career proactivity over the past two or three decades. Rather than presenting a single agreed-upon concept, it has been studied separately by a variety of concepts. Specifically, they can be divided

into two major domains, organizational behavior and occupational psychology, which have developed separately, noting issues such as conceptual overlap and comparative difficulties (Jiang et al., 2022). Akkermans and Hirschi (2023) supplemented the discussion of Jiang et al. (2022) by pointing out that there is room for consideration in the conceptual definition of career proactivity.

Nonetheless, previous studies on career proactivity have certain similarities. The concepts have implicitly or explicitly reflected the nature of proactivity by indicating agency, mastery, change orientation, self-initiation, purpose, and goal focus (Jiang et al., 2022). Meanwhile, responsibility has been mentioned in numerous studies related to career proactivity (Baruch & Sullivan, 2022; Baruch & Vardi, 2016; Gubler, Arnold & Coombs, 2014; Haenggli & Hirschi, 2020; Hall, 1996; 2004; Savickas, 2021); however, few studies have addressed it directly. One of the most prominent contemporary career concepts, the protean career, states that “pursuing the protean career requires a high level of self-awareness and personal responsibility (Hall, 1996: 10).” In this sense, responsibility may also be considered one of proactivity.

What is responsibility in the context of career development? The extant literature demonstrates that responsibility is inseparable from freedom (in the sense of being based on one's own will and not being forced by anyone) and that responsibility arises because one is free (Dennett, 2003). Responsibility in this case is the occurring responsibility that accompanies acts and decisions based on one's own will and always accompanies a free act. Assuming that individuals are free agents, in principle, they are considered responsible in the sense that they are subject to reward and punishment for the consequences of the choices, decisions, and actions they freely make based on their own will, without being forced. This is not taking responsibility but occurring responsibility.

Meanwhile, the responsibility referred to in career research is taking responsibility, not occurring responsibility (Baruch & Sullivan, 2022; Baruch & Vardi, 2016; Hall, 1996; King, 2004; 2004). Taking responsibility is about becoming better at a future point in time, that is, trying to gain control (Dennett, 2015; van de Poel & Sand, 2024). Dennett (2015) pointed out that "they (healthy self-controllers) take responsibility for what might be, very likely is, just an "accident," just one of those things. That way, they make themselves less likely to be "accident" victims in the future" (p. 157). The relationship between responsibility and control has been described in several studies (Fischer & Ravizza, 1998; van de Poel & Sand, 2024). van de Poel &

Sand (2024) suggested that in order for certain actions to be the agent's own and to be under control, they first needs to accept moral authorship or agency over these (i.e., take responsibility). Thus, taking responsibility refers to deciding how much to include in the scope of one's influence (i.e., control), regardless of one's current ability to control.

2.2.2 Expansion and contraction of career responsibility

Career proactivity is defined as an individual's self-initiated and future-oriented actions aimed at influencing, changing, and improving career circumstances, including the situation and the self (Jiang et al., 2022). The actions of "influencing, changing, and improving" are thus synonymous with "control," with the object of control in career responsibility being career circumstances, including the situation and the self. Therefore, career responsibility is more precisely defined as "an attitude that determines the extent to which one attempts to control over one's career circumstances, including the situation and the self."

Control can expand, contract, or stagnate. The same applies to taking responsibility. Dennett (2015) states that "Of course if I would rather find excuses than improve myself, I may dwell on the fact that I don't have to take responsibility for my action, since I can imagine a more fine-grained standpoint from which my predicament looms larger than I do. (If you make yourself really small, you can externalize virtually everything)" (p.157). Dennett's statement is consistent with the expand, stagnation, and shrinking characteristics of career responsibility discussed in this study. Thus, career responsibility has malleability.

Based on Dennett (2015), I argue that the actors themselves affect the malleability of career responsibility. However, it is also assumed that there will be external influences. As pointed out by Suzuki (2001) and Kato and Suzuki (2006), career drift is also caused by organizational factors in Japan. Just as the force people blow into and atmospheric pressure affect how easily a balloon inflates, both personal and environmental factors can affect how easily their career responsibilities expand and contract. Thus, how easily career responsibility is influenced depends on the context surrounding an employee, which affects the malleability of career responsibility. Therefore, loss of career proactivity is caused by two reasons: first, the influence of the context on malleability of career responsibility, and second, the organizational effect on career responsibility.

3 HYPOTHESES DEVELOPMENT

I clarified the concept of career responsibility and described the loss of career proactivity by

using it. It is inaccurate to state that losing career proactivity is synonymous with a lack of positive personality traits or proactive behavior. The phenomenon is a contraction in career responsibility. However, what I have discussed above is only a theoretically derived inference and has not been verified. Thus, I quantitatively examines the above discussion and further verifies the validity of the proposal.

Therefore, the relationship between support received from an organization, career responsibility, and career development behavior was examined. If my proposal in this study is correct, the results of the mediated model will be different from those of the direct model. The model using only organizational support and career development behavior predicts similar results in Japan and the US. However, the model using career responsibility as a mediating variable between organizational support and career development behavior predicts different outcomes in Japan and the US. The details are as follows:

In this study, I use perceived organizational support (POS) (Eisenberger, Huntington, R., Hutchison, S., & Sowa, 1986) as a proxy for organizational support and career self-management (CSM; Sturges, Guest, Conway, & Davey, 2002; Sturges, Conway, Guest, & Liefooghe, 2005; Sturges, Conway, & Liefooghe, 2010) for career development behavior. POS is defined as a global belief concerning the extent to which an organization values the contributions of its employees and care about their well-being (Eisenbergaer et. al., 1986). Cobb (1976), who highlighted social support perception, noted that receiving support leads to a relinquishment of agency. In this context, it was decided that POS, as a concept used in the context of management of social support, was appropriate for this study.

CSM is a key concept underlying the research of career proactivity (Jiang et al., 2022). The behavioral component of CSM refers to the concrete actions (e.g., networking, self-nomination, creating opportunities) undertaken by employees to realize their career goals (De Vos & Soens, 2008; King, 2004; Sturges et al., 2002; 2005; 2010). CSM was adopted in this study because there is an established existing scale (Sturges et al., 2002; 2005), and Sturges et al. (2010) verified the relationship between POS and CSM.

CSM comprises three dimensions. Two of the three dimensions indicate CSM aimed at furthering the career within the organization, and the other indicates CSM aimed at furthering the career outside the organization (Sturges et al., 2010). Although Sturges et al. (2010) expected that POS would improve CSM within the organization and reduce CSM outside the organization,

POS did not affect CSM within the organization. They indicated that a flat structure and few established career paths of the organization of their survey may have influenced the relationship between POS and organizational CSM. Additionally, POS may not have been fully functional because they used only five items of the POS scale. According to organizational support theory, POS can lead to several positive outcomes (e.g., organizational commitment, job involvement) through a sense of obligation, expectation of reward, anticipated help in times of need, or fulfillment of socioemotional needs (Eisenberger & Stinglhamber, 2011). By perceiving general support from the organization, employees are motivated to develop their careers within the organization, as they expect the necessary support from the organization for their careers as well. Thus, I propose Hypotheses 1 and 2 for the direct model.

Hypothesis 1. POS improves CSM within the organization in both countries.
Hypothesis 2. POS reduces CSM outside the organization in both countries.

Conversely, unlike the case of CSM, POS was predicted to shrink career responsibility. According to a career drift study, organizational support leads to a loss of career responsibility. However, this relationship may be different in Japan and the US. The phenomenon of losing career proactivity has been reported in Japan. Referring to Dennett (2015), taking less responsibility is not unique to Japan; however, owing to the unique characteristics of Japanese firms, employees are more likely to take less responsibility. This is because numerous Japanese firms are characterized by long-term employment; hence, career development occurs through company-initiated personnel transfers. In today's Japan, personnel transfers can be rejected, and transfers at the employees' request are accepted. It is also becoming increasingly common for employees to change jobs to develop their careers. However, in Japan, organizations still play a larger role in the career development of individuals than in the US. Thus, while POS may easily affect career responsibility in Japan, POS may struggle to affect career responsibility in the US.

Career responsibility is defined as "an attitude that determines the extent to which one attempts to control one's career circumstances, including the situation and the self." If career responsibility is extended, that is, one attempts to control a larger area of one's career circumstances, they probably does something to have this control (Dennett, 2015; van de Poel & Sand, 2024). Thus, an increase in career responsibility leads to career development behavior both

within and outside the organization. Therefore, the following hypothesis for the mediation model were derived.

Hypothesis 3. In Japan, POS shrinks career responsibility (3a), and career responsibility improves CSM within and outside the organization (3b).

Hypothesis 4. In the US, POS does not affect career responsibility (4a), and career responsibility improves CSM within and outside the organization (4b).

The mechanisms underlying losing career proactivity were demonstrated by comparing the direct and indirect models and verifying the hypotheses.

4 METHOD

4.1 Participants

Japanese data were collected by a survey agency in November 2016. This survey was designed with the following conditions: over 20 years old, employee, and gender and age distribution based on Japan's 2015 demographic statistics. The analysis was limited to full-time employees because the organizational supports that this study focused on differ between full-time and part-time employees. In total, 434 out of 520 recruited employees met our criteria for participation and completed the questionnaire (83.5% response rate). The female participants were 39.4%. The age composition of the participants was 26.3% in their 20–29 years old, 25.1% in 30–39 years old, 22.8% in 40–49 years old, and 25.8.% in over 50 years old.

US data were collected from US residents via Amazon MTurk in February, March, and July 2020. This survey was designed with the following conditions: living in the US, over 20 years old, and a HIT approval for all requesters' HITs greater than 80%. The analysis was limited to full-time employees to align the conditions with Japan's survey. Similar to HIT Approval Rate, instructional manipulation checks (IMCs) were adopted in the survey to improve the accuracy of the survey (Oppenheimer, Meyvis, & Davidenko, 2009). In total, 381 out of 461 recruited employees met our criteria for participation and completed the questionnaire (75.9% response rate). The female participants were 40.3%. The age composition of the participants was 12.9% in their 20–29 years old, 45.6% in 30–39 years old, 24.9% in 40–49 years old, and 16.6% in over 50 years old.

Both surveys were conducted following the ethical regulations of a belonging institution. Before responding, participants received a thorough written explanation of the purpose of the study and how their data would be used and stored. They only participated in the surveys if they agreed with these explanations. Additionally, they could select “prefer not to answer" in questions regarding demographic information.

4.2 Measures

In all scales, the respondents evaluated the items on a Likert scale 1 (strongly disagree)–5 (strongly agree). An overall score for each scale was formed by averaging item ratings for each scale. Higher scores indicated higher levels of the measured variable. Gender, age, and company size were control variables.

Regarding POS, the scale developed by Eisenberger et al. (1986), which includes 36 items, was used. Sturges et al. (2010) used five items and could not confirm the relationship POS and organizational CSM. A full scale was therefore used in this study. A sample item is “the organization strongly considers my goals and values.”

To measure career responsibility, the scale developed by Ichimura (2017) was used. Ichimura (2017) verified the discriminant validity, criterion-related validity, and reliability of the scale of career responsibility. In the US survey, I translated the questionnaire into English and asked for an agency back-translation. A sample item is “I have responsibility for my own career even when accidental events affect it.”

For CSM, eight items from the scale developed by Sturges et al. (2010) were used. The behavioral components of CSM comprise three dimensions: networking, visibility, and mobility. Networking and visibility refer to organizational CSM and mobility refers to outside CSM (Sturges et al., 2010). Sample items are “I have talked to senior management at company social gatherings” (networking), “I have made sure I get credit for the work I do” (visibility), and “I have made plans to leave this organization if it cannot offer me a rewarding career” (mobility).

4.3 Procedure

In this study, two types of comparison were conducted. The first comparison is between the direct and indirect models. The second comparison is between Japanese and US data. To make these comparisons, theoretical models were verified structural equation modelling (SEM) based on multiple group confirmatory factor analysis (MGCFA) because this approach has been the most widely used one to test for cross-national equivalence. The MGCFA is one of data-

analytical tools assessing constructs equivalence and “implements cross-group constraints on measurement parameters (e.g., loadings or intercepts) and compares more restricted models with less restricted models” (Davidov, Meuleman, Cieciuch, Schmidt, & Billiet, 2014: 19). Multiple group structural equation modelling (MGSEM) provides a straightforward method of dealing with multiple interrelated relationships of dependence simultaneously in different samples (D'Ancona, 2018). The MGSEM is used to verify the equality of structural relations between the latent variables (D'Ancona, 2018). In this study, it is assumed that causal paths are not consistent between Japan and the U.S. However, without confirming the validity that the factor structure between the two countries is the same, inconsistency in causal paths cannot be accurately interpreted. This is why the MGSEM was not used but SEM based on MGCFA was used. In measurement equation, the equality of relations between observed variables and latent constructs was verified using the MGCFA but in structural equation, all the parameters in the structural part of the model were estimated freely.

The MGCFA requires constructing a base model that can be commonly applied to different populations (Japan and the US). Hence, two types of base models (direct and indirect) were built and tested using data from Japan and the US. Therefore, this study has two analytical processes: base model building and model validation. First, CFA and exploratory factor analyses (EFA) on each scale were conducted using combined data from Japan and the US (n=815) to build base models that can be applied to both countries. Subsequently, a direct model for each country was verified using SEM based on the MGCFA. Finally, an indirect model for each country was tested by a same procedure.

The fit of the tested models to the data was assessed using several fit indices, which were the $\chi 2$ value (Bollen, 1989); unbiased standardized root mean square residual (uSRMR), for which value of .05 or less indicate close fit and values of .1 or less indicate adequate fit (Ximénez, Maydeu-Olivares, & Revuelta, 2022); standardized root mean square residual (SRMR), for which value of .05 or less indicate good fit and values of .06 to .08 satisfactory fit (Hu & Bentler, 1999); root mean square error of approximation (RMSEA), for which value of .05 or less indicate good fit and values of .06 to .08 satisfactory fit; the comparative fit index (CFI), for which a value above .90 indicates good fit of the model to the data (Hu & Bentler, 1999); ΔCFI, for which a value smaller than or equal to -.01 indicates that the null hypothesis of invariance should not be rejected (Cheung & Rensvold, 2002). ΔCFI was used in only model validation process

because this indicator was developed to evaluate measurement invariance in MGCFA. Following Ximénez et al. (2022) and Cheung and Rensvold (2002), uSRMR and ΔCFI were preferred because other fit indices are affected by model size and sample size. All statistics analyzes were conducted using R Statistics 4.2.1.

5 RESULTS

5.1 Model Building

To build a direct base model and an indirect base model, EFA and CFA on each variable were conducted in the combined Japanese and US data because previous studies have not confirmed the factor structure of each variable using data from both Japan and the US. EFA/CFA for POS confirmed a two-factor structure ("perceived care" and "perceived safety") ($\chi2$=1451.80, p<.001, df=404, uSRMR=.04, SRMR=.05, RMSEA=.06, CFI=.93). Perceived care represents the perception of being cared for by the organization and has 16 items (α=.95). A sample item is "the organization values my contribution to its well-being." Perceived safety represents the perception of not being mistreated by the organization and includes 14 items (α=.93). A sample item is "the organization would ignore any complain from me." For career responsibility, the EFA/CFA confirmed a one-factor structure ($\chi2$=.81, p>.05, df=2, uSRMR=.00, SRMR=.01, RMSEA=.00, CFI=1.00; α=.83). A sample item is "I have responsibility for my own career even when accidental events affect it." EFA/CFA for CSM confirmed a two-factor structure ("CSM within the organization" and "CSM outside the organization") ($\chi2$=99.25, p<.001, df=19, uSRMR=.04, SRMR=.04, RMSEA=.07, CFI=.95). CSM within the organization represents the concrete actions undertaken by employees to realize their career goals within their organizations and has six items (α=.80). A sample item is "I have built contacts with people in areas where I would like to." CSM outside the organization represents the concrete actions undertaken by employees to realize their career goals outside their organizations and has two items (α=.63). A sample item is "I have made plans to leave this organization if it cannot offer me." Table 1 presents the descriptive statistics and correlations for the study variables.

Table 1 Means, Standard Deviations, and correlations

Variables	Mean	SD	1	2	3	4	5
1. POS Care	3.26	0.82					
2. POS Safety	3.18	0.80	0.57***				
3. Career Responsibility	3.22	0.90	0.50***	0.24***			
4. CSM within the organization	3.27	0.77	0.70***	0.38***	0.42***		
5. CSM outside the organization	3.00	1.00	-0.27***	-0.46***	0.03	-0.07**	

Notes: *n*=815

†p<.10

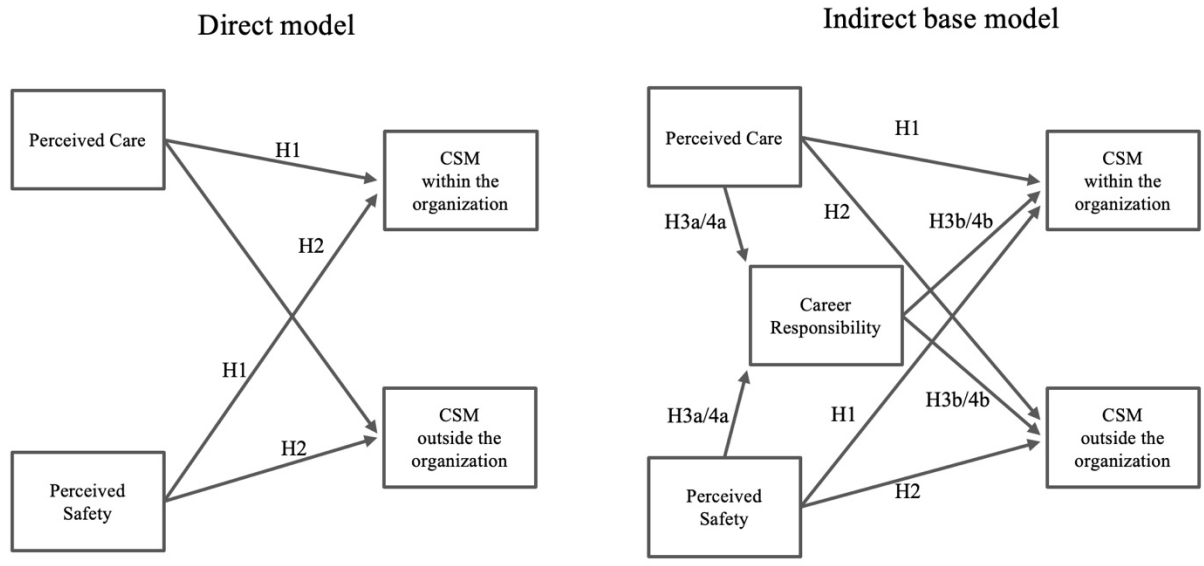
**p*<.05

***p*<.01

****p*<.001

Using two factors of POS, one factor of career responsibility and two factors of CSM, the direct and indirect base models were built (Figure 1).

FIGURE 1 The Direct Base Model And The Indirect Base Model



The indirect model in Figure 1 shows that a partial mediation model is assumed rather than a fully mediated model.

5.2 Measurement Model Validation -MGCFA

A factor structure of models was tested using the MGCFA in two populations: Japan and the US. All observed items and latent variables shown above were used because MGCFA scope to only a measurement part not a structural part.

There are five levels within which confirmation of measurement equivalence is required. Higher equivalence levels require stricter parameter equality constraints across groups and are more difficult to obtain, but they allow more extended forms of cross-national comparisons (Davidov et al., 2014). First, the most basic form is configural equivalence. This level requires that the mere factor structures are equal across groups (Davidov et al., 2014). No equality constraints are imposed on the parameters (D'Ancona, 2018). Configural equivalence is often used as a baseline for further equivalence testing, in other words, if at this level the model does not fit the data, measurement equivalence is unacceptable at any level.

Second, the higher form is called metric equivalence or weak measurement equivalence (Leitgöb, Seddig, Asparouhov, Behr, Davidov, De Roover, Jak, Meitinger, Menold, Muthén, Rudnev, Schmidt, & van de Schoot, 2023). Metric equivalence requires the factor loadings between the observed items and the latent variable are equal across the compared groups (Putnick & Bornstein, 2016). Davidov et al. (2014) stated: "Metric equivalence guarantees the cross-group equality of the intervals of the scale on which the latent concept is measured: An increase of 1 unit on the measurement scale has the same meaning in population A as in population B "(p. 20).

Scalar invariance, the third-level invariance, implies that the factor loadings and the item intercepts are equal across groups. Scalar equivalence implies that the measurement scales have the same intervals and share origins (Leitgöb et al., 2023). This makes enables comparison of raw scores of the latent factors in a valid way (Davidov et al., 2014). Fourth, testing for structural covariances imposes additional constraints on factor variances and covariances (analysis of covariance structure assumes that all observed variables are measured as deviations from their means; i.e., their means are equal to zero). The final and most stringent test of measurement equivalence is testing for residual invariance (measurement residuals 6: a combination of random measurement error and error that is specific or unique to a particular measuring instrument). However, because strict invariance (and residual invariance) does not directly affect the comparability of structural parameters across groups, most applied studies refrain from its

evaluation (Leitgöb et al., 2023).

This study compares the relationships between latent variables. Therefore, it is sufficient to confirm configural equivalence, and it is even better if equivalence at a higher level can be confirmed.

Table 2 shows results of test for measurement invariance in the twelve models obtained by MGCFA. The χ2 value, uSRMR, SRMR, RESEA, CFI, and ΔCFI were used for goodness-of-fit for tests of invariance and uSRMR and ΔCFI were prioritized. Thus, the model with good or adequate uSRMR and ΔCFI was selected as the model to proceed with the validation of the structural part.

Table 2 Fit indicators of MGCFA

Equivalence Level	uSRMR	SRMR	RMSEA	CFI	ΔCFI	χ2	df	p
configural	0.051	0.060	0.053	0.905	-	3112.940	1460	0.000
metric	0.064	0.071	0.054	0.897	-0.008	3278.582	1495	0.000
scalar	0.069	0.080	0.065	0.849	-0.056	4142.709	1530	0.000
strict	0.071	0.082	0.070	0.818	-0.087	4728.400	1570	0.000
residual	0.224	0.225	0.072	0.806	-0.099	4945.284	1575	0.000

Note: n=815

Configural model was approved (uSRMR=.051, SRMR=.060, RMSEA=.053, CFI=.905; χ2=3112.940, df=1312, p<.001) because other indicators except the χ2 value showed good or adequate fit but χ2 statics are sensitive to sample or model size (Puntnick & Bornstein, 2016; Ximénez et al., 2022).

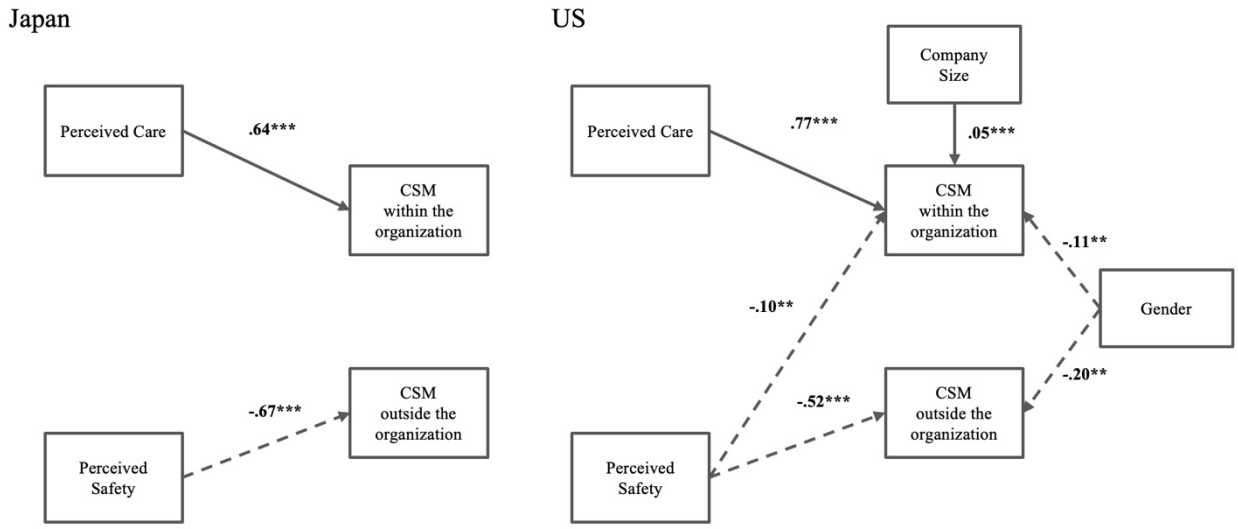
The only residual model was determined to be inappropriate (uSRMR=.224 > .1). Therefore, I retained the metric model as the measurement model for the subsequent structural part of the study; ΔCFI of the metric models was -.008 < -.01 while the ΔCFI of the higher models exceeded .01 criterion, and SRMR (.071) and RMSEA (.054) indicated satisfactory fit. CFI (.897) and χ2 value (χ2=3278.582, p<.001, df=1495) indicated poor fit. However, following Ximénez et al. (2022) and Cheung and Rensvold (2002), uSRMR and ΔCFI were preferred

because other fit indices are affected by model size and sample size.

5.3 Structural Model Validation – SEM

The next analytical step was to perform SEM to test the hypotheses using the metric model. All the parameters in the structural part of the model were estimated freely, with all the metric model as a base for the latent variables and with all the factor loadings between the observed items and the latent variable constrained to be equal in the Japanese population and the US population. Figure 2 shows the result of the direct model which indicated the best fit for each of Japanese and US data (uSRMR=.064, SRMR=.072, RMSEA=.055, CFI=.900, $\chi 2$=2972.717, p<.001, df=1344).

FIGURE 2 Result of SEM for the Direct model using Japanese and US data



Notes: Japan: n=434, the US: n=381. Observed variables are omitted.

†p<.10

*p<.05

**p<.01

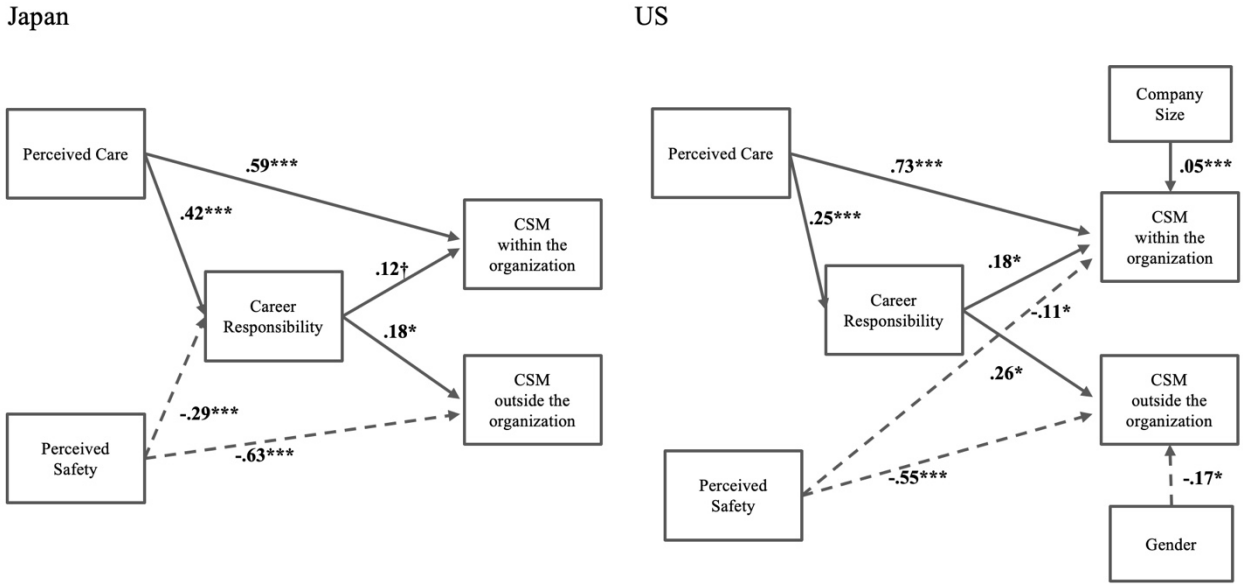
***p<.001

As predicted in advance, the relationship between POS and CSM in the direct model yielded similar results for Japanese and US data. Perceived care improved CSM within the organization (β=.64, p<.01; β=.77, p<.01), while perceived safety reduced CSM outside the organization (β=-.67, p<.01; β=-.52, p<.01). Only in US data, perceived safety weekly reduce CSM within the

organization (β=-.10, p<.05). In the direct model, hypotheses 1 that POS improves CSM within the organization in both countries and 2 that POS reduces CSM outside the organization in both countries were partially supported because POS was divided into two dimensions, contrary to the initial prediction.

Figure 3 shows the result of the indirect model which indicated the best fit for each of Japanese and US data (uSRMR=.064, SRMR=.072, RMSEA=.053, CFI=.892, $\chi 2$=3536.772, p<.001, df=1643)

FIGURE 3 Result of SEM for the Indirect model using Japanese and US data



Notes: Japan: n=434, the US: n=381. Observed variables are omitted.

†p<.10

*p<.05

**p<.01

***p<.001

Consistent with theoretical consideration, in the indirect model, the relationships between POS, CSM, and career responsibility differed between Japanese and US data. The direct effects from POS to CSM were similar to the direct model while the indirect effects mediated by career responsibility were different between Japanese and US data. In Japan, perceived care improved but in contrast perceived safety reduced career responsibility (β=.42, p<.01; β=-.29, p<.01), and

career responsibility positively affected on CSM within the organization and CSM outside the organization (β=. 12, p<.1; β=-.18, p<.05). Thus, Hypothesis 3 was partially supported. In the US, both of perceived care had positive effects on career responsibility (β=.25, p<.01), and career responsibility improved both of CSM within and outside the organization (β=.18, p<.05; β=.26, p<.05). However, perceived safety did not significantly affect career responsibility (β=.08, p=n.s.). Therefore, Hypothesis 4 was partially supported.

6 DISCUSSION AND CONCLUSION

This study sheds light on losing career proactivity using career responsibility through two comparisons, between the direct and indirect models and between Japan and the US. The findings indicate that losing career proactivity is less about a lack of proactive behavior and more about a reduction in career responsibility, and that the effect of organizational support on career responsibility is different between Japan and the US. An important point of these results is that when using only one type of data set and a behavioral aspect of proactivity, differences between Japan and the US in the impact of POS on career proactivity were not revealed.

6.1 Reduction in Career Responsibility as the Loss of Career Proactivity

As deductively predicted, the result of the indirect model was different from those of the direct model. The model using only POS and CSM had similar results in Japan and the US. Perceived care improved CSM within the organization and perceived safety reduced CSM outside the organization. Additionally, in the direct model using US data, perceived safety reduced CSM outside the organization. Based on this finding alone, it can be concluded that perceived safety suppresses career proactivity more in the US than in Japan. However, a completely different perspective can be derived from the results of the indirect model.

As the results of the indirect model showed, perceived care promoted CSM within and outside the organization through career responsibility in both of countries, however, in Japan, perceived safety suppresses CSM within and outside the organization through career responsibility, while in the US, perceived safety did not have a significant mediating effect. The definition of career responsibility is "an attitude that determines the extent to which one attempts to control over one's career circumstances including the situation and the self." Thus, in Japan, perceived safety reduces the attitude of trying to control one's career circumstances and suppresses one's actions, whereas in the US, by perceived safety one's attitude of trying to control

one's career circumstances is not diminished, but one's actions are suppressed. This result of the indirect model suggests that contrary to the inference from the direct model, career proactivity has not been lost in the US, but that career proactivity has been lost in Japan. As pointed out by Akkermans and Hirschi (2023), the behavioral aspects of career proactivity alone are not sufficient to explain the loss of career proactivity.

Looking back at career drift studies, in Japan, the loss of career proactivity is caused by the prospect of a better career path set out by the organization (Kato & Suzuki, 2006; Suzuki, 2001). The higher employees' perceived safety may reflect the prospect of a better career path in the organization. By using the concept of career responsibility, the indirect model verified in this study using Japanese data clarified the mechanism behind the phenomenon shown in career drift studies. On the other hand, in the US, the decrease in career responsibility was not observed, and the reduction in behaviors may be a different phenomenon from losing career proactivity.

6.2 Cultural Difference in the Impact of POS on Career Proactivity

From the results of this study, career responsibility in Japan is more sensitive to the influence of POS than in the US. Perceived safety significantly affects career responsibility only in Japan, and the effect of perceived care is also stronger in Japan than in the US (Japan:β=.42, US:β=.25). Using MGCFA allowed us to compare accurately Japan and the US because Davidov et al. (2014) stated that metric equivalence guarantees an increase of 1 unit on the measurement scale has the same meaning in population A as in population B. This does not mean that career responsibility in Japan and the US is conceptually different, but rather that there is a difference in the malleability of career responsibility because MGCFA guarantees the equality of conceptual structure. Malleability is the ability of a material to be shaped or deformed without breaking. It can also refer to the ability to be influenced or controlled. Like this way, the difference in the influence of POS on career responsibility between Japan and the US may be due to the difference in the ease with which career responsibility changes. Why is malleability of career responsibility different?

In contrast to the so-called Western view of the self as an independent, self-contained, and autonomous entity, Asian cultures, including Japan, have a complementary, interactive view of the self, with ambiguous boundaries with others (Markus & Kitayama, 1991). In addition, as discussed earlier, in Japan, the role and influence of companies in individual career development remain significant. Based on this view of the self and Japanese circumstances around an

employee, in Japan, the subject of career development may be not only be "I" but also "we" (I and my organization), which may blur the boundaries of career responsibility. This indicates that career responsibility is likely to expand or contract under the influence of external factors. Therefore, malleability of career responsibility is higher in Japan than in the US. This interpretation is consistent with the interviews in the career drift study mentioned at the beginning.

6.3 Implications for Research and Practice

This study makes important contributions to the literature on career proactivity. First, it elucidates the loss of career proactivity. Conventional career proactivity research has focused on how to increase proactivity, but has not examined why proactivity is sometimes lost (Akkermans & Hirschi, 2023), which is the case in Japan (Kato & Suzuki, 2006). Although the results of this study did not reveal a reduction in career responsibility in the US, it would be poor judgment to conclude that losing proactivity is a uniquely Japanese phenomenon. As seen in recent studies of “we-mood” and “we-ness” (Gallotti & Frith, 2013), the way of perceiving "we" as an action subject is not unique to Asian countries. By examining the loss of career proactivity, we expect to gain richer insights into career proactivity.

Second, it explored the old but new concept of career responsibility, which is related to the loss of career proactivity. By clarifying the concept of "career responsibility" using the concept of "control," this study introduced a new approach to answering the question of why people sometimes let go of their proactivity. By using career responsibility, it was revealed that losing career proactivity is less about a lack of proactive behavior and more about a reduction in career responsibility. As Ackermans and Hirschi (2023) stated, taking action does not necessarily mean being proactive, and inhibited action does not necessarily imply less proactive. Another contribution of focusing on responsibility is that it defines responsibility in career formation, which has not been adequately defined in previous research. For example, career responsibility may also be useful for studying the career development of people with disabilities. Previous studies have often focused on barriers in the careers of people with disabilities (Stone & Colella, 1996; Lengnick-Hall, Gaunt, & Kulkarni, 2008) and has not adequately examined the proactive career development (Kulkarni & Gopakumar, 2014). Kulkarni and Gopakumar (2014) qualitatively identified how people with disabilities successfully manage their own careers, but did not question why they are able to be proactive. As noted in the field of care ethics and

bioethics, the proactivity of people with disabilities is a very important issue because they are considered to have limited proactivity (Gómez-Vírseda, De Maeseneer, & Gastmans, 2019). However, this topic is overlooked in career research. By using career responsibility, we can approach it. Previous research on people with disabilities has emphasized that support from others enables them to exercise proactivity. For people with disabilities, support from others, including organizations, is necessary to develop their careers proactively. However, sometimes, others' support can undermine proactivity because, as I have argued in this study, in some cases, the degree to which people seek control over their careers shrinks in response to external influences such as organizational support. Using the concept of career responsibility, it may be possible to clarify the ambiguous relationship between such support and proactivity. In this study, career responsibility was more malleable in Japan than in the US, but people with disabilities may be more malleable than those without disabilities.

Finally, it identifies the characteristics of malleability of career responsibility through a comparison between Japan and the US and using MGCFA. The validity of considering career responsibility as the same concept was confirmed in both Japan and the US. However, the present study indicates that career responsibility is likely to change in Japan, whereas it is difficult to do in the US.

Furthermore, this study offers practical insights into multicultural career management. It shows that organizational support can lead to a reduction in career responsibility. Organizations are important supporters of individual career development (Baruch, 2006), but support may be a double-edged sword from a diverse cultural and institutional perspective. In particular, employees' perceptions of safety may decrease their proactivity, contrary to the intentions of the organization. Thus, organizational support can be a message to employees that goes beyond simply providing an opportunity to learn skills (Eisenberger & Stinglhamber, 2011). Therefore, when organizations develop career support policies, it is important to consider how that support will be conveyed to diverse employees with different cultural backgrounds and that it will not lead to the loss of proactivity. That is, the messages conveyed through support may be highly nuanced (Caesens & Stinglhamber, 2020). Thus, it is important that support does not lead to a perception of security. It would be effective to send the message that it takes effort on both sides to maintain the employment relationship while providing career support.

6.4 Limitations and Future Research Directions

The current study has certain limitations. The first is the validity of the operationalization of career responsibility. The measure used in the current study was based on Ichimura (2017) and developed solely based on Japanese data, and thus its validity has not been extensively verified. Therefore, refinement of the career responsibility scale will be an important topic for future research on career responsibility.

Second, the mechanism underlying the decrease in career responsibility has not been fully elucidated. In this study, the shrinkage of career responsibility was observed only in Japan and in only one dimension of POS. However, it would not be surprising if the shrinkage of career responsibility also occurred in the US. As this study was designed with reference to the phenomenon observed in Japan, in which responsibility shrinks because of receiving support from an organization, it is possible that this is reflected in the results. Thus, it is necessary to conduct a qualitative study to observe whether the phenomenon of reduced responsibility occurs in the US as well.

The third limitation relates to the design of the survey. The Japanese data were obtained from a 2016 survey, while the U.S. data were obtained in 2020. This four-year gap may have led to differences in the results of this study's analysis. In other words, although this study interpreted the differences in the results between Japan and the U.S. as relying on cultural and institutional differences, they may be attributable to temporal changes. In addition, this study is based on cross-sectional data and cannot be said to have clarified causal relationships. Therefore, further investigation based on data collection at the same time point, in addition to longitudinal data, is needed.

Finally, cultural differences were not sufficiently examined. This study sought to answer the same questions in Japan and the US without directly accounting for cultural differences. Therefore, it is impossible to determine whether the differences in the results in Japan and the US reflect cultural, institutional, or environmental differences between the two countries. Future research should include cultural, institutional, and environmental differences in the survey items to identify those responsible for the differences in results.

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High-frequency trading and price efficiency: a unified model

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Abstract

I study the impact of high-frequency trading (HFT) on price efficiency, taking into account both the asset demand from HFT itself and the change it induces in the demand from informed traders. HFT trades against demand shocks when demand shocks typically originate from noise trading. Conversely, HFT trades with demand shocks when demand shocks typically originate from a change in fundamentals. This pattern enhances price efficiency on average, holding the behavior of informed traders constant. However, HFT lowers the expected profit of informed traders, who may react either by withdrawing from the market or by using order randomization to mislead HFT. Such responses lower the weight of fundamentals in global price variance, which decreases price efficiency. Overall, the impact of HFT on price efficiency is ambiguous. The model accommodates the bulk of the findings of the now mature HFT literature, even those that appear contradictory at first glance.

Keywords: High-frequency Trading, Price Efficiency, Randomization, Information treatment, Information content.
JEL classification: G12, G14, G23.

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1. Introduction

Consider a patient who suffers from insomnia, and is prescribed sleeping pills. Intuitively, the pills should improve the sleep quality of the patient, as they typically end each insomnia episode. Nevertheless, in the long-run, sleeping pills typically increase the number of insomnia episodes as the patient's body becomes less able to generate melatonin on its own. If this long-run reaction is particularly strong, the costs of more insomnia episodes may outweigh the benefits more sleep conditional on an insomnia episode. Overall the impact of taking sleeping pills on sleep quality is unclear.

A sizable academic literature[1] suggests that a similar trade-off arises in the relationship between high-frequency trading and price efficiency. On the one hand, HFT speeds up the process of incorporation of relevant information into prices. On the other hand, HFT diverts profit away from informed investors, which lowers their incentive to obtain and disseminate information. HFT enhances price efficiency only if the benefits of a better treatment of existing information outweighs the cost of a long-term decrease in the information content of the market.

Objective. This paper assesses the overall desirability of HFT for price efficiency, taking into account both its impact on information treatment and its impact on information content. I provide a model in which a representative high-frequency trader (HFTr) interacts with a representative informed trader (ITr) and a representative liquidity trader (LTr), in a market for a single asset. HFTr i) observes the order flow from LTr and ITr, ii) uses this information to estimate the fundamental value of the asset, and iii) trades before other participants can trade again. I study the impact of this trading rule on the level of price efficiency of the market, first holding the behavior of ITr constant, and second allowing ITr to respond to HFTr through exit or order randomization.

Findings. The trading pattern of HFTr crucially depends on the ratio ρ of the variance of noise trading, defined as the sum of the demand from LTr and a random component in the demand from ITr, over the variance of fundamental trading, defined as the component in the demand from ITr that reflects fundamental information. When ρ is above a threshold ρ^*, unexpected demand shocks typically drive the price away from its fundamental value. In this market prices revert on average at subsequent periods, and HFTr trades against any demand shock it observes to benefit from this reversion, a strategy referred to as market making. By contrast, when ρ is below ρ^*, unexpected demand shocks typically drive the price towards its fundamental value. In this market the price is positively autocorrelated on average, and HFTr trades with any demand shocks it observes to benefit from this movement, a strategy referred to as backrunning. Market making leads HFTr to downplay fundamental shocks by trading against them, while backrunning leads HFTr to exaggerate meaningless noise shocks by trading with them. However the HFTr trading rule is correct on average, and consequently HFTr enhances the process of shock incorporation into prices. This is the information treatment effect.

Maintaining constant the flow of new information being generated by ITr, better information

[1] See Chordia et al. (2013), O'Hara (2015), or Menkveld (2016) for surveys

treatment makes HFTr desirable from a price efficiency perspective. However, because the increase in price efficiency spurred by HFTr lowers the utility of ITr, ITr reacts to HFTr over certain parameter sets. This reaction may take two forms. First, ITr can exit the market if the cost of acquiring information exceeds the benefits of exploiting mispricings. Second, ITr can randomize its orders, thereby reducing the expected utility of HFTr when HFTr backruns. For ITr, randomization entails a utility cost stemming from the risk and transaction costs it involves, but ITr utility shoots up if randomization successfully drives HFTr out of market. Both exit and randomization imply that the share of fundamental trading over noise trading falls, decreasing price efficiency. This is the information content effect. For both ITr exit and randomization the information content effect dominates the information treatment effect: the level of mispricing when HFTr threatens to enter is higher than it would be if HFTr never existed. Nevertheless, randomization constitutes a second best equilibrium in parameter sets for which ITr would have exited if randomization was not an option.

Method. The model is built on two blocks. The first block solves for equilibrium prices and utilities in the market in which both HFTr and ITr feature. This is done by using rational expectations to pinpoint how HFTr extract fundamental information from the order flow. The modeling of HFTr is comparable to the modeling of the market maker in Kyle (1985). The second block considers the strategic game played by HFTr and ITr before trading starts. The game uses a Stackelberg (1934) setup in which ITr moves first knowing the best response of HFTr. ITr must decide between three strategies: participating without randomization, participating with randomization, and exiting. The model is solved recursively: the expected utilities in the market with both HFTr and ITr, obtained from the first block, are fed into the game. The final impact of HFTr is given by the equilibrium level of price efficiency defined by rational expectations, in the equilibrium market structure defined by the strategic game.

Literature. The model's study of HFTr holding ITr behavior constant relates closely to an extensive empirical literature that studies HFT within a given market whose characteristics remain constant during the sample period. This literature has produced the following results. HFT may trade with or against the order flow shocks it observes (van Kervel and Menkveld (2019), Korajczyk and Murphy (2019)) depending on the structure of the market it operates in. This pattern generally enhances price efficiency (Brogaard et al. (2014), Carrion (2013)), perhaps at the expense of some excess volatility (Bershova and Rakhlin (2013), Boehmer et al. (2021)), and perhaps not (Hasbrouck and Saar (2013), Chaboud et al. (2014)). HFT generally provides liquidity (Hendershott, et al. (2011), Frino et al. (2014)) but sometimes switches to liquidity taking (Kervel (2015)). Finally, HFT diverts profits away from informed investors (e.g., Hirschey (2021), Tong (2015)) and from the market marker (e.g., van Kervel (2015), Biais et al. (2015)).

The model's study of the response of ITr to HFTr in terms of participation relates to a broad body of literature pioneered by Grossman and Stiglitz (1980), whose general message is that information acquisition decreases when those who invest in information are not those rewarded for it. Specifically, several recent empirical papers report a significantly negative link between HFT and information

acquisition (Lee and Watts (2021), Gider et al. (2021)), in line with the theoretical contributions of Baldauf and Mollner (2020) and Weller (2018). Less work has been undertaken on the issue of the strategies used by ITr to dissimulate information from HFTr. Van Kervel and Menkveld (2019, vKM henceforth) and O'Hara et al. (2014) show that institutional investors seek to avoid detection by HFT, by slowing down the pace of their position taking or by using odd lots. Hoffman (2014) provides a theoretical model in which "slow traders" trade less in the presence of HFT. To the best of my knowledge, only one paper (Yang and Zhu (2020), YZ henceforth) explicitly studies randomization. In YZ, the decision to randomize orders by "fundamental investors" depends on the number of high-frequency traders, as well as the quality of their order flow information.

Both vKM and YZ are the closest in terms of approach to this study. Similarity with vKM is derived from following a similar methodological path: firstly, characterizing the demand of HFT, secondly, examining the way this demand impacts informed traders, and finally investigating how informed traders respond to HFT. In this way this paper can be seen as a theoretical basis for vKM's empirical evidence. In the case of YZ, similarity comes from the focus on randomization as a response to HFT. The present study differs because it provides a general model in which HFTr may trade either with or against ITr and in a full dynamic mode.[2] Furthermore, YZ focus primarily on the profits of fundamental traders relative to HFT, whereas I focus on the desirability of randomization from a price efficiency perspective.

In terms of modeling, this study is linked to theoretical papers in which agents seek to extract information from the order flow (see Kyle (1985), Glosten and Milgrom (1985), or Muth (1960) in a more general setting). At the heart of these models is the statistical problem of estimating the permanent component of a variable that is subjected to both permanent shocks and transitory white noise shocks. In a linear setup the optimal rule can be derived analytically, which in my case allows for the obtainment of closed forms on different indicators of market quality such as investor utilities, market depth, or price efficiency. Several theoretical models have recently added HFT to these classic models for different purposes (e.g., Foucault et al. (2016), Budish et al. (2015)).

Contributions. This paper makes two notable contributions. The first is to provide a unified theoretical framework that accommodates the bulk of the findings in the HFT literature. In effect the paper can be seen as a model-based literature review. In particular, the results of the model on the market impact of HFT when the flow of information is held constant match well the results of the empirical literature on the market impact of HFT within a fixed market structure. Findings that are consensual in this literature –such as the impact of HFT on the utility of informed traders or price efficiency– correspond to the results that do not depend on the value of the parameter set in the model. By contrast, issues over which this literature is divided – such as the short-term

[2]This approach differs from YZ who focus on backrunning in a 2 period setup. Interestingly such a generalization is called for by YZ, who write on page 5 *"A full dynamic model would be more realistic [...]. In addition, our theory is meant to capture only one aspect of HFTs, namely their back-running strategies. The other side of the coin, namely, the market-making strategies of HFTs, also receives strong empirical support[...]. A useful future research direction is to incorporate multiple dimensions of HFT strategies in a coherent theoretical framework"*

impact of HFT on excess volatility or liquidity– correspond to results that depend on whether HFTr acts as a backrunner or as a market maker, which itself depends on the ratio ρ of the variance of noise trading over the variance of fundamental trading. Interestingly, empiricists have suspected the importance of parameter ρ. vKM notably states that HFT trades with institutional investors when "the information component dominates the transitory component in [investors] order's overall price impact".

The second contribution of this paper is to make a set of new predictions. Some of these are concerned with the way HFTr treats information, such as the prediction that fundamental shocks should be downplayed in markets dominated by noise trading. However the most novel results of the model relate to the responses of ITr to HFTr. They can be summarized as follows. Exit and randomization both unambiguously reduce price efficiency relative to an absence of response to HFTr by ITr. However, randomization is an attractive second-best if it prevents ITr exit. The appearance of randomization depends on its efficiency in reducing HFTr utility, its cost for ITr, and the utility gain for ITr of driving HFTr out. Driving HFTr out of the market is easier when noise trading is high, because noise trading decreases the utility of backrunning. The region of the parameter set over which randomization prevents ITr from exiting is smaller than the region over which it prevents ITr from staying without randomizing.

The paper proceeds as follows. Section 2 presents the framework. Section 3 characterizes the inference problem and trading rule of HFTr. Section 4 discusses the impact of HFTr on price efficiency and ITr utility when ITr behavior is held constant. Section 5 studies the participation and randomization response of ITr to HFTr, and what this response implies for price efficiency. Section 6 concludes.

2. Framework

2.1. Basic features

2.1.1. Asset, investors, and price movement

Consider a market for a single asset evolving over a trading cycle that contains a large finite number T of periods. At the start of each period t, the asset has a price of P_t and a fundamental value of F_t, which is assumed to move exogenously following a random walk:

$$F_t = F_{t-1} + \varepsilon_t^f \tag{1}$$

with ε_t^f an i.i.d normal shock with a mean of 0 and a variance of σ_f^2.

Three traders interact on the market: a liquidity trader, an informed trader, and a high-frequency trader. The demand from LTr at each period is denoted by ε_t^l, while the demands from ITr and HFTr are denoted respectively by Q_t^I and Q_t^h. LTr is assumed to buy and sell in erratic fashion according to its idiosyncratic needs. Thus ε_t^l is an i.i.d normally distributed shock with a mean of 0 and a variance σ_l^2. By contrast, ITr and HFTr trading is motivated by a desire to buy (sell) the asset when its price P_t is below (above) its fundamental value F_t.

Both ITr and HFTr know all the model parameters, including the distributions of all shocks. However they do not observe the exact realizations of the shocks, neither at t nor at subsequent periods. Thus neither HFTr nor ITr knows F_t. Both agents crucially differ in the tools they can invest in to estimate F_t: ITr can obtain an informational advantage over other traders in exchange for the payment of a fixed utility cost of C_I prior to the start of the trading cycle, while HFTr can obtain a speed advantage over other traders in exchange for the payment of a fixed utility cost of C_h prior to the start of the trading cycle

The informational advantage of ITr takes the form of a noisy private signal about the value of F_t, received at the start of each period. The value of F_t as expected by ITr upon reception of the signal is denoted by $E_t^I(F_t)$. The discrepancy between this value and the real fundamental value :

$$\varepsilon_t^s = E_t^I(F_t) - F_t \tag{2}$$

is an i.i.d normal shock with a mean of 0 and a variance of σ_s^2.

The speed advantage of HFTr is derived from an the ability to 1) observe the joint demand $Q_t^I + \varepsilon_t^l$ from ITr and LTr at the start of a period, 2) use this joint demand to form its estimate of the fundamental value $E^h(F_t) = E\left(F_t | Q_t^I + \varepsilon_t^l\right)$, and 3) trade in period t before ITr and LTr trade again. If agent $k = (I, h)$ does not pay the cost C_k, it sits out the trading cycle, demanding $Q_t^k = 0$ at all t.

2.1.2. Demand and price movement in a period

Chronologically, each trading period is split into two subperiods. In the first period, ITr demands Q_t^I, and LTr demands ε_t^l shortly after. In the second subperiod, HFTr observes the joint demand $Q_t^I + \varepsilon_t^l$ and demands Q_t^h. The point in time in period t at which the first subperiod ends is denoted by $(t, 1)$.

Orders are sent to an unmodeled market maker (MM) who changes its price quotes according to the demand received. Two assumptions underlie the behavior of the market maker. First, MM uses an exogenous linear rule[3] in which one unit of demand moves the price by an amount b. Second, MM continuously updates its quotes. Consider for instance that a buy order from an agent k for a quantity Q_t^k of the asset is initiated at given point in time z of period t. MM executes the first unit of this demand at a price P_t at time (t, z), and the second unit at a price of $P_t + b$ at $(t, z + \iota)$, where ι is an infinitesimal amount of time. The third unit is executed at a price of $P_t + 2b$ at $(t, z + 2\iota)$, so on until $P_t + bQ_t^k$. This modeling implies that the order of Q_t^k units has a total impact on price of bQ_t^k, and is executed at a mean price of $P_t + \frac{b}{2}Q_t^k$. It is designed to match tick changes arising from an order book gradually being filled.

The process of order treatment by MM is assumed to be so quick that it is considered as immediate from the model's perspective. Therefore at the end of the first subperiod, after ITr and

[3]The exogenous pricing rule of the market marker is not necessarily optimal in the sense of Kyle (1985). If it was, there would not be no rationale for the existence of HFT.

LTr have sent their demand to MM, the price is:

$$P_{t,1} = P_t + b\left(Q_t^I + \varepsilon_t^l\right) \tag{3}$$

. Similarly the price P_{t+1} at the end of period t (or beginning of period $t+1$), after HFTr posts its demand, is :

$$P_{t+1} = P_{t,1} + bQ_t^h \tag{4}$$

. Figure 1 summarizes the timing of events.

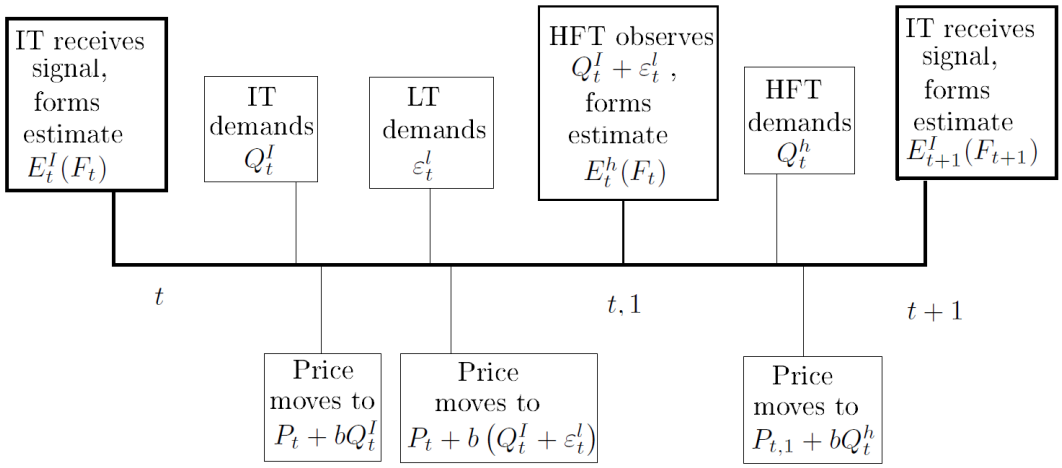

Figure 1: Timeline of demand shocks and price movement in a given period.

2.2. The ITr and HFTr problem

This section specifies the utility function and optimal demand of ITr and HFTr at each trading period, if they chose to participate to the trading cycle.

2.2.1. ITr trading utility and demand

At a point in time ι of period t, ITr derives a surplus of $(F_t - P_{t,\iota})$ from buying one unit of the asset at a lower price than its fundamental value, and a surplus of $(P_{t,\iota} - F_t)$ from selling one unit of the asset at a higher price than its fundamental value. Using the fact that the mean execution price of an order of Q_t^I units of is $P_t + \frac{b}{2}Q_t^I$, the total surplus obtained by ITr over period t is $Q_t^I\left(F_t - (P_t + \frac{b}{2}Q_t^I)\right)$. For ITr at the start of period t, this total surplus is a random variable with an expected value of $Q_t^I\left(E_t^I(F_t) - P_{t,\iota}\right) - \frac{b}{2}(Q_t^I)^2$ and a variance of $(Q_t^I)^2\sigma_s^2$. Using a mean-variance function with a coefficient of risk aversion of $\frac{1}{2\tau}$, the utility $U_{t,\iota}^I$ function of ITr at time t is:

$$U_t^I = Q_t^I\left(E_t^I(F_t) - P_{t,\iota}\right) - (Q_t^I)^2\frac{1}{2\lambda} \tag{5}$$

where $1/\lambda = \frac{\sigma_s^2}{\tau} + b$ captures the utility cost of investing Q_t^I, which comes in part from the risk $\frac{\sigma_s^2}{\tau}$ involved in investing Q_t^I, and in part from the transaction costs b involved in investing Q_t^I.

Maximizing Equation (5) yields the following optimal ITr demand $Q^*_{I,t}$ at time t :

$$Q_t^{I*} = \lambda(F_t - P_t) + \lambda\varepsilon_t^s \tag{6}$$

. Equation (6) states that absolute optimal ITr demand increases on average with the extent to which the asset is mispriced $|F_t - P_t|$, and decreases with the estimation risk and transaction costs contained in λ.

Importantly, ITr can decide to add a noise of ε_t^r around its optimal demand Q_t^{I*} to artificially decrease the share of its demand that carries information about F_t. This is randomization. The randomizing noise ε_t^r is set to be an i.i.d normally distributed with a mean of zero and a variance of σ_r^2, and is defined by:

$$Q_t^I = Q_t^{I*} + \varepsilon_t^r \tag{7}$$

. The variance σ_r^2 represents the level of randomization. It is set as constant across periods of the trading cycle to ease notation and without loss of generality.[4]

Before proceeding, it is worth noting that $b\lambda = \frac{b\tau}{\sigma_s^2 + b\tau} < 1$. This means that the demand from ITr is not sufficiently strong to immediately bring prices to their fundamental value on average. Thus ITr demand is positively autocorrelated on average, consistent with empirical observation (O'Hara (2015)).

2.2.2. HFTr utility and demand

Similar to ITr, HFTr derives a utility surplus of $F_t - P_{t,\iota}$ on each unit of a buy order executed at time (t, ι), and a surplus $P_{t,\iota} - F_t$ on each unit of a sell order executed at (t, ι). The total HFTr surplus over period t obtained from demanding Q_t^h at time $(t, 1)$ is $Q_t^h \left(F_t - (P_{t,1} + \frac{b}{2}Q_t^h)\right)$. For HFTr at the time $(t, 1)$ of posting its order, F_t is a random variable with an expected value of $E_{t,1}^h(F_t)$. However, contrary to ITr, HFTr is modeled as risk-neutral. This difference is motivated by the fact that ITr is typically a human being, while HFTr is a machine. This modeling implies that the total HFTr utility U_t^h throughout period t is:

$$U_t^h = Q_t^h \left(E_{t,1}^h(F_t) - P_{t,1}\right) - \left(Q_t^h\right)^2 \left(\frac{b}{2}\right) \tag{8}$$

where $P_{t,1}$ is the price of the asset when HFTr posts its order, and the negative term $\left(Q_t^h\right)^2 \left(\frac{b}{2}\right)$ stems from the transactions costs involved in demanding Q_t^h.

No new information regarding fundamentals comes to HFTr between $(t, 1)$ and $(t + 1, 1)$, which implies that $E_{t,1}^h(F_t) = E_{t+1}^h(F_{t+1})$. The demand that maximizes U_t^h is then:

$$Q_t^h = \frac{E_{t+1}^h(F_{t+1}) - P_{t,1}}{b} \tag{9}$$

[4]It is the average level of randomization throughout the trading cycle that matters

where $E^h_{t+1}(F_{t+1}) = E\left(F_t|Q^I_t + \varepsilon^l_t\right)$ is the HFTr's estimate of the fundamental value after observing the joint demand by LTr and ITr. Plugging the HFTr demand defined in Equation (9) into Equation (4) leads to:

$$P_{t+1} = E^h_{t+1}(F_{t+1}) \tag{10}$$

. HFTr buys or sells the asset until its price converges to its estimate of the fundamental value.

2.3. Decision making before trading

Prior to the start of a given trading cycle, ITr and HFTr make strategic decisions that will apply through the entire cycle. First, both ITr and HFTr decide whether to pay the fixed cost to participate in the cycle. Second, ITr chooses a level of randomization σ^2_r, conditional on entry. The strategic game played by ITr and HFTr resembles a Stackelberg (1934) setup: ITr moves first knowing the best response of HFTr, and does not deviate from its randomization and participation choices after choosing.

Formally, at the start of each trading cycle, the set of strategies available to ITr is $S_I = \left(I_{\not r}, I_r, \not I\right)$, which stand respectively for entering without using randomization, entering using randomization, and not entering. $I = \left(I_{\not r} \vee I_r\right)$ denotes ITr entrance for any level of randomization. On the other hand, HFTr must choose between strategies $S_h = (h, \not h)$, which represent respectively entering and not entering. The utility that any agent $k = (I, h)$ gets if it does not enter is zero. Defining as $c_k = \frac{C_k}{T}$ the mean information/speed cost per period of a trading cycle, the mean utility $\bar{U^k}$ per period of a trading cycle that agent k gets if it enters is:

$$\bar{U^k} = E(U^k_t) - c_k \tag{11}$$

where $E(U^k_t)$ is the utility that agent k expects from any period t, which is equal to mean trading utility across the cycle $\frac{\sum_{t=1}^{t=T} U^k_t}{T}$ since T is large. Table 1 illustrates the payoff matrix associated to the ITr/HFTr game.

IT\HFT	h	$\not h$
$I_{\not r}$	$\left((\bar{U^I})^{I,h}_{\not r}, (\bar{U^h})^{I,h}_{\not r}\right)$	$\left((\bar{U^I})^{I,\not h}_{\not r}, 0\right)$
I_r	$\left((\bar{U^I})^{I,h}_r, (\bar{U^h})^{I,h}_r\right)$	$\left((\bar{U^I})^{I,\not h}_r, 0\right)$
$\not I$	$\left(0, (\bar{U^h})^{\not I,h}\right)$	$(0,0)$

Table 1: Payoff table for the strategic game between ITr and HFTr prior to each trading cycle

This game and its implications for price efficiency will be studied in section 5. For now the analysis focuses on characterizing the (I, h) market in which ITr and HFTr coexist. Section 3 draws the behavior of HFTr and price dynamics in the (I, h) market. Section 4 compares the characteristics of the (I, h) market to those of the $(I, \not h)$ market, holding the ITr strategy $s_I = \left(I_{\not r} \vee I_r\right)$ constant.

3. HFTr inference, trading, and utility

Section 3.1 solves the inference problem of HFTr. Section 3.2 derives HFTr demand. Section 3.3 draws HFTr utility.

3.1. HFTr inference

3.1.1. The HFTr inference problem

Using Equations (6) and (7), the joint demand $Q_t^I + \varepsilon_t^l$ of ITr and LTr can be expressed as :

$$Q_t^I + \varepsilon_t^l = \lambda(F_t - P_t) + \varepsilon_t^n \tag{12}$$

where $\varepsilon_t^n = \lambda\varepsilon_t^s + \varepsilon_t^r + \varepsilon_t^l$ is the sum of LTr demand and the elements in ITr demand that are unrelated to fundamentals, which is referred to as noise trading. ε_t^n is normally distributed with a mean of 0 and a variance of $\sigma_n^2 = \lambda^2\sigma_s^2 + \sigma_r^2 + \sigma_l^2$. By contrast, λF_t is the part of the ITr demand that carries fundamental information, referred to as fundamental trading.

The goal of HFTr is to efficiently relate movements in $Q_t^I + \varepsilon_t^l$ to movements in F_t. The key to doing this is to note that the difference $\Psi_t^f = F_t - E_t^h(F_t)$ between the real fundamental value and the fundamental value as expected by HFTr is linearly related to the difference $\Psi_t^d = Q_t^I + \varepsilon_t^l - E_t^h\left(Q_t^I + \varepsilon_t^l\right)$ between the real demand from LTr and ITr and the demand from LTr and ITr as expected by HFTr. Formally:

$$\Psi_t^d = \lambda(F_t - P_t) + \varepsilon_t^n - E_t^h\left(\lambda(F_t - P_t) + \varepsilon_t^n\right) \tag{13}$$

$$\Rightarrow \Psi_t^d = \lambda\Psi_t^f + \varepsilon_t^n \tag{14}$$

where I used the fact that $E_t^h(P_t) = P_t$ and $E_t^h(\varepsilon_t^n) = 0$, since HFTr observes prices at the start of t but not noise trading shocks.

As all shocks in the model are normally distributed, estimating Ψ_t^f knowing Ψ_t^d is a classic signal extraction problem. Its solution[5] is:

$$E_{t+1}^h(\Psi_t^f) = E(\Psi_t^f|\Psi_t^d) = \frac{\delta}{\lambda}\Psi_t^d \tag{15}$$

where $\delta = 1 - \frac{\sigma_n^2}{\sigma_{\Psi,d}^2}$ is the share of the observable gap between actual and expected demand Ψ_t^d that is assigned to Ψ_t^f by HFTr, i.e., the share of $Q_t^I + \varepsilon_t^l$ that reflects a change in fundamentals.

[5]Let $Z = X + Y$ with $X \sim N(0, \sigma_x^2)$ and $Y \sim N(0, \sigma_y^2)$. The conditional distribution of X given $Z = z$ is normal, and since X and Y have zero means, simplifies to:
$E(X|Z = z) = \left(\frac{cov(x,z)}{\sigma_x\sigma_z}\right)\left(\frac{\sigma_x}{\sigma_z}\right)z = \left(\frac{cov(x,x+y)}{\sigma_z^2}\right)z = \left(\frac{\sigma_x^2}{\sigma_x^2+\sigma_y^2}\right)z$

3.1.2. Optimal inference

Using $\Psi_t^f = F_t - E_t^h(F_t)$, $E_{t+1}^h(F_{t+1})$ can be rewritten as:

$$E_{t+1}^h(F_{t+1}) = E_{t+1}^h(F_t) = E_{t+1}^h(E_t^h(F_t) + \Psi_t^f) = E_t^h(F_t) + E_{t+1}^h(\Psi_t^f) \tag{16}$$

. When forming its expectations about F_t at time $t+1$, HFTr starts from its previous estimate $E_t^h(F_t)$ and corrects it via its ex-post estimate of its ex-ante forecast error $E_{t+1}^h(\Psi_t^f)$.

Plugging (15) and (14) into (16) yields:

$$E_{t+1}^h(F_{t+1}) = E_t^h(F_t) + \frac{\delta}{\lambda}\left(\lambda\Psi_t^f + \varepsilon_t^n\right) \tag{17}$$

. Taking the difference between (1) and (17) leads to:

$$\Psi_{t+1}^f = (1-\delta)\Psi_t^f + \varepsilon_{t+1}^f - \frac{\delta}{\lambda}\varepsilon_t^n \tag{18}$$

. Appendix A-1 shows that systemically substituting Ψ_t^f until $\Psi_{f,0}$ yields the following expression for the expected squared forecast error of F_t by HFTr:

$$\sigma_{\Psi,f}^2 = E\left((\Psi_t^f)^2\right) = E\left(F_t - E_t^h(F_t)\right)^2 = \frac{\sigma_f^2 + \left(\frac{\delta}{\lambda}\right)^2\sigma_n^2}{2\delta - \delta^2} \tag{19}$$

. The objective of the rational HFTr is to find the value of δ that minimizes its expected squared forecast error $E\left(F_t - E_t^h(F_t)\right)^2$. Appendix A-2 proves that this value is:

$$\delta = \frac{1}{2\rho}\left(\sqrt{1+4\rho} - 1\right) \tag{20}$$

where $\rho = \frac{\lambda^2\sigma_s^2 + \sigma_r^2 + \sigma_l^2}{\lambda^2\sigma_f^2}$ is the ratio of the variance of noise trading over the variance of fundamental trading, which plays an important role in the model. Appendix A-3 shows that δ increases when ρ decreases: HFTr assigns a higher proportion of unexpected demand shocks to fundamental trading when fundamental trading drives a high share of the total variation in demand.

Appendix A-4 plugs the expression of δ given in Equation (20) back into the expected squared forecast error given in Equation (19) to get the value of expected squared forecast error in equilibrium:

$$\sigma_{\Psi,f}^2 = \frac{\sigma_f^2}{\delta} = \frac{2\sigma_f^2\rho}{\sqrt{1+4\rho} - 1} \tag{21}$$

3.2. HFTr demand

3.2.1. Pattern

Using Equations (10), (12), and (4), the total HFTr demand Q_t^h throughout period t can be expressed as:

$$Q_t^h = \frac{1}{b}\left[E_{t+1}^h(F_{t+1}) - E_t^h(F_t) - b\left(\lambda(F_t - P_t) + \varepsilon_t^n\right)\right] \tag{22}$$

. Plugging Equation (17) into Equation (22) then yields:

$$Q_t^h = \frac{1}{b\lambda}(\delta - b\lambda)\left(\lambda(F_t - P_t) + \varepsilon_t^n\right) \tag{23}$$

. HFTr trades against any demand shocks it observes when $\delta < b\lambda$ and in the same direction as the demand shocks when $\delta > b\lambda$. Using (20), the condition $\delta \lessgtr b\lambda$ can be showed to be equivalent to:

$$\rho^* = \frac{(1 - b\lambda)}{(b\lambda)^2} \lessgtr \rho \tag{24}$$

Proposition 1: HFTr trades against demand shocks from non-HFT agents when the variance of noise trading relative to fundamental trading is above a certain threshold $\rho^* = \frac{(1-b\lambda)}{(b\lambda)^2}$ and in the same direction as demand shocks from non-HFT agents otherwise.

Proof: $Q_t^h \times (\lambda(F_t - P_t) + \varepsilon_t^n) < 0$ if $\delta < b\lambda \Leftrightarrow \rho^* < \rho$, and $Q_t^h \times (\lambda(F_t - P_t) + \varepsilon_t^n) > 0$ if $\delta > b\lambda \Leftrightarrow \rho^* > \rho$

Proposition 1 states that the trading behavior of HFTr depends on the broader structure of the market it operates in. This is explained by the fact that noise trading is mean-reverting, while fundamental trading is positively autocorrelated. A positive (negative) noise trading shock at period t leads the price P_t to increase (decrease) while the fundamental value F_t remains constant. On average, this leads the asset to become overvalued (undervalued), which means that ITr demand should sell (buy) at the following period, bringing the price down (up). By contrast, a positive fundamental shock implies that price P_t increases, but less so than the fundamental value F_t, because $b\lambda < 1$. On average, this leads the asset to become undervalued (overvalued), which means that ITr should buy (sell) at the following period, bringing the price up (down). $\rho^* < \rho$ means that noise trading is sufficiently strong relative to fundamental trading to make prices revert at the following period on average. HFTr then hopes to benefit from the future mean reversion by trading against any demand shock that it observes. Conversely, $\rho^* > \rho$ means that the variance in the demand for the asset is driven more by fundamentals and thus reflects a change in the long-run value of the asset. In this case, HFTr tags along the process the convergence towards the new F_t by trading with demand shocks. Finally in the special case $\rho = \rho^* \Rightarrow \delta = b\lambda$, the price at $(t, 1)$ matches exactly the expected fundamental value as expected by HFTr, who does not trade.

3.2.2. Link to literature

Distinguishing strategies that trade against other investors (against the wind strategies) from strategies that trade with other investors (with the wind strategies) has been an important topic in the HFT literature. Against the wind trading is close to market-making, and has notably been considered as such by Grossman and Miller (1988). With-the-wind trading can reflect different strategies (Brunnermeier and Pedersen (2005)), but the way HFTr behaves in this model is particularly close to backrunning, which involves using publicly available data on past order flow from

informed traders to estimate fundamentals (YZ).

Several theoretical models consider both market making and backrunning by HFT (e.g., Foucault et al. (2016), Baldauf and Mollner (2020)). However to my knowledge this paper is the first to define the conditions under which HFT will switch between both rules. The role of ρ in the model is consistent with several empirical contributions (e.g., Korajczyk and Murphy (2019) vKM). vKM in particular demonstrates that high-frequency traders usually trade against the wind, but can trade with the wind if "the information component dominates the transitory component in [investors] order's overall price impact". vKM also report evidence that investors need some time (around seven hour) to comprehend to true nature of a shock, which is conceptually close to the learning process presented in section 3.1.[6]

3.3. HFTr utility

3.3.1. Expression

Appendix B-1 shows that the mean HFTr utility per period is :

$$\bar{U^h} = \left(\frac{\sigma_f^2}{\delta^2}\right) \frac{1}{2b} \left(b\lambda - \delta\right)^2 - c_h \tag{25}$$

. This leads to Lemma 1.

Lemma 1: HFTr utility increases with the distance between b and $\frac{\delta}{\lambda}$
Proof : see Appendix B-2

The intuition for Lemma 1 is the following. HFTr feeds off deviations at $(t, 1)$ between its estimate of fundamental value $E^h_{t,1}(F_t)$, and the price specified by the market maker $P_{t,1}$. $E^h_{t,1}(F_t)$ is the most educated guess that can be made about F_t for an agent who only observes the order flow. If the market maker is as knowledgeable/quick as HFTr, it chooses $b = \frac{\delta}{\lambda}$ such that prices instantly move to $P_{t,1} = P_t + b\left(\lambda\left(F_t - P_t\right) + \varepsilon^n_t\right) = E^h_{t+1}(F_t)$. In this case the HFTr demand is null at every period. If however MM chooses a rule b that is far from the correct $\frac{\delta}{\lambda}$, HFTr has plenty of mispricings to prey on.

[6]Despite this strong connection, one notable feature of vKM is not reproduced in the model in its current form. vKM shows that HFT may switch from against-the-wind trading to with-the-wind trading following a single fundamental shock. In the model HFTr demand reverts but never changes sign following a fundamental shock in a noise trading dominated market. This pattern could be accommodated by an extended model in which demand shocks from informed traders are allowed to follow an ARCH process. In this case a large shock $\varepsilon_{f,t}$ would imply both an increase in F_t and an increase in the value of σ_f^2 for the subsequent periods as more fundamental shocks are expected to occur. The resulting fall in ρ could lead to $\rho < \rho^*$, and thus make HFTr switch to with the wind trading. Finding a process for $\varepsilon_{f,t}$ that exactly matches the dynamic patterns of HFT demand is an interesting subject, but one that would significantly complexity the model without altering the main intuition that the trading rule of HFTr depends on the structure of the market.

3.3.2. Link to literature

Lemma 1 implies that HFTr and MM are in a competition to incorporate shocks into prices, which closely connects with a sizable body of theoretical literature (e.g., Easley et al. (2011), van Kervel (2015), Biais et al. (2015)). Its overall message is that, following the apparition of fundamental news, HFTr (MM) races to take (remove) stale orders in order to earn (avoid losing) the difference between the price and the true value of the asset. Menkveld and Zoican (2017) provide a MM versus HFT model in which the "news-to-liquidity-trader ratio" $-\rho$ in the model– plays a key part. Lemma 1 also relates to casual observation of the recent developments in the high-frequency world. The efficiency of market makers increased in recent years in response to HFT (Pagnotta and Philippon (2015)). Alternative trading venues such as dark pools developed. The fees for collocation services rose. Finally, the profits of the HFT industry have been on a declining trend, particularly those related to cross-venue arbitrage in which the race for stale orders occurs in its purest form (Foucault et al. (2017)). This suggests that market makers were to an extent successful in hurting high-frequency traders.

4. Impact of HFTr in the absence of ITr response

This section characterizes the market (I, h) with ITr and HFTr, and compares it to the market $(I, \not{h})$ with ITr and without HFTr, holding the ITr strategy $s_I = I = \left(I_{\not{r}} \vee I_r\right)$ constant. Section 4.1 studies price efficiency, while section 4.2 studies ITr utility and access to liquidity.

4.1. HFTr impact on price efficiency

Price efficiency in a given market at the start of a period t is inversely measured by the squared distance between the price of the asset and its fundamental value at that time $(F_t - P_t)^2$. Section 4.1.1 studies the sum $\sum_{t=0}^{t=\infty} (F_t - P_t)^2$ of the mispricings following a single shock (fundamental or noise). Section 4.1.2 studies the global tendency of the asset to be mispriced $M = E\left((F_t - P_t)^2\right)$.

4.1.1. Single shock incorporation

Price movement in the market with ITr and HFTr is obtained by plugging the HFTr demand specified in Equation (23) and the ITr+LTr demand specified in Equation (12) into the price movement Equations (4) and (3). This yields:

$$P_{t+1}^{I,h} = P_t^{I,h} + \delta\left(F_t - P_t^{I,h}\right) + \frac{\delta}{\lambda}\varepsilon_t^n \tag{26}$$

. On the other hand, price movement in the $(I, \not{h})$ market is obtained by plugging the ITr+LTr demand specified in Equation (12) into the price movement Equation (3). This yields:

$$P_{t+1}^{I,\not{h}} = P_t^{I,\not{h}} + b\lambda(F_t - P_t^{I,\not{h}}) + b\varepsilon_t^n \tag{27}$$

Studying the impulse response functions of Equations (26) and (27) to a unique noise trading and/or a fundamental shock at $t = 0$ leads to Proposition 2.

Proposition 2: Holding ITr behavior constant and following a fundamental (noise) shock, HFTr speeds up the process of convergence towards fundamental value if order flow innovations typically come from fundamental (noise) trading, but slows down the process of convergence towards fundamental value if order flow innovations typically come from noise (fundamental) trading.

Proof : see Appendix C.

Proposition 2 states that in any market structure HFTr helps to incorporate one type of shock but at the expense of the other type. When noise trading is sufficiently common compared to fundamental trading, HFTr rationally trades against non-HFTr demand at all t. In this market, if a given demand shock in fact emanated from fundamental trading at a given t, HFTr mistakenly trades against the incorporation of the fundamental shock into prices. Conversely when fundamental trading is sufficiently common compared to noise trading, HFTr rationally trades with non-HFTr demand at all t. If this demand in fact emanated from noise trading at a given t, HFTr mistakenly exaggerates a meaningless shock.

Only a limited amount of research explored the possibility that HFT occasionally downplays fundamental shocks. vKM shows that price changes have a lower tendency to be permanent when HFT trades against the wind, but only relative to when HFT trades with the wind, not relative to a market without HFT. More work has been undertaken on the possibility that HFT exaggerates meaningless shocks. This literature did not reach a consensus. Bershova and Rakhlin (2013) and Boehmer et al. (2021) find a link between HFT and excess volatility, while Hasbrouck and Saar (2013) and Chaboud et al. (2014) do not. The model is consistent with such mixed results, as it implies that the presence of excess volatility depends on the underlying structure of the market.

4.1.2. Global price efficiency

Since HFTr helps to incorporate one type of shock (noise or fundamental) but hampers the incorporation of the other type of shock, the question of its overall impact on price efficiency remains open. To investigate, I compare the expected mispricing $M^{I,h} = E\left(\left(F_t - P_t^{I,h}\right)^2\right)$ in the market with ITr and HFTr to the expected mispricing $M^{I,\not h} = E\left(\left(F_t - P_t^{I,\not h}\right)^2\right)$ in the market with ITr but without HFTr.

Because $P_t = E_t^h(F_t)$ when HFTr is present on the market, $M^{I,h}$ corresponds to the forecast HFTr error $\sigma^2_{\Psi,f} = E\left(\left(F_t - E_t^h(F_t)\right)^2\right)$, which was pinned down in Equation (21). Therefore:

$$M^{I,h} = \frac{\sigma_f^2}{\delta} = \frac{2\sigma_f^2\rho}{\sqrt{1+4\rho}-1} \tag{28}$$

. On the other hand, mispricing in the no-HFTr market –obtained in Appendix D-1– is:

$$M^{I,\not h} = \frac{\sigma_f^2 + b^2\sigma_n^2}{2b\lambda - (b\lambda)^2} \tag{29}$$

. Appendix D-2 shows that:

$$M^{I,h} - M^{I,h\backslash} = -\left(\frac{1}{1-(1-b\lambda)^2}\right)\left(\frac{\sigma_f^2}{\delta^2}\right)(b\lambda-\delta)^2 \tag{30}$$

Proposition 3: Holding the behavior of ITr constant, HFTr has a positive impact on global price efficiency, i.e., $M^{I,h} \leq M^{I,h\backslash}$

Proof : immediate from Equation (30).

Proposition 3 states that, although HFTr does not lead all shocks to a more efficient incorporation into prices, it leads to a better incorporation of shocks in general. The reason is that HFTr is helpful in incorporating the type of shock that is the most common in the market in which it operates, i.e., fundamental shocks when $\rho < \rho^*$ and noise shocks when $\rho > \rho^*$. This is the information treatment effect: HFTr is quick and efficient (on average) in incorporating shocks into prices. This conclusion is in line with an extensive literature that investigated the direct impact of HFT on price efficiency in the early 2010's (e.g., Carrion (2013); Riordan and Storkenmaier (2012), Conrad et al. (2015)). Particularly consistent with the model are Brogaard et al. (2014) and Hirschey (2021), who show that the impact on high-frequency traders on price efficiency comes from their ability to trade against transitory shocks and with permanent shocks on average.

Further investigation of $M^{I,h} - M^{I,h\backslash}$ leads to Lemma 2.

Lemma 2: Holding the behavior of ITr constant, the impact of HFTr on price efficiency :
- is null for a market structure in which $b = \frac{\delta}{\lambda}$
- increases with the deviations of b from $\frac{\delta}{\lambda}$

Proof: immediate from Equation (30).

Lemma 2 states that the increase in price efficiency provided by HFTr is a growing function of the distance $|b - \frac{\delta}{\lambda}|$ between the pricing rule b used by the market marker and the optimal rule $\frac{\delta}{\lambda}$. This is logical: the efficiency gain provided by HFTr is large when the existing treatment of information by MM is very inefficient.

4.2. HFTr impact on ITr

Section 4.2 studies what the presence of HFTr implies for ITr, from both a market liquidity perspective (section 4.2.1) and a utility perspective (section 4.2.2).

4.2.1. HFTr liquidity provision to ITr

Liquidity is studied through market depth, denoted by md. Market depth for non-HFTr investors is formally defined as the amount of non-HFTr demand required to move prices by one unit between t and $t+1$, i.e., $md = \frac{(Q_t^I + \varepsilon_t^l)}{P_{t+1} - P_t}$. If the market is shallow (md is low), ITr and LTr demand shocks

move prices by a large amount. This situation imposes a cost on ITr as it increases transaction costs. By contrast, if the market is deep (md is high), ITr benefits from lower transaction costs.

md in the market with ITr and HFTr is obtained rapidly by plugging Equations (23) and (3) into (4). This yields:

$$md^{I,h} = \frac{\lambda}{\delta} \tag{31}$$

. On the other hand, if HFTr is not present on the market the price reaction to demand shocks is defined by the MM rule given in Equation (3). Depth in this case is $md^{I,\not h} = 1/b$. It follows that:

$$md^{I,h} - md^{I,\not h} = \lambda/\delta - 1/b \tag{32}$$

Lemma 3: HFTr:

- increases market depth for ITr when non-HFTr demand typically comes from noise trading.

- decreases market depth for ITr when non-HFTr demand typically comes from fundamental trading.

Proof : $\lambda/\delta - 1/b \lessgtr 0 \Rightarrow b\lambda \lessgtr \delta \Leftrightarrow \rho \lessgtr \rho^*$

Lemma 3 is a natural consequence of proposition 1: when HFTr trades in the same direction as non-HFTr it takes liquidity, and conversely. The main interest of Lemma 3 lies with its ability to reconcile two opposing views on the link between HFT and liquidity. On the one hand, the general conclusion of the academic literature is that HFT enhances liquidity (Frino et al. (2014), Boehmer et al. (2021)). On the other hand, market participants typically argue that the HFT liquidity is "phantom", i.e., vanishes when informed traders post their orders (Lewis, 2014). The model suggests that both positions are not as opposed as they appear. If HFT typically trades against the wind but switches when informed trading is high, as suggested by vKM, it is logical to observe both i) a positive link between liquidity and HFT on average, and ii) a vanishing liquidity following informed demand shocks. A number of studies focused on liquidity are consistent with this postulate. van Kervel (2015) notably considers liquidity provision across venues in the presence of HFT. He finds that a buying order in a given venue triggers new limit orders on the bid side of the order book in other venues, but cancellations of limit orders on the ask side. In a similar vein, Breckenfelder (2019) finds that market liquidity deteriorates when HFT follows speculative strategies ($\delta > b\lambda$ in the model).

4.2.2. HFTr impact on ITr utility

This section considers the impact of HFTr on the mean utility per trading period $\bar{U^I}$ of ITr. The general expression for $\bar{U^I}$ is quickly obtained by plugging Equation (6) into (7) and into Equation (5). This yields:

$$\bar{U^I} = \frac{\lambda}{2}M - \frac{1}{2\lambda}\left(\sigma_r^2 + \lambda^2\sigma_s^2\right) - c_I \tag{33}$$

. Equation (33) implies that, for any level of randomization:

$$\left(\bar{U^I}\right)^{I,h} - \left(\bar{U^I}\right)^{I,\not h} = \frac{\lambda}{2}(M^{I,h} - M^{I,\not h}) = -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\left(\frac{\sigma_f^2}{\delta^2}\right)(b\lambda-\delta)^2 \qquad (34)$$

Proposition 4: Holding the behavior of ITr constant, ITr utility is lower when HFTr is present on the market.

Proof: $\left(\bar{U^I}\right)^{I,h} - \left(\bar{U^I}\right)^{I,\not h} \leq 0$, immediate from Equation (34)

Proposition 4 states that high-frequency trading imposes a cost on informed traders because it increases price efficiency. This result is consensual in the literature. Aquilina et al. (2022) estimate the profit diverted from IT by HFT to $5 billion annually in global equity markets. Hirschey (2021), vKM, and Korajczyk and Murphy (2019) jointly discuss the issues of IT costs and price efficiency, as Equation (34) does.

In the model the negative relationship between HFTr and ITr utility holds regardless of whether HFTr acts as a backrunner or a market maker. However, because HFTr provides liquidity to ITr when acting as a market maker (i.e., $b\lambda > \delta$), one may expect the utility loss of ITr to be lower in this context. To investigate I define as $\omega = |b - \frac{\delta}{\lambda}|$ the distance between the MM pricing rule b and the optimal pricing rule $\frac{\delta}{\lambda}$, in absolute value. I then compare the value of $\left(\bar{U^I}\right)^{I,h} - \left(\bar{U^I}\right)^{I,\not h}$ when $b = \frac{\delta}{\lambda} + \omega$, which implies that HFTr acts as a market maker ($b\lambda > \delta$), to $\left(\bar{U^I}\right)^{I,h} - \left(\bar{U^I}\right)^{I,\not h}$ when $b = \frac{\delta}{\lambda} - \omega$, which implies that HFTr acts as a backrunner ($b\lambda < \delta$). This leads to Lemma 4.

Lemma 4: The ITr utility cost induced by HFTr is higher when HFTr backruns.

Proof : see Appendix D-3.

Lemma 4 confirms that the liquidity provision of HFTr when $b\lambda > \delta$ limits the utility loss it imposes on ITr. By providing depth, HFTr leads prices to be more sluggish, which implies that an investor with private information about F_t will manage to buy more of the asset before the price converges back to F_t. In effect ITr has less mispricings to exploit, but draws more revenue from the mispricings that do occur. By contrast, when $b < \frac{\delta}{\lambda}$, ITr loses on both accounts: there are less instances of mispricing to exploit on average and less room to exploit them when they do occur, as prices are quicker to converge to F_t.

Despite its more specific nature, Lemma 4 is supported by the literature. Tong (2015) notably finds that "institutional trading costs are more pronounced when HFTs engage in directional strategies". vKM confirm this finding. Hirschey (2021) finds that the diversion of profit from non-HFT to HFT is stronger when non-HFT traders are particularly eager to buy or sell, i.e., when δ is high. Finally, Malinova et al. (2018) provide evidence that the liquidity provision of HFT has a negative

impact on IT implementation costs, which is consistent with the idea that the asymmetric effect of HFT comes from liquidity.

5. Impact of HFTr allowing for ITr response

Section 4 discussed the price efficiency impact of HFTr for a given ITr strategy. This section studies the possibility that ITr changes strategy when HFTr would enter unless prevented from doing so by ITr (i.e., $(\bar{U^h})^{I,h} > 0$). This is done by solving the strategic game that arises between ITr and HFTr prior to the trading cycle. Section 5.1 solves the game. Section 5.2 analyzes the conditions under which the market moves from one equilibrium to another. Section 5.3 discusses the implications of the game in terms of price efficiency.

5.1. The ITr/HFTr game

5.1.1. Optimal level of randomization

The first step toward solving the game is to derive the level of randomization chosen by ITr when playing I_r. Plugging the expected HFTr utility in the market with ITr and HFTr, given by Equation (25), into Equation (11), the participation condition of HFTr can be rewritten as:

$$(\bar{U^h})^{I,h} > 0 \Rightarrow \left(\frac{\sigma_f^2}{\delta^2}\right)\frac{1}{2b}\left(b\lambda - \delta\right)^2 - c_h > 0 \tag{35}$$

. $(\bar{U^h})^{I,h}$ increases with δ if $b\lambda < \delta$, which implies that $(\bar{U^h})^{I,h}$ decreases with σ_r^2 if $b\lambda < \delta$. In words, by lowering the share of order flow that contains fundamental information through randomization, ITr makes backrunning less profitable for HFTr. Setting $(\bar{U^h})^{I,h} = 0$ and using Equation (20) yields the threshold level of randomization $\bar{\sigma_r^2}$ above which HFTr chooses not to enter the market:

$$\bar{\sigma_r^2} = \left(\frac{1-\bar{\delta}}{\bar{\delta}^2}\right)\lambda^2\sigma_f^2 - \lambda^2\sigma_s^2 - \sigma_l^2 \tag{36}$$

where $\bar{\delta}$ is the threshold value for δ under which HFTr exits and is given by :

$$\bar{\delta} = \frac{b\lambda}{\left(1 - \sqrt{\frac{2bc_h}{\sigma_f^2}}\right)} \tag{37}$$

Lemma 5: The threshold value for randomization above which HFTr exits the market decreases with σ_l^2 , σ_s^2 , $b\lambda$ and c_h, and rises with σ_f^2 .

Proof: follows directly from Equations (36) and (37)

The negative relationship between $\bar{\sigma_r^2}$ and σ_s^2 reflects the fact that randomization and other sources of noise are perfect substitutes. Non-randomizing noise provides natural camouflage for ITr, who does not need to randomize as much. The negative relationship between $\bar{\sigma_r^2}$ and $b\lambda$ comes from

the fact that $E(U_t^h)^{I,h}$ decreases with $b\lambda$ when HFTr backruns ($b\lambda < \delta$). In other words, when $b\lambda < \delta$ the market marker is using an overly sluggish price rule, a rise in $b\lambda$ then means that MM is becoming more efficient. This hurts HFTr and makes it easier to expel by ITr. A high c_h also hurts HFTr and makes it easier to expel. Finally, the positive relationship between $\bar{\sigma_r^2}$ and σ_f^2 comes from two channels. First, when fundamental trading is high, the marginal impact of σ_r^2 on δ is low. Second, $\bar{\delta}$ falls with σ_f^2 because a rise in σ_f^2 increases HFTr utility, making it harder to expel. In other words each unit of randomization is less efficient, and more units of randomization are needed.

5.1.2. ITr optimal strategy and Nash equilibria

It is easy to show[7] that in any market ITr utility ($\bar{U^I}$) decreases with σ_r^2. In words, an increase in randomization that is insufficient to remove HFTr from a market with HFTr, or an increase in randomization in a market that is already without HFTr, is unambiguously utility reducing for ITr. It follows that ITr necessarily chooses the minimum randomization level $\bar{\sigma_r^2}$ such that HFTr exits if it engages in randomization, i.e., $\sigma_r^2 = \bar{\sigma_r^2}$ if $S_I = I_r$.

The level of randomization $\bar{\sigma_r^2}$ chosen by ITr, if it randomizes, ensures that HFTr does not enter the market. Formally this means that $S_h^* = \emptyset$ if $S_I = I_r$. On the other hand, by construction the game between ITr and HFTr only arises if HFTr would enter if not prevented from doing so by ITr, i.e., $S_h^* = h$ if $S_I = I_\emptyset$. ITr knows the model parameters, which means that it knows the utility expected by HFTr in each possible equilibrium. ITr thus knows that playing $S_I = I_\emptyset$ will result in the market structure $(I_\emptyset, h)$, while playing $S_I = I_r$ will result in $(I_r, \emptyset)$. Consequently, the optimal strategy for ITr is as follows:

1) play $S_I = I_\emptyset$ if $(\bar{U^I})_\emptyset^{I,h} - (\bar{U^I})_r^{I,\emptyset} > 0$ and $(\bar{U^I})_\emptyset^{I,h} > 0$, i.e., if the utility $(\bar{U^I})_\emptyset^{I,h}$ from not randomizing and sharing the market with HFTr exceeds the utility $(\bar{U^I})_r^{I,\emptyset}$ from randomizing to exclude HFTr, and the zero utility from not participating.

2) play $S_I = I_r$ if $(\bar{U^I})_\emptyset^{I,h} - (\bar{U^I})_r^{I,\emptyset} < 0$ and $(\bar{U^I})_r^{I,\emptyset} > 0$, i.e., if the utility $(\bar{U^I})_r^{I,\emptyset}$ from randomizing to exclude HFTr exceeds the utility $(\bar{U^I})_\emptyset^{I,h}$ from not randomizing and sharing the market with HFTr, and the zero utility from not participating.

3) play $S_I = \emptyset$ if $0 > (\bar{U^I})_\emptyset^{I,h}$ and $0 > (\bar{U^I})_r^{I,\emptyset}$, i.e., if the zero utility from not participating exceeds the utility $(\bar{U^I})_r^{I,\emptyset}$ from randomizing to exclude HFTr, and the utility $(\bar{U^I})_\emptyset^{I,h}$ from not randomizing and sharing the market with HFTr.

The Nash equilibria associated with the first two possibilities are $(I_\emptyset, h)$ and $(I_r, \emptyset)$, respectively. By contrast, if $S_I = \emptyset$, the Nash equilibrium can theoretically be either $(\emptyset, \emptyset)$ or $(\emptyset, h)$. For conciseness I treat both market structures as one, referred to as $(\emptyset) = ((\emptyset, h), (\emptyset, \emptyset))$. The reason is that, as will become clear shortly, both markets without ITr are equivalent in that they both lead to a complete divergence of the price of the asset from its fundamental value.

[7] A formal proof is available on request

5.1.3. Proposition and link to literature

Proposition 5 summarizes the different market structures that may arise from the ITr/HFTr game.

Proposition 5: The possibility of HFTr entering the market ($(\bar{U}^h)_{\nwarrow}^{I,h} > 0$) splits the parameter set into three regions:

1) one such that $(\bar{U}^I)_{\nwarrow}^{I,h} > max\left((\bar{U}^I)_r^{I,h}, 0\right)$, in which ITr enters using no randomization and HFTr enters.

2) one such that $(\bar{U}^I)_r^{I,h} > max\left((\bar{U}^I)_{\nwarrow}^{I,h}, 0\right)$, in which ITr enters using randomization and HFTr exits.

3) one such that $0 > max\left((\bar{U}^I)_{\nwarrow}^{I,h}, (\bar{U}^I)_r^{I,h}\right)$, in which ITr exits.

Proof: immediate from above.

Proposition 5 is consistent with the findings from two strands of literature. The first focuses on the link between HFT and the general level of information acquisition by other participants. Theoretical contributions on this issue include, for instance, Baldauf and Mollner (2020) and Biais et al. (2015). Empirically, Lee and Watts (2021) and Weller (2018) show that stocks that are more exposed to HFT have lower levels of information acquisition prior to earning announcements. Meling (2021) shows that a positive shock to order anonymity on the Oslo stock exchange lead to increased trading activity by institutional investors. Shkilko and Sokolov (2020) report an increase in non-arbitrage trading volume following an exogenous drop in the speed differential between agents. The second strand of literature focuses on the strategies developed by informed investors to counter robots. Artificial increasing of the ratio of noise trading over fundamental trading through randomization is studied theoretically by YZ. These authors notably find that randomization is optimal " if the standard deviation of the noise in signal is below a certain threshold". In Hoffman (2014), the ratio of noise trading over fundamental trading increases because informed investors trade less in the presence of HFT. Empirically, vKM and O'Hara et al. (2014) show that institutional investors seek to avoid detection by HFT by slowing down the pace of their position taking or by using odd lots.

5.2. Critical points

5.2.1. Mathematical and graphical expression in the (c_I, c_h) space

Setting $(\bar{U}^I)_r^{I,h} - (\bar{U}^I)_{\nwarrow}^{I,h} = 0$, $(\bar{U}^I)_r^{I,h} = 0$, and $(\bar{U}^I)_{\nwarrow}^{I,h} = 0$ spurs the critical points of the parameter set at which the market moves from one equilibrium to another. Appendix E shows that these conditions can be reexpressed in the (c_I, c_h) space as:

$$c_h^* = \frac{\sigma_f^2}{2b}\left(1 - b\lambda \frac{\frac{2\left(\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_{\nwarrow}^{I,h} - M_{\nwarrow}^{I,h}\right) + \lambda^2\sigma_s^2 + \sigma_l^2\right)}{\lambda^2\sigma_f^2}}{\sqrt{1 + 4\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_{\nwarrow}^{I,h} - M_{\nwarrow}^{I,h}\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}} - 1}\right)^2 \tag{38}$$

$$c_h^{**} = \frac{\sigma_f^2}{2b}\left(1 - b\lambda \frac{\frac{2\left(\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2}M_{\setminus}^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2\right)}{\lambda^2\sigma_f^2}}{\sqrt{1 + 4\frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2}M_{\setminus}^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}} - 1}\right)^2 \tag{39}$$

$$c_I^* = \frac{\lambda}{2}M_{\setminus}^{I,h} - \frac{\lambda}{2}\sigma_s^2 \tag{40}$$

. c_h^* is the threshold value for c_h past which ITr randomizes instead of entering and not randomizing, c_h^{**} is the threshold value for c_h past which ITr randomizes instead of exiting the market, and c_I^* is the threshold value past which ITr exits the market instead of entering and not randomizing. To illustrate, Figure 2 provides an informal plot of the phase diagram of the market in the (c_I, c_h) space.

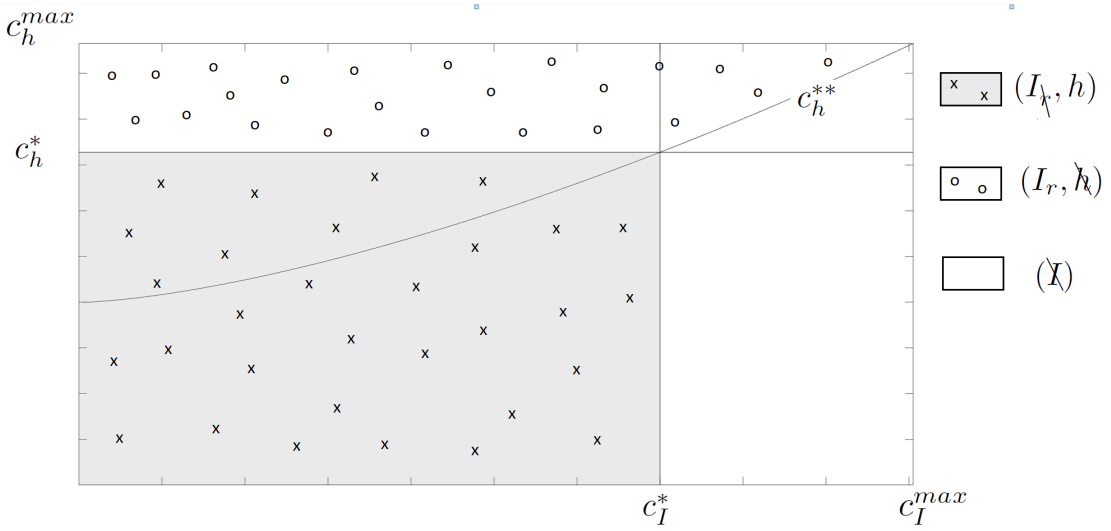

Figure 2: Phase diagram of the market in the (c_I, c_h) space. This figure plots Equations (38) to (40), which split the parameter set into different regions according to the equilibrium market structure it generates. The area with circle markers is the region of the (c_I, c_h) space in which ITr randomizes. The shaded area with cross markers is the region of the (c_I, c_h) space for which ITr and HFTr coexist. The area without markers is the region for which ITr exits. c_k^{max} represents the fixed cost for agent k past which k has a dominant strategy in not entering.

5.2.2. Sensitivity analysis : unambiguous parameters

This section seeks to identify parameters that have an unambiguous effect on the region boundaries c_h^*, c_h^{**}, and c_I^*.

Lemma 6: The threshold value c_I^* below which ITr prefers entering without randomizing to not entering increases with the variance of the demand from liquidity traders σ_l^2 and the variance of the fundamental value of the asset σ_f^2

Proof: see Appendix F-1

Lemma 6 comes from the fact that the utility that ITr obtains from entering the market increases with σ_l^2 and σ_f^2, while the zero utility of not participating remains constant. The reason is that ITr benefits from more variation in either the price P_t or the fundamental value F_t of the asset, as such variation increases expected mispricing $E\left((P_t - F_t)^2\right)$. Graphically, a rise in σ_l^2 or σ_f^2 moves c_I^* to the right in figure 2, increasing the size of the $(I_{\nwarrow}, h)$ region relative to the $(\nwarrow)$ region.

Lemma 7: The threshold value c_h^{**} above which ITr prefers entering and randomizing to not entering decreases with the variance of the demand from liquidity traders σ_l^2 and increases with the fixed cost of information acquisition c_I

Proof: see Appendix F-2

The negative relationship between σ_l^2 and c_h^{**} comes from two channels. The first is that more noise increases mispricing, which makes entering more desirable for ITr as in Lemma 6. The second channel is that a rise in σ_l^2 decreases the utility of HFTr, which lowers the amount of randomization needed to remove HFTr from the market as highlighted by lemma 5. This further increases the desirability of entering and randomizing for ITr. This latter channel explains why σ_f^2 has an ambiguous effect on c_h^{**}. Fundamental noise increases mispricing, which makes entering more desirable for ITr, but also increases the utility from entering for HFTr, making it more costly for ITr to expel HFTr. The positive relationship between c_I and c_h^{**} is intuitive: when entering is costly, ITr has little utility to spend on randomizing and thus only randomizes if HFTr is easy to expel, i.e., if c_h is above a high threshold.

5.2.3. Sensitivity analysis : ambiguous parameters

Several parameters have an ambiguous impact on the region boundaries. Two observations can be made regarding this group. The first one is that σ_l^2 and σ_f^2 –which have a clear relationship with c_h^{**} and/or c_I^*– do not have a clear relationship with c_h^*. This comes from the fact that σ_l^2 and σ_f^2 increase both the gain from and cost of expelling HFTr for ITr. To see why, recall that the impact of HFTr on price efficiency is an increasing function of the distance between the MM pricing rule b and the correct pricing rule $\frac{\delta}{\lambda}$. A rise in σ_l^2 (or a fall in σ_f^2) brings the correct pricing rule $\frac{\delta}{\lambda}$ closer to the rule b used by the market maker when HFTr backruns ($\delta > b\lambda$), and thus lowers the gains from expelling HFTr. Nevertheless the convergence between δ and $b\lambda$ also lowers the utility from backrunning of HFTr, and thus the cost of expelling HFTr through randomization.

The second observation relates to several model parameters that may have been expected to have an unambiguous effect on the region boundaries, but do not. This notably applies to the noise σ_s^2 of the signal received about the value of F_t by ITr, or ITr risk aversion τ, which is contained in λ. Intuitively such variables should lower the utility that ITr obtains from entering the market and thus make not entering relatively more likely. However, the relationship between σ_s^2 or τ and $\bar{U^I}$ is ambiguous. Risk aversion or a less precise signal do have a direct utility cost, but also cause ITr to use a more sluggish trading rule, which increases mispricings. For some parameter sets this latter effect dominates, and ITr utility increases with σ_s^2 or τ. YZ reach a conceptually similar

result for HFT in their model. They find that, over certain parameter sets, "a higher accuracy of back-runners' order flow information can harm back-runners".

5.3. Price efficiency in equilibrium

5.3.1. Overall impact of HFTr

This section evaluates the total impact of HFTr on price efficiency accounting for ITr response. I compare the level of mispricing in each possible equilibrium (I, h), (I_r, h), and (I) when HFTr would enter unless prevented from doing so by ITr ($(\bar{U}^h)^{I,h} > 0$) to the level of mispricing in the no-HFTr market (I, h) that arises when HFTr never enters (i.e., $(\bar{U}^h)^{I,h} < 0$).

Proposition 2 showed that $M^{I,h} \leq M^{I,h}$ for any level of σ_r^2, which means that $M^{I,h} \leq M^{I,h}$. A quick glance at Equation (29) indicates that $M^{I,h} < M_r^{I,h}$, i.e., randomization is bad for price efficiency in the (I, h) market. Finally, Appendix G shows that mispricing tends to infinity in any market $(I) = ((I, h), (I, h))$ without ITr, i.e., $lim_{t\to+\infty} M^{I,h} = lim_{t\to+\infty} M^{I,h} = +\infty$. Since there is a large but finite number of periods T in a given trading cycle, any market without ITr leads to a large but finite level of mispricing. Therefore, the following rankings of mispricings can be established:

$$M^{I,h} \leq M^{I,h} < M_r^{I,h} < M^{I} \tag{41}$$

Proposition 6: The possibility of HFTr entering the market splits the parameter set into three regions:

1) one such that $(\bar{U}^I)^{I,h} > max\left((\bar{U}^I)_r^{I,h}, 0\right)$ and price efficiency increases relative to a situation with no HFTr.

2) one such that $(\bar{U}^I)_r^{I,h} > max\left((\bar{U}^I)^{I,h}, 0\right)$ and price efficiency decreases relative to a situation with no HFTr.

3) one such that $0 > max\left((\bar{U}^I)^{I,h}, (\bar{U}^I)_r^{I,h}\right)$ and price efficiency collapses relative to a situation with no HFTr.

Proof: immediate from Expression (41) and Proposition 5.

Proposition 6 outlines that HFTr is no longer unambiguously desirable when accounting for the possibility of ITr exit/randomization. If the behavior of ITr is not impacted by HFTr participation, fundamental information circulates in the same way it would without HFTr, and is being treated more efficiently. However if ITr randomizes or exits in response to HFTr's willingness to enter, the circulation and/or dissemination of fundamental information decreases. In both cases the decrease in information content dominates the increase in information treatment, and overall price efficiency falls. Nevertheless, the two responses do not have the same impact on price efficiency: exit is far more harmful than randomization, as it completely cuts off information generation. Interestingly, HFTr does not have to be present in the market in equilibrium to have a negative impact on price efficiency. The mere threat of entry by HFTr is sufficient to discourage ITr from entering or convincing it to randomize.

Proposition 6 reconciles two strands of empirical literature that have reached seemingly opposite conclusions: one that studies HFT on a given market and associates it with a rise in efficiency (reviewed in Section 4) and one that studies HFT across markets or regulations and associates it with a decrease in information acquisition (reviewed in section 5). The conclusion that the negative effect of HFT on information content dominates the positive effect of HFT on information treatment is supported by the literature. Several of the papers that report a decrease in information acquisition when HFT activity is high also report an overall drop in price efficiency (Lee and Watts (2021), Weller (2018)). Gider et al. (2021) find a negative impact of HFT on price efficiency across exchanges.

5.3.2. Randomization and price efficiency

This section studies the desirability of randomization from a price efficiency perspective, by comparing a situation in which ITr can randomize to a hypothetical situation in which randomization is either impossible or too costly. Recall that ITr randomizes if $(\bar{U}^I)_r^{I,\not h} > (\bar{U}^I)_{\not r}^{I,h}$ and $(\bar{U}^I)_r^{I,\not h} > 0$, i.e., if the utility from randomizing to exclude HFTr exceeds the utility from not randomizing and sharing the market with HFTr and the utility from not participating. The randomization equilibrium $(I_r, \not h)$ thus replaces the $(I_{\not r}, h)$ equilibrium if $(\bar{U}^I)_{\not r}^{I,h} > 0$, i.e., if without randomization ITr would have coexisted with HFTr instead of exiting. Conversely, the randomization equilibrium $(I_r, \not h)$ replaces the $(\not I)$ equilibrium if $(\bar{U}^I)_{\not r}^{I,h} < 0$, i.e., if without randomization ITr would have exited the market instead of coexisting with HFTr.

Proposition 7: The region of the parameter set in which ITr randomizes can be split into 2 subregions:

1) one such that $(\bar{U}^I)_{\not r}^{I,h} > 0$, in which price efficiency decreases relative to a situation with no randomization.

2) one such that $(\bar{U}^I)_{\not r}^{I,h} < 0$, in which price efficiency increases significantly relative to a situation with no randomization.

Proof: immediate from Expression (41)

Proposition 7 states that randomization can be a second-best equilibrium from a price efficiency perspective. $(I_r, \not h)$ is never preferable to the $(I_{\not r}, h)$ market in which ITr and HFTr coexist, but it may prevent the emergence of the most undesirable market structure $(\not I)$.

Lemma 8: The threshold value c_h^{**} above which ITr prefers entering and randomizing to not entering is higher than the threshold value c_h^* above which ITr prefers entering and randomizing to entering and not randomizing.

Proof: $c_h^{**} = c_h^*$ when $c_I = c_I^*$, and $\frac{d\, c_h^{**}}{d\, c_I}$ as shown in Appendix F-2

Lemma 8 states that randomization is less efficient in preventing ITr exit than it is in preventing peaceful coexistence between ITr and HFTr. This comes from the fact that ITr considers exiting

only when its utility is low. In this context, ITr has less utility to spend on randomization, ceteris paribus. By contrast, the fact that ITr wants to enter the market with or without HFTr suggests that it benefits a lot from entering, and can afford to pay the utility cost of expelling HFTr. This result implies that HFTr can be particularly undesirable for markets in which the returns to informed trading are low. It also lowers the desirability of randomization from a price efficiency perspective. Nevertheless, the gains from avoiding ITr exit far exceed the costs from avoiding coexistence, implying that even a small likelihood of avoiding this outcome may suffice to make randomization desirable.

Figure 3 informally summarizes the price efficiency impact of HFTr and randomization by region of the phase diagram in the (c_I, c_h) space.

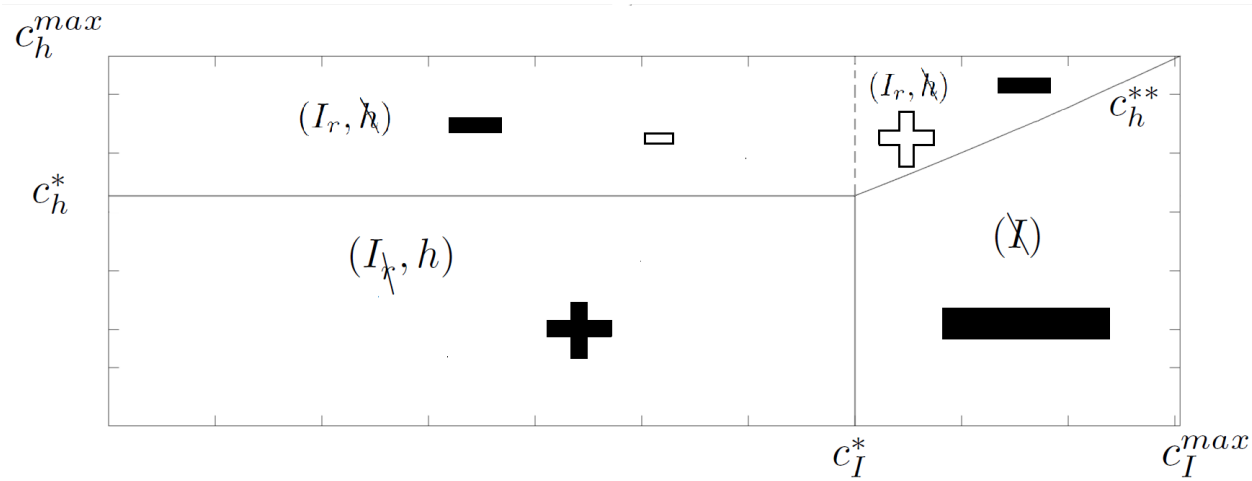

Figure 3: Price efficiency by region of the phase diagram in the (c_I, c_h)space. The black plus and minus signs indicate the level of price efficiency of a given region with respect to the price efficiency of the same region in the model without HFTr. The white plus and minus signs indicate the level of price efficiency of a given region with respect to the price efficiency of the same region in the model without randomization. The size of the plus/minus is an approximate (author-drawn) proxy for the magnitude of the difference with the reference market. c_k^{max} represents the fixed cost for agent k past which k has a dominant strategy in not entering.

6. Conclusion

High-frequency trading is desirable from a price efficiency perspective only if ITr does not react to it. If ITr randomizes its orders, the gains from HFTr are more than offset in equilibrium. If ITr exits the market in response to HFT, information stops flowing in and the market fails. Which option emerges in a given market crucially boils down to the characteristics of the market.

An implication of this paper is that regulation of HFT should be market and time dependent. If high-frequency traders act primarily as market markers, and/or the cost of acquiring information is low, the gains from HFT are likely to outweigh its costs. However, if high-frequency traders have a tendency to backrun and the profits of informed traders are low, the regulator or the exchange may consider implementing anti-HFT rules. This may include penalties on canceled orders, stochastic execution time, or asymmetric speed bumps.

Appendix A

A-1

This Appendix derives the expression for the expected squared the forecast error $\sigma^2_{\Psi,f} = E\left((\Psi^f_t)^2\right)$. Start from Equation (18), which states:

$$\Psi^f_{t+1} = (1-\delta)\Psi^f_t + \varepsilon^f_{t+1} - \frac{\delta}{\lambda}\varepsilon^n_t$$

substituting until $t = 0$ yields :

$$\Psi^f_{t+1} = (1-\delta)^{t+1}\Psi^f_0 + \left[(1-\delta)^t\varepsilon^f_1 + (1-\delta)^{t-1}\varepsilon^f_2 + ... + (1-\delta)\varepsilon^f_t + (1-\delta)^0\varepsilon^f_{t+1}\right] - \frac{\delta}{\lambda}\left[(1-\delta)^t\varepsilon^n_0 + (1-\delta)^{t-1}\varepsilon^n_1 + ... + (1-\delta)\varepsilon^n_{t-1} + (1-\delta)^0\varepsilon^n_t\right]$$

it follows that:

$$\sigma^2_{\Psi,f} = E((\Psi^f_{t+1})^2) = \left[(1-\delta)^{2t}\sigma^2_f + (1-\delta)^{2(t-1)}\sigma^2_f + ... + (1-\delta)^2\sigma^2_f + (1-\delta)^0\sigma^2_f\right] + \left(\frac{\delta}{\lambda}\right)^2\left[(1-\delta)^{2t}\sigma^2_n + (1-\delta)^{2(t-1)}\sigma^2_n + ... + (1-\delta)^2\sigma^2_n + (1-\delta)^0\sigma^2_n\right]$$

where I have used the fact that all shocks are independent. Using the properties of geometric series

$$\sigma^2_{\Psi,f} = \sigma^2_f\frac{1-(1-\delta)^{2(t+1)}}{1-(1-\delta)^2} + \left(\frac{\delta}{\lambda}\right)^2\sigma^2_n\frac{1-(1-\delta)^{2(t+1)}}{1-(1-\delta)^2}$$

. When t is large:

$$\sigma^2_{\Psi,f} = \frac{\sigma^2_f + \left(\frac{\delta}{\lambda}\right)^2\sigma^2_n}{2\delta - \delta^2}$$

A-2

This Appendix derives the value of δ that minimizes the expected squared forecast error $\sigma^2_{\Psi,f}$ for HFTr, given in Equation (19). Define:

$$u = \sigma^2_f + \left(\frac{\delta}{\lambda}\right)^2\sigma^2_n$$
$$u' = \frac{\sigma^2_n}{\lambda^2}2\delta$$
$$v = 2\delta - \delta^2$$
$$v' = 2 - 2\delta$$

$$\frac{d\sigma^2_{\Psi,f}}{d\delta} = \frac{u'v - v'u}{v^2} = 0 \Rightarrow u'v - v'u = 0$$
$$\Rightarrow \left(\frac{\sigma^2_n}{\lambda^2}2\delta\right)\left(2\delta - \delta^2\right) - (2-2\delta)\left(\sigma^2_f + \left(\frac{\delta}{\lambda}\right)^2\sigma^2_n\right) = 0$$
$$\Rightarrow 2(2-2\delta)\left(\frac{\delta}{\lambda}\right)^2\sigma^2_n - (2-2\delta)\sigma^2_f - (2-2\delta)\left(\frac{\delta}{\lambda}\right)^2\sigma^2_n = 0$$
$$\Rightarrow (2-2\delta)\left(\frac{\delta}{\lambda}\right)^2\sigma^2_n - (2-2\delta)\sigma^2_f = 0$$
$$\Rightarrow \frac{\sigma^2_n}{\lambda^2}\delta^2 + \delta\sigma^2_f - \sigma^2_f = 0$$
$$\triangle = (\sigma^2_f)^2 - 4\frac{\sigma^2_n}{\lambda^2}\left(-\sigma^2_f\right)$$
$$\triangle = 4\sigma^2_f\left[\sigma^2_f + 4\frac{\sigma^2_n}{\lambda^2}\right]$$

$\delta_{1,2} = \frac{\lambda^2\left[\pm\sigma_f\sqrt{\left[\sigma_f^2+4\frac{\sigma_n^2}{\lambda^2}\right]}-\sigma_f^2\right]}{2\sigma_n^2}$

. One root is negative and thus is not eligible. Therefore:

$\delta = \frac{\lambda^2\left[\sigma_f\sqrt{\sigma_f^2+4\frac{\sigma_n^2}{\lambda^2}}-\sigma_f^2\right]}{2\sigma_n^2}$

$$\delta = \frac{1}{2\rho}\left[\sqrt{1+4\rho}-1\right]$$

A-3

This Appendix studies the derivative of δ with respect to ρ, starting from the expression of δ given above (Equation (20) in the body of the text).

$\frac{d\delta}{d\rho} = \frac{1}{2}\left[\left(-\frac{1}{\rho^2}\right)\left(\sqrt{1+4\rho}-1\right)+\frac{4}{2\sqrt{1+4\rho}}\frac{1}{\rho}\right]$

$\frac{d\delta}{d\rho} = -\frac{\left(\sqrt{1+4\rho}-1\right)\sqrt{1+4\rho}}{2\rho^2\sqrt{1+4\rho}}+\frac{2\rho}{2\rho^2\sqrt{1+4\rho}}$

$$\frac{d\delta}{d\rho} = \frac{\sqrt{1+4\rho}-(1+2\rho)}{2\rho^2\sqrt{1+4\rho}}$$

$\frac{d\delta}{d\rho} < 0 \Rightarrow \sqrt{1+4\rho} < (1+2\rho) \Rightarrow 1+4\rho < (1+2\rho)^2$

$\Rightarrow 1+4\rho < 1+4\rho+4\rho^2 \Rightarrow 0 < 4\rho^2$

True by definition, therefore $\frac{d\delta}{d\rho} < 0$.

A-4

This Appendix simplifies Equation (19), whose expression is :

$$\sigma_{\Psi,f}^2 = \frac{\sigma_f^2+\left(\frac{\delta}{\lambda}\right)^2\sigma_n^2}{2\delta-\delta^2}$$

where $\delta = \frac{\lambda\left[\sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}-\lambda\sigma_f^2\right]}{2\sigma_n^2}$ as proven in Appendix A-2.

Let NUM designate the numerator of equation (19), and DEN designate its denominator.

First consider the numerator:

$NUM = \sigma_f^2+\left(\frac{\delta}{\lambda}\right)^2\sigma_n^2$

$NUM = \left(\frac{1}{4\sigma_n^2}\right)4\sigma_n^2\sigma_f^2+\frac{\left[\sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}-\lambda\sigma_f^2\right]^2}{4\sigma_n^2\sigma_n^2}\sigma_n^2$

$NUM = \left(\frac{1}{4\sigma_n^2}\right)\left(4\sigma_n^2\sigma_f^2+\sigma_f^2(\lambda^2\sigma_f^2+4\sigma_n^2)+(\lambda\sigma_f^2)^2-2\sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}\lambda\sigma_f^2\right)$

$NUM = \left(\frac{1}{4\sigma_n^2}\right)\left(\sigma_f^2\left(\lambda^2\sigma_f^2+4\sigma_n^2\right)+\sigma_f^2(\lambda^2\sigma_f^2+4\sigma_n^2)-2\sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}\lambda\sigma_f^2\right)$

Define $X = \sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}$

$NUM = \left(\frac{1}{2\sigma_n^2}\right)\left(X^2-\lambda\sigma_f^2X\right)$

Second consider the denominator:

$DEN = 2\delta-\delta^2 = \delta(2-\delta)$

$$= \delta \left(2 - \frac{\lambda\left[\sigma_f \sqrt{\lambda^2\sigma_f^2+4\sigma_n^2} - \lambda\sigma_f^2\right]}{2\sigma_n^2} \right)$$
$$= \delta \left(\frac{4\sigma_n^2+\lambda^2\sigma_f^2-\lambda\sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}}{2\sigma_n^2} \right)$$
$$= \delta \left(\frac{\sigma_f^2\left(\lambda^2\sigma_f^2+4\sigma_n^2\right)-\lambda\sigma_f^2\sigma_f\sqrt{\lambda^2\sigma_f^2+4\sigma_n^2}}{2\sigma_n^2\sigma_f^2} \right)$$
$$= \delta \left(\frac{X^2-\lambda\sigma_f^2 X}{2\sigma_n^2\sigma_f^2} \right)$$

. It follows that:

$$\sigma^2_{\Psi,d} = \frac{NUM}{DEN} = \frac{\left(\frac{1}{2\sigma_n^2}\right)\left(X^2-\lambda\sigma_f^2 X\right)}{\frac{\delta}{\sigma_f^2}\left(\frac{X^2-\lambda\sigma_f^2 X}{2\sigma_n^2}\right)} = \frac{1}{\left(\frac{\delta}{\sigma_f^2}\right)}$$

$$\sigma^2_{\Psi,f} = \frac{\sigma_f^2}{\delta}$$

Appendix B

B-1

This Appendix draws the expression for the expected utility $E(U_t^h)$ of HFTr. Start from Equation (8), which states:

$$U_t^h = Q_t^h(E_{t,1}^h(F_t) - P_{t,1}) - \frac{b}{2}\left(Q_t^h\right)^2$$

. Using Equations $E_{t,1}^h(F_t) = P_{t+1}$ and $P_{t+1} = P_{t,1} + bQ_t^h$, U_t^h can be reexpressed as:

$$U_t^h = \left(Q_t^h\right)(bQ_t^h) - \frac{b}{2}\left(Q_t^h\right)^2$$

$$E(U_t^h) = \left(\frac{b}{2}\right) E\left((Q_t^h)^2\right)$$

. Plugging Equation (23) and using the fact that $E_t(F_t) = P_t$ leads to:

$$E(U_t^h) = \left(\frac{b}{2}\right)\left(\frac{1}{b\lambda}(\delta - b\lambda)\right)^2 E\left(\lambda(F_t - E_t(F_t)) + \varepsilon_t^n\right)^2$$

$(F_t - E_t(F_t))$ and ε_t^n are independent, since $P_t = P_{t,0}$ is the price before the noise shocks materialize. Therefore:

$$E(U_t^h) = \left(\frac{1}{2b}\right)(\delta - b\lambda)^2\left(\sigma^2_{\Psi,f} + \frac{\sigma_t^n}{\lambda^2}\right) \tag{42}$$

. Appendix A showed that:

$$\sigma^2_{\Psi,f} = \frac{\sigma_f^2}{\delta} = \frac{\sigma_f^2 + \left(\frac{\delta}{\lambda}\right)^2\sigma_n^2}{2\delta - \delta^2} \tag{43}$$

which implies that:

$$\sigma_f^2 (1-\delta) = \left(\frac{\delta}{\lambda}\right)^2 \sigma_n^2 \tag{44}$$

. Plugging Equations (44) and (43) into (42) yields:

$$E(U_t^h) = \left(\frac{1}{2b}\right)(\delta - b\lambda)^2 \left(\frac{\sigma_f^2}{\delta} + \frac{\sigma_f^2 (1-\delta)}{\delta^2}\right)$$

$$\Rightarrow E(U_t^h) = \left(\frac{\sigma_f^2}{\delta^2}\right)\left(\frac{1}{2b}\right)(b\lambda - \delta)^2$$

B-2

This Equation studies the derivative of $E(U_t^h)$, expressed above and in Equation (25) in the body of the text, with respect to b. Define:

$u = (b\lambda - \delta)^2 = b^2\lambda^2 - 2b\lambda\delta + \delta^2$
$u' = 2b\lambda^2 - 2\lambda\delta$
$v = b$
$v' = 1$

$\frac{dE(U_t^h)}{db} = \frac{1}{2}\left(\frac{\sigma_f^2}{\delta^2}\right)\left[\frac{u'v - v'u}{v^2}\right]$
$\frac{dE(U_t^h)}{db} = \frac{1}{2}\left(\frac{\sigma_f^2}{\delta^2}\right)\left[\frac{\left(2b\lambda^2 - 2\lambda\delta\right)b - (b\lambda-\delta)^2}{b^2}\right]$
$\frac{dE(U_t^h)}{db} = \frac{1}{2}\left(\frac{\sigma_f^2}{\delta^2}\right)\left[\frac{2b\lambda(b\lambda-\delta) - (b\lambda-\delta)^2}{b^2}\right]$
$\frac{dE(U_t^h)}{db} = \frac{1}{2}\left(\frac{\sigma_f^2}{\delta^2}\right)\left[\frac{(b\lambda-\delta)(2b\lambda - (b\lambda-\delta))}{b^2}\right]$
$\frac{dE(U_t^h)}{db} = \frac{1}{2}\left(\frac{\sigma_f^2}{\delta^2}\right)\left[\frac{(b\lambda-\delta)(b\lambda+\delta)}{b^2}\right]$

$$\frac{dE(U_t^h)}{db} = \frac{1}{2}\left(\frac{\sigma_f^2}{\delta^2}\right)\left(\frac{(b\lambda)^2 - \delta^2}{b^2}\right)$$

$\frac{dE(U_t^h)}{db} < 0$ if $b\lambda < \delta$, and $\frac{dE(U_t^h)}{db} > 0$ if $b\lambda > \delta$.
Thus $E(U_t^h)$ decreases with b if $b\lambda < \delta$, and increases with b if $b\lambda > \delta$

Appendix C

This Appendix draws the price impulse response functions in the $(I, \not{h})$ and (I, h) markets. C-1 considers a fundamental shock. C-2 considers a noise trading shock.

C-1

Using Equations (26) and (1), $F_t - P_t^{I,h}$ can be reexpressed as:

$$F_t - P_t^{I,h} = F_{t-1} + \varepsilon_t^f - \left(P_{t-1}^{I,h} + \delta\left(F_{t-1} - P_{t-1}^{I,h}\right) + \tfrac{\delta}{\lambda}\varepsilon_{t-1}^n\right)$$
$$F_t - P_t^{I,h} = (1-\delta)\left(F_{t-1} - P_{t-1}^{I,h}\right) - \tfrac{\delta}{\lambda}\varepsilon_{t-1}^n + \varepsilon_t^f$$

Consider that a single fundamental shock $\varepsilon_{f,0}$ occurs at time $t = 0$, starting from a situation in which the price is equal to the fundamental value. This implies that:

$$F_t - P_t^{I,h} = (1-\delta)\left(F_{t-1} - P_{t-1}^{I,h}\right)$$
$$F_t - P_t^{I,h} = (1-\delta)^t\left(F_0 - P_0^{I,h}\right)$$
$$F_t - P_t^{I,h} = (1-\delta)^t\varepsilon_0^f$$
$$\left(F_t - P_t^{I,h}\right)^2 = (1-\delta)^{2t}\left(\varepsilon_0^f\right)^2$$

Using the properties of geometric series, the sum $TD_f^{I,h}$ of all the squared mispricings that occur in the (I,h) market following a fundamental shock is :

$TD_f^{I,h} = \sum_{t=0}^{t=\infty}\left(F_t - P_t^{I,h}\right)^2 = (1-\delta)^2\left(\frac{1-(1-\delta)^\infty}{1-(1-\delta)^2}\right)\left(\varepsilon_0^f\right)^2$

$$TD_f^{I,h} = \left(\varepsilon_0^f\right)^2\frac{(1-\delta)^2}{1-(1-\delta)^2} \tag{45}$$

The same expression for the (I,h) market is easily obtained by noting that Equation (26) boils down to Equation (27) when $\delta = b\lambda$. Therefore:

$$TD_f^{I,h} = \left(\varepsilon_0^f\right)^2\frac{(1-b\lambda)^2}{1-(1-b\lambda)^2} \tag{46}$$

. Define a function $f(x) = \frac{(1-x)^2}{1-(1-x)^2} = \frac{1}{\frac{1}{(1-x)^2}-1}$. Its derivative is:

$$\frac{df(x)}{dx} = \frac{df(x)}{d\frac{1}{(1-x)^2}-1}\frac{d\frac{1}{(1-x)^2}}{d(1-x)^2}\frac{d(1-2x+x^2)}{dx} = \left[-\left(\frac{1}{\frac{1}{(1-x)^2}-1}\right)^2\right]\left[-\left(\frac{1}{(1-x)^2}\right)^2\right][-2+2x] < 0$$

It follows that $TD_f^{I,h} < TD_f^{I,h}$ if $\delta > b\lambda \Leftrightarrow \rho^* > \rho$, and $TD_f^{I,h} > TD_f^{I,h}$ if $\delta < b\lambda \Leftrightarrow \rho^* < \rho$

C-2

Using the price recurrence Equation (26) and Equation (1), $F_t - P_t^{I,h}$ can be reexpressed as:

$$F_t - P_t^{I,h} = F_{t-1} + \varepsilon_t^f - \left(P_{t-1}^{I,h} + \delta\left(F_{t-1} - P_{t-1}^{I,h}\right) + \tfrac{\delta}{\lambda}\varepsilon_{t-1}^n\right)$$
$$F_t - P_t^{I,h} = (1-\delta)\left(F_{t-1} - P_{t-1}^{I,h}\right) - \tfrac{\delta}{\lambda}\varepsilon_{t-1}^n + \varepsilon_t^f$$

Consider that a single noise trading shock $\varepsilon_{n,0}$ occurs at time $t = 0$, starting from a situation in which the price was equal to the fundamental value. This implies that:

$F_t - P_t^{I,h} = (1-\delta)^{t-1}\left(F_1 - P_1^{I,h}\right) = (1-\delta)^{t-1}\left(-\frac{\delta}{\lambda}\varepsilon_0^n\right)$

$\left(F_t - P_t^{I,h}\right)^2 = (1-\delta)^{2(t-1)}\left(\frac{\delta}{\lambda}\right)^2(\varepsilon_0^n)^2$

Using the properties of geometric series, the sum $TD_n^{I,h}$ of all the squared mispricings that occur in the (I,h) market following a noise trading shock is :

$TD_f^{I,h} = \sum_{t=0}^{t=\infty}\left(F_t - P_t^{I,h}\right)^2 = \left(\frac{\delta}{\lambda}\right)^2\left(\frac{1-(1-\delta)^{2\infty}}{1-(1-\delta)^2}\right)(\varepsilon_0^n)^2$

$$TD_n^{I,h} = \left(\frac{\varepsilon_0^n}{\lambda}\right)^2 \frac{\delta^2}{1-(1-\delta)^2} \tag{47}$$

The same expression for the $(I,\not h)$ market is easily obtained by noting that Equation (26) boils down to Equation (27) when $\delta = b\lambda$. Therefore:

$$TD_n^{I,\not h} = \left(\frac{\varepsilon_{n,0}}{\lambda}\right)^2 \frac{(b\lambda)^2}{1-(1-b\lambda)^2} \tag{48}$$

. Define a function $f(x) = \frac{x^2}{1-(1-x)^2} = \frac{x^2}{1-(1-2x+x^2)} = \frac{x^2}{2x-x^2} = \frac{1}{\frac{2}{x}-1}$. It is immediate that its derivative is positive. It follows that $TD_n^{I,h} > TD_n^{I,\not h}$ if $\delta > b\lambda \Leftrightarrow \rho^* > \rho$, and $TD_n^{I,h} < TD_n^{I,\not h}$ if $\delta < b\lambda \Leftrightarrow \rho^* < \rho$

Appendix D

Appendix D-1 draws the mispricing level in the $(I,\not h)$ market. Appendix D-2 compares it to the mispricing level in the (I,h) market. Appendix D-3 compares the utility $\left(\bar{U^I}\right)^{I,h}$ of ITr with HFTr to the utility $\left(\bar{U^I}\right)^{I,\not h}$ of ITr without HFTr, and studies the behavior of the difference in ITr utility $\triangle\bar{U^I} = \left(\bar{U^I}\right)^{I,h} - \left(\bar{U^I}\right)^{I,\not h}$.

D-1

As showed in Appendix A-1

$\sigma^2_{\Psi,f} = E(F_{t+1} - P_{t+1})^2 = \frac{\sigma_f^2 + \left(\frac{\delta}{\lambda}\right)^2\sigma_n^2}{2\delta - \delta^2}$

As noted in Appendix 3, the price dynamics in the $(I,\not h)$ market given in Equation (27) corresponds to the price dynamics of the (I,h) market given in Equation (26) when $\delta = b\lambda$. Therefore:

$$M^{I,\not h} = \frac{\sigma_f^2 + \left(\frac{b\lambda}{\lambda}\right)^2\sigma_n^2}{2b\lambda - (b\lambda)^2}$$

D-2

Using Equation (28) and (29):

$M^{I,\not h} - M^{I,h} = \frac{\sigma_f^2 + \left(\frac{b\lambda}{\lambda}\right)^2\sigma_n^2}{2b\lambda - (b\lambda)^2} - \frac{2\sigma_f^2\rho}{\sqrt{1+4\rho}-1}$

. Using $\rho = \frac{\lambda^2\sigma_s^2+\sigma_r^2+\sigma_l^2}{\lambda^2\sigma_f^2} = \frac{\sigma_n^2}{\lambda^2\sigma_f^2}$:

$= \frac{1}{2b\lambda-(b\lambda)^2}\left[\sigma_f^2 + b^2\sigma_n^2 - \frac{2}{\left(\sqrt{1+4\rho}-1\right)}\frac{\sigma_n^2}{\lambda^2}(2b\lambda-\lambda^2)\right]$

$= \frac{1}{2b\lambda-(b\lambda)^2+1-1}\left[\left(\frac{\sigma_n^2}{\lambda^2}\right)\frac{4}{1+4\frac{\sigma_n^2}{\lambda^2\sigma_f^2}-1} + b^2\sigma_n^2 - \frac{\sigma_n^2}{\lambda^2}\frac{4b\lambda}{\sqrt{1+4\rho}-1} + \frac{\sigma_n^2}{\lambda^2}\frac{2b^2\lambda^2}{\sqrt{1+4\rho}-1}\right]$

$= \frac{1}{1-(1+b^2\lambda^2-2b\lambda)}\left[b^2\sigma_n^2 + \frac{\sigma_n^2}{\lambda^2}\frac{4}{\left(\sqrt{1+4\rho}-1\right)\left(\sqrt{1+4\rho}+1\right)} - \frac{\sigma_n^2}{\lambda^2}\frac{4b\lambda}{\sqrt{1+4\rho}-1} + \sigma_n^2\frac{2b^2}{\sqrt{1+4\rho}-1}\right]$

$= \frac{1}{1-(1-b\lambda)^2}\left[b^2\sigma_n^2 + \frac{\sigma_n^2}{\lambda^2}\left(\frac{\sqrt{1+4\rho}+1}{\sqrt{1+4\rho}-1}\right)\left(\frac{4}{\left(\sqrt{1+4\rho}+1\right)^2} - \frac{4b\lambda}{\sqrt{1+4\rho}+1}\right) + \frac{2\sigma_n^2b^2}{\sqrt{1+4\rho}-1}\right]$

$= \frac{1}{1-(1-b\lambda)^2}\left[\frac{\sigma_n^2}{\lambda^2}\left(\frac{\sqrt{1+4\rho}+1}{\sqrt{1+4\rho}-1}\right)\left(\frac{4}{\left(\sqrt{1+4\rho}+1\right)^2} - \frac{4b\lambda}{\sqrt{1+4\rho}+1}\right) + b^2\sigma_n^2\left(\frac{2}{\sqrt{1+4\rho}-1}+1\right)\right]$

$= \frac{1}{1-(1-b\lambda)^2}\left[\frac{\sigma_n^2}{\lambda^2}\left(\frac{\sqrt{1+4\rho}+1}{\sqrt{1+4\rho}-1}\right)\left(\frac{4}{\left(\sqrt{1+4\rho}+1\right)^2} - \frac{4b\lambda}{\sqrt{1+4\rho}+1}\right) + b^2\sigma_n^2\left(\frac{2+\sqrt{1+4\rho}-1}{\sqrt{1+4\rho}-1}\right)\right]$

$= \frac{1}{1-(1-b\lambda)^2}\left(\frac{\sigma_n^2}{\lambda^2}\right)\left(\frac{\sqrt{1+4\rho}+1}{\sqrt{1+4\rho}-1}\right)\left[\frac{4}{\left(\sqrt{1+4\rho}+1\right)^2} - \frac{4b\lambda}{\sqrt{1+4\rho}+1} + b^2\lambda^2\right]$

$= \frac{1}{1-(1-b\lambda)^2}\sigma_f^2\rho\left(\frac{\sqrt{1+4\rho}+1}{\sqrt{1+4\rho}-1}\right)\left(b\lambda - \frac{2}{\sqrt{1+4\rho}+1}\right)^2$

. Now note using Equation (20) that:

$\delta = \frac{1}{2\rho}\left(\sqrt{1+4\rho}-1\right) = \frac{\left(\sqrt{1+4\rho}-1\right)\left(\sqrt{1+4\rho}+1\right)}{2\rho\left(\sqrt{1+4\rho}+1\right)} = \frac{1+4\rho-1}{2\rho\left(\sqrt{1+4\rho}+1\right)} = \frac{2}{\sqrt{1+4\rho}+1}$

which notably implies that:

$\frac{1}{\delta^2} = \left(\frac{\sqrt{1+4\rho}+1}{2}\right)\frac{2\rho}{\sqrt{1+4\rho}-1} = \rho\left(\frac{\sqrt{1+4\rho}+1}{\sqrt{1+4\rho}-1}\right)$

. It follows that:

$$M^{I,h} - M^{I,h} = \left(\frac{1}{1-(1-b\lambda)^2}\right)\left(\frac{\sigma_f^2}{\delta^2}\right)(b\lambda-\delta)^2$$

D-3

Consider the pricing rule $b = \frac{\delta}{\lambda} - \omega \Rightarrow \lambda(b+\omega) = \delta$. Let $\triangle\bar{U}^I{}_{-\omega} = \left(\bar{U}^I\right)^{I,h} - \left(\bar{U}^I\right)^{I,h}$ be the utility loss imposed by HFTr on ITr when MM uses this rule. Using Equation (34):

$\triangle\bar{U}^I{}_{-\omega} = -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\sigma_f^2\left(\frac{b\lambda}{\delta}-1\right)^2 = -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\sigma_f^2\left(\frac{b}{b+\omega}-1\right)^2$

Similarly, when $b = \frac{\delta}{\lambda} + \omega \Rightarrow \lambda(b-\omega) = \delta$, the utility loss imposed by HFTr on ITr is :

$\triangle\bar{U}^I{}_{+\omega} = -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\sigma_f^2\left(\frac{b\lambda}{\delta}-1\right)^2 = -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\sigma_f^2\left(\frac{b}{b-\omega}-1\right)^2$

Let us pose:

$\triangle\bar{U}^I{}_{-\omega} > \triangle\bar{U}^I{}_{+\omega} \Rightarrow -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\sigma_f^2\left(\frac{b}{b+\omega}-1\right)^2 > -\frac{\lambda}{2}\left(\frac{1}{1-(1-b\lambda)^2}\right)\sigma_f^2\left(\frac{b}{b-\omega}-1\right)^2$

This inequality can be reexpressed as:

$\Rightarrow \left(\frac{b}{b+\omega}-1\right)^2 < \left(\frac{b}{b-\omega}-1\right)^2$

$\Rightarrow 1 - \frac{b}{b+\omega} < \frac{b}{b-\omega} - 1$

$\Rightarrow 2 < \frac{b(b-\omega)}{(b-\omega)(b+\omega)} + \frac{b(b+\omega)}{(b-\omega)(b+\omega)}$

$\Rightarrow 2 < \frac{b(b-\omega)+b(b+\omega)}{(b-\omega)(b+\omega)}$
$\Rightarrow 2 < \frac{2b^2}{(b-\omega)(b+\omega)}$
$\Rightarrow (b-\omega)(b+\omega) < b^2$
$\Rightarrow b^2 - \omega b + \omega b - \omega^2 < b^2$
$\Rightarrow -\omega^2 < 0$

True by definition. For a given level of pricing efficiency, the HFTr impact on ITr utility is higher when $b < \frac{\delta}{\lambda}$, i.e., when HFTr backruns.

Appendix E

This Appendix obtains the critical points c_h^* , c_h^{**} and c_I^* at which the equilibrium market structure changes. It focuses on c_h^* and c_h^{**}, since c_I^* is obtained immediately as follows:

$$(\bar{U}^I)_{\nwarrow}^{I,h} = \frac{\lambda}{2} M_{\nwarrow}^{I,h} - \frac{\lambda}{2}\sigma_s^2 - c^I = 0 \Rightarrow c_I^* = \frac{\lambda}{2} M_{\nwarrow}^{I,h} - \frac{\lambda}{2}\sigma_s^2$$

E-1

First consider c_h^*, the threshold value for c_h past which ITr randomizes instead of staying and not randomizing, obtained by setting $(\bar{U}^I)_r^{I,\nwarrow} - (\bar{U}^I)_{\nwarrow}^{I,h} = 0$. Applying the general expression for ITr utility given in Equation (33) to both market structures yields:

$$(\bar{U}^I)_r^{I,\nwarrow} - (\bar{U}^I)_{\nwarrow}^{I,h} = \frac{\lambda}{2}\left(M_r^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) - \frac{1}{2\lambda}\bar{\sigma_r^2} = 0 \Rightarrow \frac{\lambda}{2}\left(M_r^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \frac{1}{2\lambda}\sigma_r^2$$

. Using the expression for expected mispricing in the absence of HFTr given in Equation (29) leads to:
$M_r^{I,\nwarrow} = \frac{\sigma_f^2 + b^2\left(\lambda^2\sigma_s^2 + \sigma_r^2 + \sigma_l^2\right)}{2b\lambda - (b\lambda)^2} = \frac{\sigma_f^2 + b^2\left(\lambda^2\sigma_s^2 + \sigma_l^2\right)}{2b\lambda - (b\lambda)^2} + \frac{b^2\sigma_r^2}{2b\lambda - (b\lambda)^2} = M_{\nwarrow}^{I,\nwarrow} + \frac{b^2}{2b\lambda - (b\lambda)^2}\sigma_r^2$
. It follows that :

$\frac{\lambda}{2}\left(M_r^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \frac{\lambda}{2}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) + \frac{\lambda}{2}\frac{b^2}{2b\lambda-(b\lambda)^2}\sigma_r^2 = \frac{1}{2\lambda}\sigma_r^2$
$\Rightarrow \frac{\lambda}{2}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \left(\frac{2b\lambda-(b\lambda)^2}{2\lambda(2b\lambda-(b\lambda)^2)} - \frac{\lambda}{2}\frac{2\lambda b^2}{2\lambda(2b\lambda-(b\lambda)^2)}\right)\sigma_r^2$
$\Rightarrow \frac{\lambda}{2}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \left(\frac{2b\lambda-(b\lambda)^2-\lambda^2b^2}{2\lambda(2b\lambda-(b\lambda)^2)}\right)\sigma_r^2$
$\Rightarrow \frac{\lambda}{2}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \left(\frac{2-2b\lambda}{2\lambda(2-b\lambda)}\right)\sigma_r^2$

$\Rightarrow \frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \sigma_r^2$
. Replacing σ_r^2 with its equilibrium value $\bar{\sigma_r^2}$ given in Equation (36) yields:

$\Rightarrow \frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) = \left(\frac{1-\bar{\delta}}{\bar{\delta}^2}\right)\lambda^2\sigma_f^2 - \lambda^2\sigma_s^2 - \sigma_l^2$

$\Rightarrow \frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_{\nwarrow}^{I,\nwarrow} - M_{\nwarrow}^{I,h}\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}\bar{\delta}^2 - 1 + \bar{\delta} = 0$

The solutions of the second degree polynomial are:

$$\bar{\delta}_{1,2} = \frac{-1 \pm \sqrt{1+4\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}}}{2\left(\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}\right)}$$

One is negative. The other is positive and corresponds to the threshold for $\bar{\delta}$ past which the expression becomes positive, i.e., the investor randomizes. The equilibrium value for $\bar{\delta}$ is thus:

$$\bar{\delta}^* = \frac{\sqrt{1+4\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}}-1}{2\left(\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}\right)}$$

Using the expression for $\bar{\delta}$ given in Equation (37) leads to:

$$\frac{b\lambda}{\left(1-\sqrt{\frac{2bc_h^*}{\sigma_f^2}}\right)} = \frac{\sqrt{1+4\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}}-1}{2\left(\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}\right)}$$

which yields the final result:

$$c_h^* = \frac{\sigma_f^2}{2b}\left(1 - b\lambda\frac{2\left(\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}\right)}{\sqrt{1+4\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h}-M_r^{I,h}\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}}-1}\right)^2$$

which using the expression for $\bar{\delta}^*$ above can also be expressed as $c_h^* = \frac{\sigma_f^2}{2b}\left(1-\frac{b\lambda}{\bar{\delta}^*}\right)^2$.

E-2

Consider now c_h^{**}, the threshold value for c_h past which ITr randomizes instead of exiting, obtained by setting $(\bar{U}^I)_r^{I,h} = 0$. Applying the general expression for ITr utility given in Equation (33) to the market (I_r, h) gives:

$$(\bar{U}^I)_r^{I,h} = \frac{\lambda}{2}M_r^{I,h} - \frac{1}{2\lambda}\left(\bar{\sigma_r^2} + \lambda^2\sigma_s^2\right) - c_I = 0 \Rightarrow \frac{\lambda}{2}M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I = \frac{1}{2\lambda}\sigma_r^2$$

Using the expression for expected mispricing in the absence of HFTr given in (29) leads to :

$$M_r^{I,h} = \frac{\sigma_f^2+b^2\left(\lambda^2\sigma_s^2+\sigma_r^2+\sigma_l^2\right)}{2b\lambda-(b\lambda)^2} = \frac{\sigma_f^2+b^2\left(\lambda^2\sigma_s^2+\sigma_l^2\right)}{2b\lambda-(b\lambda)^2} + \frac{b^2\sigma_r^2}{2b\lambda-(b\lambda)^2} = M_r^{I,h} + \frac{b^2}{2b\lambda-(b\lambda)^2}\sigma_r^2$$

It follows that :

$$\Rightarrow \frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I = \frac{\lambda}{2} M_r^{I,h} + \frac{\lambda}{2}\frac{b^2}{2b\lambda-(b\lambda)^2}\sigma_r^2 - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I = \frac{1}{2\lambda}\sigma_r^2$$

$$\Rightarrow \left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) = \sigma_r^2$$

Replacing σ_r^2 with its equilibrium value $\bar{\sigma}_r^2$ given in Equation (36) yields:

$$\Rightarrow \left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) = \left(\frac{1-\bar{\delta}}{\bar{\delta}^2}\right)\lambda^2\sigma_f^2 - \lambda^2\sigma_s^2 - \sigma_l^2$$

$$\Rightarrow \left(\frac{\frac{\lambda^2(2-b\lambda)}{2(1-b\lambda)}\left(M_r^{I,h} - M_r^{I,h}\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}\right)\bar{\delta}^2 - 1 + \bar{\delta} = 0$$

The solutions of the second degree polynomial are:

$$\bar{\delta}_{1,2} = \frac{-1 \pm \sqrt{1 + 4\frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}}}{\frac{2\left(\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2\right)}{\lambda^2\sigma_f^2}}$$

One is negative. The other is positive and corresponds to the threshold for $\bar{\delta}$ past which the expression becomes positive, i.e., the investor randomizes. The equilibrium value for $\bar{\delta}$ is thus:

$$\bar{\delta}^{**} = \frac{\sqrt{1 + 4\frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}} - 1}{\frac{2\left(\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2\right)}{\lambda^2\sigma_f^2}}$$

Using the expression for $\bar{\delta}$ given in Equation (37) leads to:

$$\sqrt{\frac{2bc_h^{**}}{\sigma_f^2}} = 1 - b\lambda \frac{\frac{2\left(\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2\right)}{\lambda^2\sigma_f^2}}{\sqrt{1 + 4\frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}} - 1}$$

which yields the final result:

$$c_h^{**} = \frac{\sigma_f^2}{2b}\left(1 - b\lambda \frac{\frac{2\left(\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2\right)}{\lambda^2\sigma_f^2}}{\sqrt{1 + 4\frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2} M_r^{I,h} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2}} - 1}\right)^2$$

Appendix F

This Appendix studies the derivative of c_I^* with respect to σ_f^2 and σ_l^2, and the derivative of c_h^{**} with respect to σ_l^2 and c_I.

F-1

Plugging Equation (28) into $c_I^* = \frac{\lambda}{2} M_{\nwarrow}^{I,h} - \frac{\lambda}{2}\sigma_s^2$ leads to:

$$c_I^* = \frac{\lambda}{2}\frac{\sigma_f^2}{\delta_{\nwarrow}} - \frac{\lambda}{2}\sigma_s^2$$

The derivative of $\delta_{\nwarrow}$ with respect to $x = \{\sigma_f^2, \sigma_l^2\}$ is $\frac{d\,\delta_{\nwarrow}}{d\,x} = \left(\frac{d\,\delta_{\nwarrow}}{d\,\rho_{\nwarrow}}\right)\left(\frac{d\,\rho_{\nwarrow}}{d\,x}\right)$. Using Appendix A-3 and the expression for $\rho_{\nwarrow} = \frac{\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}$ leads to:

$$\frac{d\,\delta_{\nwarrow}}{d\,x} = \underbrace{\left(\frac{\sqrt{1+4\,\rho_{\nwarrow}} - \left(1+2\,\rho_{\nwarrow}\right)}{2\,\rho_{\nwarrow}^2\sqrt{1+4\,\rho_{\nwarrow}}}\right)}_{<0}\left(\frac{d\,\frac{\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2}}{d\,x}\right)$$

It follows immediately that:

$$\frac{d\,c_I^*}{d\,\sigma_l^2} = \frac{\lambda\sigma_f^2}{2}\left(\frac{d\,1/\delta_{\nwarrow}}{d\,\delta_{\nwarrow}}\right)\left(\frac{d\,\delta_{\nwarrow}}{d\,\sigma_l^2}\right) = \frac{\lambda\sigma_f^2}{2}\underbrace{\left(\frac{d\,1/\delta_{\nwarrow}}{d\,\sigma_l^2}\right)}_{<0}\underbrace{\left(\frac{\sqrt{1+4\,\rho_{\nwarrow}} - \left(1+2\,\rho_{\nwarrow}\right)}{2\,\rho_{\nwarrow}^2\sqrt{1+4\,\rho_{\nwarrow}}}\right)}_{<0}\underbrace{\left(\frac{1}{\lambda^2\sigma_f^2}\right)}_{>0}$$

$$\Rightarrow \frac{d\,c_I^*}{d\,\sigma_l^2} > 0$$

Consider now $\frac{d\,c_I^*}{d\,\sigma_f^2}$, whose expression can be decomposed as:

$$\frac{d\,c_I^*}{d\,\sigma_f^2} = \frac{\lambda}{2}\left(\frac{\delta_{\nwarrow} - \left(\frac{d\,\delta_{\nwarrow}}{d\,\sigma_f^2}\right)\sigma_f^2}{\delta_{\nwarrow}^2}\right) = \frac{\lambda}{2}\left(\frac{\delta_{\nwarrow} - \left(\frac{\sqrt{1+4\,\rho_{\nwarrow}} - \left(1+2\,\rho_{\nwarrow}\right)}{2\,\rho_{\nwarrow}^2\sqrt{1+4\,\rho_{\nwarrow}}}\right)\left(-\frac{\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\left(\sigma_f^2\right)^2}\right)\sigma_f^2}{\delta_{\nwarrow}^2}\right)$$

$$\frac{d\,c_I^*}{d\,\sigma_f^2} > 0 \Rightarrow \delta_{\nwarrow} + \left(\frac{\sqrt{1+4\,\rho_{\nwarrow}} - \left(1+2\,\rho_{\nwarrow}\right)}{2\,\rho_{\nwarrow}^2\sqrt{1+4\,\rho_{\nwarrow}}}\right)\rho_{\nwarrow} > 0$$

Using the expression for $\delta_{\nwarrow}$ given in Equation (20) :

$$\Rightarrow \frac{1}{2\rho_{\nwarrow}}\left(\sqrt{1+4\rho_{\nwarrow}} - 1\right) > \left(\frac{\left(1+2\,\rho_{\nwarrow}\right) - \sqrt{1+4\,\rho_{\nwarrow}}}{2\,\rho_{\nwarrow}\sqrt{1+4\,\rho_{\nwarrow}}}\right)$$
$$\Rightarrow \left(\sqrt{1+4\rho_{\nwarrow}} - 1\right)\sqrt{1+4\,\rho_{\nwarrow}} > \left(1+2\,\rho_{\nwarrow}\right) - \sqrt{1+4\,\rho_{\nwarrow}}$$
$$\Rightarrow 1+4\rho_{\nwarrow} - \sqrt{1+4\,\rho_{\nwarrow}} > \left(1+2\,\rho_{\nwarrow}\right) - \sqrt{1+4\,\rho_{\nwarrow}}$$
$$\Rightarrow 4\rho_{\nwarrow} > 2\,\rho_{\nwarrow} \Rightarrow 2 > 1$$

$$\frac{d\,c_I^*}{d\,\sigma_f^2} > 0$$

F-2

Start from the expression :

$$c_h^{**} = \frac{\sigma_f^2}{2b}\left(1 - \frac{b\lambda}{\bar{\delta}^{**}}\right)^2 \tag{49}$$

given in Appendix E-2. The first step is to define :

$$f = \frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2}M_{\lambda}^{I,\lambda} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right) + \lambda^2\sigma_s^2 + \sigma_l^2}{\lambda^2\sigma_f^2} \tag{50}$$

which allows to rewrite $\bar{\delta}^{**}$ given in Appendix E-2 as:

$$\bar{\delta}^{**} = \frac{\sqrt{1+4f}-1}{2f}$$

The derivative with respect to the liquidity variance σ_l^2 can be decomposed as:

$$\frac{d\,c_h^{**}}{d\,\sigma_l^2} = \frac{\sigma_f^2}{2b}\underbrace{\left(\frac{d\left(1-\frac{b\lambda}{\bar{\delta}^{**}}\right)^2}{d\,1-\frac{b\lambda}{\bar{\delta}^{**}}}\right)}_{>0}\underbrace{\left(\frac{d\,1-\frac{b\lambda}{\bar{\delta}^{**}}}{d\,\bar{\delta}^{**}}\right)}_{>0}\underbrace{\left(\frac{d\,\bar{\delta}^{**}}{d\,f}\right)}_{<0}\left(\frac{d\,f}{d\,\sigma_l^2}\right)$$

See Appendix A-3 for the proof that $\frac{d\,\bar{\delta}^{*}}{d\,f} < 0$. To find $\frac{d\,f}{d\,\sigma_l^2}$, first note using that Equation (29) f can be reexpressed as :

$$f = \frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\left(\frac{\lambda}{2}\frac{\sigma_f^2+b^2\sigma_n^2}{2b\lambda-(b\lambda)^2} - \frac{1}{2\lambda}\lambda^2\sigma_s^2 - c_I\right)+\lambda^2\sigma_s^2+\sigma_l^2}{\lambda^2\sigma_f^2} = \frac{\left(\frac{\lambda(2-b\lambda)}{1-b\lambda}\right)\frac{\lambda}{2}\frac{b^2\sigma_n^2}{b\lambda(2-b\lambda)}}{\lambda^2\sigma_f^2} + \frac{\sigma_l^2}{\lambda^2\sigma_f^2} + cst$$

where cst is a constant with respect to σ_l^2. Further simplification leads to:

$$f = \frac{b\left(\lambda^2\sigma_s^2+\sigma_r^2+\sigma_l^2\right)}{2\lambda(1-b\lambda)\sigma_f^2} + \frac{\sigma_l^2}{\lambda^2\sigma_f^2} + cst = \frac{b\sigma_l^2}{2\lambda(1-b\lambda)\sigma_f^2} + \frac{\sigma_l^2}{\lambda^2\sigma_f^2} + cst$$

It follows that $\frac{d\,f}{d\,\sigma_l^2} > 0$ which means that :

$$\frac{d\,c_h^{**}}{d\,\sigma_l^2} < 0$$

By the same token the derivative with respect to the ITr's fixed cost c_I can be decomposed as:

$$\frac{d\,c_h^{**}}{d\,c_I} = \frac{\sigma_f^2}{2b}\underbrace{\left(\frac{d\left(1-\frac{b\lambda}{\bar{\delta}^{**}}\right)^2}{d\,1-\frac{b\lambda}{\bar{\delta}^{**}}}\right)}_{>0}\underbrace{\left(\frac{d\,1-\frac{b\lambda}{\bar{\delta}^{**}}}{d\,\bar{\delta}^{**}}\right)}_{>0}\underbrace{\left(\frac{d\,\bar{\delta}^{**}}{d\,f}\right)}_{<0}\left(\frac{d\,f}{d\,c_I}\right)$$

$\frac{d\,f}{d\,c_I} < 0$ is immediate from Equation (50), implying that :

$$\frac{d\,c_h^{**}}{d\,c_I} > 0$$

Appendix G

This Appendix shows that, in any market structure $(\mathcal{I}) = ((\mathcal{I}, h), (\mathcal{I}, \mathcal{h}))$ without ITr, mispricing tends to infinity as t rises.

G-1

Start with the $(\mathcal{I}, h)$ market. The first step to obtaining mispricings is to solve for the equilibrium price dynamics. In a trading cycle without ITr, HFTr's best bet about the fundamental value is the price at the start of the cycle $E^h_{t,1}(F_t) = P_0$, which may contain some trace of ITr trading in previous cycles.

The optimal demand of HFTr in the first period is thus:

$$Q^h_0 = \frac{P_0 - (P_0 + b\varepsilon^l_0)}{b} = -\varepsilon^l_0$$

The best strategy for HFTr is to fully counter any demand shock since it necessarily comes from liquidity traders. This implies that the total demand received by MM is null, which means that $P_1 = P_0$.

The same logic applies for the following period. In general, neither the HFTr estimate of the fundamental value $E^h_t(F_t) = P_0$ nor the price at the start of each period $P_t = P_0$ changes. The optimal rule for HFTr is always to counter noise trading shocks:

$$Q^h_t = -\varepsilon^l_t$$

Mispricings in $(\mathcal{I}, h)$ are obtained immediately by noting that the price does not change :
$F_t - P_t = F_0 + \sum_{i=0}^{i=t} \varepsilon^f_i - P_0$
$F_t - P_t = F_0 - P_0 + \sum_{i=0}^{i=t} \varepsilon^f_i$
$\Rightarrow E\left((F_t - P_t)^2\right) = E\left((F_0 - P_0)^2\right) + \sum_{i=0}^{i=t} \left(\varepsilon^f_i\right)^2$
Thus:

$$M^{\mathcal{I},h}_t = M^{I,\mathcal{h}}_0 + t\sigma^2_f$$

where $M^{I,\mathcal{h}}_0$ is the expected mispricing at the start of the cycle. The expected mispricing across the cycle $M^{\mathcal{I},h}_2$ is then :

$$M^{\mathcal{I},h} = \frac{\sum_{t=0}^{t=T} M^{\mathcal{I},h}_{2,t}}{T} = \frac{TM^{I,\mathcal{h}}_1 + \sigma^2_f + 2\sigma^2_f + ... + T\sigma^2_f}{T}$$

Using the properties of arithmetic sequences:

$$M^{\mathcal{I},h} = M^{I,\mathcal{h}}_0 + \frac{T(T+1)\sigma^2_f}{2}$$

G-2

I now turn to the (L, h) market. In the absence of ITr and HFTr only LTr demand the asset. The evolution of the price through time is then:

$$P_t = P_{t-1} + b\varepsilon_t^l = P_0 + b\sum_{i=0}^{i=t} \varepsilon_i^l$$

It follows that :

$F_t - P_t = F_0 + \sum_{i=0}^{i=t} \varepsilon_i^f - \left(P_0 + b\sum_{i=0}^{i=t} \varepsilon_i^l\right)$

$\Rightarrow E\left((F_t - P_t)^2\right) = E\left((F_0 - P_0)^2\right) + \sum_{i=0}^{i=t} \left(\varepsilon_i^f\right)^2 + b^2 \sum_{i=0}^{i=t} \left(\varepsilon_i^l\right)^2$

Thus:

$$M_t^{L,h} = M_0^{L,h} + t\left(\sigma_f^2 + b^2\sigma_l^2\right)$$

The expected mispricing across the cycle $M^{L,h}$ is then :

$$M^{L,h} = M_0^{L,h} + \frac{T(T+1)\left(\sigma_f^2 + b^2\sigma_l^2\right)}{2}$$

Thus both $M^{L,h}$and $M^{L,h}$ tend to infinity when T is large, and $M^{L,h} < M^{L,h}$

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The Impacts of the Climate Disclosure Proposal and Institutional Factors on Sustainability Ratings in Higher Education

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Abstract

Purpose: The study has two main goals. First, it aims to measure whether there is a statistically significant difference in the sustainability (STARS®) ratings of North American higher education institutions (HEIs) after the Securities and Exchange Commission's (SEC) proposal on climate-related disclosure (CD). Second, it analyzes the last three reporting cycles to determine whether the institutional characteristics of HEIs are determinants of sustainability ratings, based on the tenets of institutional theory.

Design/methodology/approach: The sample includes 743 observations in the last three reporting periods. The hypotheses regarding the change in sustainability (sub)scores were tested using a paired-sample t-test. The hypotheses about the institutional characteristics were tested via state-year-country fixed effects regression.

Findings: Although the institutional type (private versus public) has no impact on the sustainability scores, institutional control, and full-time equivalent (FTE) enrollment are the significant determinants of the scores, which, overall, supports the proposition of the institutional theory. Moreover, a significant difference (increase) exists between the sustainability scores of the HEIs in the last two cycles. The positive changes in the sub-ratings also support this significant change in the total score.

Originality: This study identifies the significant increase in the HEIs' sustainability (sub)scores in the last reporting cycle. It demonstrates that HEIs have evolved to respond to the CD requirements in practice, thereby contributing to the ongoing academic debate. Moreover, it investigates institutional characteristics by comparing them with the reference category, which differs from

prior studies. It reports the State effect, e.g., being in California, etc., on HEIs' STARS® (sub)scores.

Keywords: Sustainability, Sustainability Education, Institutional Characteristics, Institutional Theory

1. INTRODUCTION

Historically, the roots of sustainability education and green campuses in North America depend on the Stockholm Declaration (1972), the Talloires Declaration (1990), US Green Building Council principles, and United Nation's Sustainable Development Goal 4 (SDGs) (Rasli *et al,* 2022; Washington-Ottombre *et al*., 2018). The rising awareness of sustainability worldwide has prompted higher education institutions (HEIs) to reevaluate their curricula. They have started expanding courses focusing on sustainability and equipping their graduates with the skills to create sustainable organizations (Adomßent *et al.,* 2019).

Some of the prior researchers (Klußmann *et al.,* 2019; Lang, 2015; Roosa & Mischen, 2022; Semeraro & Boyd, 2017; Washington-Ottombre & Bigalke, 2018) questioned whether the structural factors significantly predict the HEIs' sustainability scores in the USA, Canada, and Germany. However, this study differs from the prior ones for the following reasons: First, it is one of the few studies that conducted a comprehensive analysis of sustainability scores and sub-scores simultaneously. Second, institutional characteristics were analyzed by comparing them to the reference category, providing a relative perspective on different institutional types. Third, since fixed effect regression is more robust and reliable than OLS regression in the longitudinal dataset, the state-year-country fixed effect regression method was used. Fourth, this study examined the State impact on sustainability scores, whereas previous research focused only on climate regions. Fifth, the study questioned the existence of any significant change in the HEIs' sustainability ratings after the SEC's proposal on CD, which has not yet been done in prior studies.

This research contributes to the literature and practice by enlarging the theoretical knowledge of institutional theory, presenting the current state of HEIs in North America, and discussing HEIs' responses to CD regulation. These results also enhance leaders' and standard setters' awareness of how institutional factors may significantly influence the HEIs' sustainability ratings.

The paper is organized as follows: the literature review and theoretical framework section formulates hypotheses based on previous research and institutional theory; the methodology section outlines the research design, sample, and empirical methods; the result section presents findings and robustness checks; and the final section covers the conclusion, implications, limitations, and suggestions for future research.

2. Literature Review and Theoretical Background

2.1 Institutional Theory

"*Institutional (organizational) theory* posits a diverse and differentiated world of organizations and seeks to explain variation among organizations in structure and behavior. *Isomorphism* is a constraining process that forces one unit in a population to resemble other units facing the same social conditions or institutional context" (DiMaggio & Powell, 1983). Meyer & Rowan (1977) explained the three types of forces (coercive, mimetic, and normative pressure) causing isomorphism (similar behavioral patterns). Understanding these forces helps explain why organizations align their practices with institutional expectations. For instance, Cardona *et al.* (2020) realized that each institution's source of isomorphism may differ even in a similar situation.

Krause *et al.* (2016) and Kantabutra (2020) also set their research framework for the determinants of the organizations' sustainability strategies based on institutional theory. They stated that an organization's effectiveness in implementing a sustainability strategy is shaped by its organizational structure and institutional factors. Similarly, this paper questions how

institutional characteristics affect sustainability performance in the HEI context based on *"institutional isomorphism"* to expand the theoretical assumption of institutional theory.

2.2 Sustainability Education

Sustainability education research is extensive, and prior scholars have analyzed the various aspects of sustainability in HEIs, such as sustainable curricula, green campuses, sustainability assessment tools in higher education, organizational structure, the impact of financial performance and COVID-19 on sustainability ratings, etc. However, the determinants of HEIs' sustainability score and the change in the HEIs' sustainability ratings after the SEC's proposal on CD have been under research. Hence, the main goal of this paper is to contribute to the scarce literature based on the tenets of institutional theory.

For instance, prior literature (Beamond *et al.*, 2024; Frizon & Eugenio, 2022; Frizon *et al.*, 2024; Udawatta *et al.*, 2021) highlighted the importance of sustainability education and green campuses. Despite the prior literature emphasizing the prominence, and Gen Z's rising concerns about sustainability, Stead & Sullivan (2024) found that business schools are stagnant, have not fully grasped the perceived relevance of sustainability, or are unaware of sustainability issues in their institutions. Other scholars (Schlobohm & Johnson, 2024; Srivastava *et al,.* 2020; Ting *et al.*, 2024) also mentioned the implementation challenges of sustainability in HEIs due to lack of funding and involvement, political pressures, and leadership mindset. In contrast, AASHE (2021) assured that the HEI's commitments to sustainability, primarily environmental issues, have been rising since the 1970s despite the political pressures. As noted, there are two strands of thought on this topic: some researchers state HEIs are stagnant, but others believe HEIs are keeping pace with sustainability requirements. This research also contributes to this argument by confirming the change/increase in HEI's sustainability ratings.

Second, Berzosa *et al.* (2017) and Gutiérrez-Mijares *et al.* (2023) investigated the sustainability assessment tools of the HEIs. Both reviewed the 23 rating institutions and discussed the 27 criteria for assessing the HEIs' sustainability status. They realized that the assessment criteria of each tool are unique, so achieving the highest score on one tool does not guarantee strong performance on the others. On the other hand, the shared objective of all the tools is to inspire participants to develop a stronger sustainability mindset. It is recommended that HEIs should select the assessment tool that best matches their institutional sustainability strategy. Urbanski & Filho (2015) and Kirrane *et al.* (2020) focused only on the STARS® rating system, which is more commonly preferred by Canadian and American HEIs. Shi & Lai (2013) also stated that STARS® and the Green Report Card are respectable sustainability systems due to their comprehensive list of criteria.

Third, Roosa & Mischen (2022) questioned the impact of organizational characteristics on the HEIs' sustainability performance, and they found that the doctoral-granting institutions and the HEIs with a sustainability office/committee, more staff in the sustainability office, more frequent STARS® submissions, and more comprehensive sustainability plan are likely to have higher sustainability scores. Moreover, they found that doctorate-granting institutions have both sustainability office and committee, leading to higher sustainability scores. Gardner (2010) mentioned that doctorate-granting institutions have a 'striving culture' and focus on rankings/ratings. Thus, doctoral-granting/research-based institutions are selected as a reference category in this paper's analysis.

Klußmann *et al.* (2019), Lang (2015), Semeraro & Boyd (2017), and Washington-Ottombre & Bigalke (2018) examined the organizational factors, as well. They found that climatic zones, institutional types, funding, leadership mindset, strategic plan, and economic stability determine

the HEIs' sustainability performance. Moreover, Salleh *et al.* (2020) listed the critical success factors of HEIs' sustainable development as research, education, awareness, training, and organizational structure.

As noted, the organizational structure is identified as one of the key factors of sustainable performance. Hence, hypotheses are formulated for the total sustainability score and five sub-scores- (*Academics (AC), Engagement (EN), Operations (OP), Planning & Administration (PA), and Innovation & Leadership (IN)*. Henceforth, abbreviated forms will be used for sub-scores.

***H_1**: There is a significant association between institutional control and the total sustainability score of the institution.*

***$H_{\text{for sub-scores}}$**: There is a significant association between institutional control and the institution's sub-sustainability scores.*

***H_2**: There is a significant association between institutional type and the total sustainability score of the institution.*

***$H_{\text{for sub-scores}}$**: There is a significant association between institutional type and the institution's sub-sustainability scores.*

***H_3**: There is a significant association between FTE enrollment and the total sustainability score of the institution.*

***$H_{\text{for sub-scores}}$**: There is a significant association between FTE enrollment and the institution's sub-sustainability scores.*

Lastly, prior scholars have discussed the changes in HEIs' sustainability performance and academic curricula after specific events, such as COVID-19 and digitalization. However, they have not yet measured the change in HEIs' sustainability performances after the SEC's proposal on CD in North America. In March 2022, the SEC proposed the CD for publicly listed companies to

enhance and standardize them. The SEC adopted the final rule in March 2024 (SEC, 2024). Since the SEC *initiated* sustainability with the *proposed rules* in 2022, it has become a central concern for corporate America. Thus, to meet stakeholders' expectations and create greener campuses, it was expected that HEIs would probably be triggered to enhance their sustainability scores by expanding their curricula and re-evaluating their performances in operations, engagement, planning, administration, leadership, and innovation. *Thus, hypotheses are formulated as follows:*

***H_4**: Statistically significant differences exist between the total sustainability scores of North American higher education institutions (HEIs) before and after the SEC's proposal on CD.*

***$H_{\text{for sub-scores}}$: Statistically significant differences exist between the sustainability sub-scores of North American higher education institutions (HEIs) before and after the SEC's proposal on CD.*

3. Methodology

3.1 Sample and Data Collection

The sample comprises American and Canadian institutions from 40 American and 7 Canadian States. Institutional factors and STARS® ratings were collected from the Association for the Advancement of Sustainability in Higher Education (AASHE) database. STARS® stands for Sustainability Tracking and Rating System. It is a "voluntary, self-reporting framework for recognizing and gauging relative progress toward sustainability for colleges and universities" (AASHE, 2019). Although the data is self-reported, AASHE offers HEIs review templates and conducts a peer review process to minimize errors and inaccuracies. It has a staff review process that partially assesses all submitted reports and mandates revisions before publication. AASHE also performs periodic audits, allows public data flagging, and facilitates revisions to promote accuracy (AASHE, 2025a).

The sustainability (sub)scores are all reported on a 100 % scale (0- lowest and 100%-highest). The methodology of calculating STARS® (V2.2) ratings is as follows: "An institution's STARS score is based on the percentage of points it earns by pursuing relevant credits across the four main categories: *AC, EN, OP, and PA*. In addition, an institution may earn up to four *IN* points for exemplary and path-breaking initiatives that are not covered by other STARS credits or that exceed the highest criterion of a standard credit" (AASHE, 2025b).

$$\text{STARS}^{®} \text{ scoring formula} = (A/B*100) + C$$

Where;
A = Total points earned across AC, EN, OP, and PA;
B = Total points available across AC, EN, OP, and PA;
C = Innovation points earned"

The *total* scores are grouped into four recognition levels by the minimum score required: platinum (min: 85%), gold (min: 65%), silver (min: 45%), and bronze (min: 25%). On the other hand, a total score below 25% qualifies for a 'reporter' designation, which results in an unscored and not publicly disclosed (AASHE, 2025b). Thus, the sample's minimum *total* sustainability score is 25.13% (Table 6).

The variable 'reporting cycle' or the year-issued includes "last three reporting cycles. Each institution's reporting cycle (the year the report was issued) changes based on its inclusion into the system. Each sustainability score is valid for three years. Some institutions prefer reporting more often, but some report every 3 years. Therefore, the term 'reporting cycle' is preferred. For H_1 to H_3, *743 observations (661—USA and 82—Canada)* were analyzed in the last three reporting periods. On the other hand, for H_4, *the sample was limited to 250 observations (222- USA and 28-Canada)* by considering the SEC's CD proposal timeline. The HEIs' sustainability (sub)scores were analyzed for the last two cycles. To be included in the sample, HEIs' should have both reports available, and the last report should have been issued between 2022 and 2024. This timeline was

selected because, on March 21, 2022, the SEC released the proposed rule requiring companies to include CD in their financial reports, which was the initiating point of the greener economy (Darnaud, 2022).

3.2 Model and Method

The *dependent variables* are the total and sub-scores. The sub-scores are *AC*, *EN*, *OP*, *PA*, and *IN*. The methodology, data quality, and assurance of STARS® ratings were explained in the previous section.

The *independent variables* are institutional factors, including institutional control, institutional type, and FTE enrollment. Institutional control has four categories: associate, baccalaureate, master, and doctoral/research. Institutional type is grouped as private or public. FTE enrollment has four groups: 1) less than 5,000, 2) 5,000-9,999, 3) 10,000-19,999, and 4) more than 20,000. The *control variables* are state, country, and year/reporting cycle.

INSERT TABLE 1 HERE

Due to the longitudinal panel dataset, H_1 to H_3 were tested via state-year-country fixed effects regression, and H_4 was tested via paired-sample t-statistics. The analyses were conducted by using SPSS.

4. Results

4.1 Descriptive Results and Correlation

Tables 2 to 7 display sample descriptive statistics. Table 8 shows correlation analyses. Of the institutional types, 62.2% of American institutions are public, and the rest are private. In Canada, all are public institutions (Table 2).

INSERT TABLE 2 HERE

Of the institutional control, 54.2% and 57.3% are doctoral-granting institutions in the USA and Canada, respectively. In the American sample, 25.6%, 17.5%, and 2.7% are masters, baccalaureate, and associate degree institutions. In the Canadian sample, 28%, 8.5%, and 6.2% are associate, baccalaureate, and master's degree-granting institutions (Table 3).

INSERT TABLE 3 HERE

For FTE enrollment, each category is almost equally represented in the American sample: 28.9% have less than 5,000 FT students, 18.8% have 5,000-9,999, 20.7% have 10,000-19,999, and 31.6% have more than 20,000. On the other hand, in the Canadian sample, 8.5% have less than 5,000 FT students, 11% have 5,000-9,999, 37.8% have 10,000-19,999, and 42.7% have more than 20,000 (Table 4).

INSERT TABLE 4 HERE

Table 5 lists the last reporting cycle's top performers (platinum level). Arizona State and Colorada State in the USA and Université de Sherbrooke and Université Laval in Canada are the top two institutions based on their total sustainability scores.

INSERT TABLE 5 HERE

In Table 6, the total sustainability ratings' min, max, and mean were 25.13%, 91.10%, and 60.70% in the USA and 33.58%, 92.73%, and 64.40% in Canada, respectively. Table 7 reveals the mean statistics of the sustainability (sub)scores for each state/province. Arizona (73.4%), Iowa (68.7%), and Oregon (67.8%) in the USA, and Nova Scotia (71.9%) and Quebec (67.9%) in Canada have the highest means based on the *total* sustainability scores in three reporting cycles.

INSERT TABLES 6 & 7 HERE

Table 8 reports the Pearson correlations. Institutional control ($p<0.01$), FTE enrollment ($p<0.01$), and country ($p<0.05$) significantly correlate to the total sustainability rating. However,

no significant correlation exists between institutional type (private, public) and total sustainability score.

INSERT TABLE 8 HERE

4.2 Results

Results on the Institutional Factors

Tables 9 and 10 report the state-year-country fixed effects regression results. Model 1 shows the findings for the association between institutional factors and *total* sustainability score (H_1 to H_3). Models 2 to 6 (in Tables 9 & 10) report the findings for the relationship between institutional factors and five *sub-scores* (for hypotheses ***for sub-scores***).

In Model 1 Table 9, institutional control (H_1) and FTE enrollment (H_3) are significant predictors of the HEIs' total sustainability scores at the 1 percent level. Thus, *H_1 and H_3 are supported*. However, the institutional type (H_2) is not statistically significant. This suggests that HEIs' sustainability scores are not significantly different, regardless of whether they are public or private.

Moreover, the total sustainability scores differ significantly between doctoral/research institutions and both master (b: -6.36, $p<0.01$) and associate institutions (b: -10.98, $p<0.01$). In simpler terms, compared to the reference category of doctoral-granting institutions, their total sustainability scores are significantly lower, which supports the argument of Gardner (2010) and Roosa & Mischen (2022). As addressed earlier, doctorate-granting institutions have a 'striving culture' and focus more on rankings/ratings than teaching-based institutions, so it was expected that their ratings could be comparably higher.

For FTE Enrollment, compared to the reference category of 'more than 20,000', the HEIs with less than 5,000 (b: -6.70, $p<0.01$) and between 5,000 and 9,999 (b: -4.77, $p<0.01$) enrollments have significantly lower total sustainability scores. On the other hand, there are no significant

differences in total sustainability scores between HEIs with enrollments exceeding 20,000 and those with enrollments between 10,000 and 19,999. It also supports the prior argument if it is considered that most doctoral institutions in the sample have more than 20,000 (53%) and between 10,000 and 19,999 (29%) enrollments.

Furthermore, for the country effect, there are no statistically significant differences in total sustainability scores between HEIs in the USA and Canada. However, in contrast to Canada, the state is a significant determinant of the HEIs' total sustainability scores in the USA. For the states, the reference category is Wisconsin (mean: 57.5, Table 7), as the last state in the list. For instance, in Model 1 Table 9, HEIs in California (b: 9.89, $p<0.01$), Maine (b: 16.16, $p<0.05$), Minnesota (b:11.20, $p<0.05$), Vermont (b:16.10, $p<0.05$)), and Oregon (b:16.17, $p<0.10$) are significantly better in their *total* sustainability scores. On the other hand, HEIs in Hawaii (b: -17.85, $p<0.01$) and South Dakota (b: -15.86, $p<0.05$) have significantly lower *total* sustainability scores.

For the five *sub-scores*, the results in Models 2 to 6 (Tables 9 & 10) support the main finding on the States, institutional control, and FTE enrollment. This means that *hypotheses 1's and 3's sub-scores are also supported.* The only exception is for the PA sub-score (Model 5-Table 10), where the PA sub-scores of private institutions (b: -2.60, $p<0.05$) are significantly lower than those of public institutions. However, no significant differences exist in the remaining sub-scores (AC, EN, OP, IN) based on institutional type. This means *hypothesis 2's sub-score is only supported for PA,* not other sub-scores.

For the states with sub-scores in Model 2, Table 9, compared to the reference category of WI (mean AC: 65.1% and EN: 59.5%- Table 7), the HEIs in Arizona (b: 21.71, $p<0.05$), Iowa (b:18.17, $p<0.10$), Maine (b:17.74, $p<0.10$), and Minnesota (b: 14.02, $p<0.10$) have *significantly higher AC scores*. The HEIs in Maine (b: 15.82, $p<0.10$) and Vermont (b: 16.07, $p<0.10$) have a *higher EN*;

but the HEIs in Hawaii (b: -19.17, p<0.05), South Dakota (b: -19.53, p<0.05), and Rhode Island (b:18.01, p<0.10) have a significantly *lower EN rating* (Model 3).

Compared to the reference category of WI (Mean OP: 43.6%, Table 7), the HEIs in California (b: 11.33, p<0.01), Maine (b: 16.95, p<0.01), Vermont (b: 19.24, p<0.01), and Oregon (b: 12.42, p<0.05), New York (b: 6.85, p<0.10), and Massachusetts (b: 7.69, p<0.10) have a significantly *higher OP*; but the HEIs in Hawaii (b: -24.84, p<0.01), South Dakota (b: -12.12, p<0.05), Alabama (b:-11.31, p<0.10), and Rhode Island (b:-12.08, p<0.10) have a *lower OP rating* (Model 4).

In Model 5 Table 10, compared to the reference category of WI (Mean PA: 54.6% and IN: 67.8%, Table 7), California (b: 8.98, p<0.05) and Minnesota (b:10, p<0.10) have a significantly *higher PA score*. On the other hand, South Dakota (b: -22.38, p<0.01), Alabama (b: -15.34, p<0.05), Texas (b: -9.74, p<0.05), Tennessee (b: -14.64, p<0.05), and Florida (b: -8.97, p<0.10) have a significantly *lower PA score*. Lastly, in Model 6, the HEIs in California, Minnesota, and Washington have significantly *higher IN scores* at the 1 percent level, and HEIs in New York, New Jersey, Massachusetts, Oregon, Pennsylvania, Vermont, Utah, and Virginia have a significantly *higher IN scores* at the 5 percent level. On the other hand, Hawaii (b: -27.82, p<0.10) has a significantly *lower IN score*.

INSERT TABLES 9 & 10 HERE

In short, state differences may be explained by local governments' reactions to the new SEC regulation on ESG disclosure. For instance, *California* is one of the American states where the local government publicly supported the SEC regulation (Vanderford, 2024). In *Maine*, the law requires the Maine public employees' retirement system (ERS) to divest from the fossil fuel industry by 2026. In *Minnesota*, as of 2024, the state bill would require the state board of investment to develop, publish, and implement a sustainable investment policy to manage its

funds. The state bill would require the ERS to divest from fossil fuel companies in *Vermont* and *Hawaii.* The negative significant result and the mean total score of 31.3% (Table 7) for Hawaii's public HEIs indicate that, despite the state's proactive governmental sustainability initiatives, there is considerable room for improvement within its HEIs. As supporting the negative results and the mean total score of 42.5% (Table 7), *South Dakota* belongs to one of the 19 U.S. states opposing the SEC's CD rule (Debevoise, 2024).

Results on the Improvement in Sustainability Scores

The paired sample t-test aims to determine whether there are statistically significant differences between the sustainability (sub)scores of HEIs before and after the SEC's proposal on CD (H_4). The paired sample statistics, including means, std deviations, and std. error means, are shown in Table 11. The mean score of the HEIs' total sustainability rating before the SEC's proposal on CD (before 2022) was 61.03%, which increased to 66.35% after the SEC's proposal, between 2022 and 2024, which is also supported by the mean score increases in all of the sub-scores (Table 11). Table 12 shows a significant positive correlation between the total scores and sub-scores before and after the SEC's proposal at the 1 percent level.

INSERT TABLES 11 & 12 HERE

Table 13 reports the results of H_4 and $H_{\text{for sub-scores}}$, all supported at the 1 percent level. This means there was a statistically *significant increase* in the sustainability (sub)scores of HEIs before and after the SEC's proposal on CD. Cohen's effect sizes for both total score and sub-scores, which are all above 0.20, provide additional assurance since Cohen (1988) states that with an effect size of more than 0.20, the magnitude of its effect is significant. It can be grouped as a small effect ($d \geq 0.2$) for EN, PA, and IN sub-scores, but a medium effect ($d \geq 0.5$) for AC and OP sub-scores, and a large effect ($d \geq 0.8$) for total sustainability score.

INSERT TABLE 13 HERE

4.3 Robustness checks

For the robustness check of H_1-H_3, the regression assumptions of linearity, normality, outliers, homoscedasticity, multicollinearity, and independent errors were checked. Based on the histogram and normal probability plot (P-P), scatterplot, and case-wise diagnostics, the model is linear and normally distributed with no extreme outliers. Based on the collinearity statistics (VIF < 10) and Pearson correlation analysis ($r < 0.90$), there are no substantial correlations between predictors (Table 8), which means that there is no issue of multi-collinearity. Multi-collinearity is checked for Models 1 to 6 for total sustainability score and sub-scores. However, due to the word count limit, the correlation tables for five sub-scores were not disclosed. It can be provided upon request. Lastly, the Durbin-Watson (D-W) statistics were within the acceptable range ($1<DW<3$), so the model is free from independent errors (no autocorrelation) (Landers, 2013).

For the robustness checks of H_4, the assumptions of paired sample t-test were checked via histogram, Q-Q plot, and box plot analysis (Field, 2013; Landers, 2013; Newbold *et al*., 2013). It is found that the parent distribution of the differences between the scores is normally distributed, and the two populations have equal variance (homogeneity of variance). In other words, the model is normally distributed, there is no heterogeneity issue, and there are no major outliers. Moreover, as discussed in the previous section, Cohen's d scores ($d \geq 0.2$, Table 13) provide additional assurance (Cohen, 1988). Thus, it can be concluded that the model is robust, and the findings are reliable.

5. Conclusion, Implications, Limitations, and Future Research

The paper's findings supported the *isomorphism assumption* of the institutional theory by proving that institutions have similar behavioral patterns in their total sustainability scores if they have

similar FTE enrollment and institutional control. Moreover, it is the first study identifying the state's impact on HEIs in the USA. Overall, the HEIs in California, Maine, Minnesota, Vermont, and Oregon are significantly *better* in their *total* sustainability scores; however, the HEIs in Hawaii and South Dakota have significantly *lower total* sustainability scores. Moreover, there were statistically significant increases between the total sustainability (sub)scores of North American HEIs before and after the SEC's proposal on CD. It proves that HEIs were triggered by the SEC's proposal to create greener campuses and develop sustainability consciousness.

As a first limitation, due to the missing data, the sample includes only the HEIs in 40 American states and 7 Canadian provinces. The second limitation of this study is that the results contribute to the isomorphism proposition in the HEI context. However, as explained in the theory section, the type(s) of isomorphism was not identified. Therefore, this paper paves the way for comprehensive future research, enabling scholars to define the types of isomorphism influencing the changes in HEIs' sustainability rating in response to the SEC's proposal.

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TABLES

Table 1- Definition of the Variables

Variables	Definition
Dependent Variables	
Sustainability Score (STARS® Rating)	Total Sustainability Score (0% Lowest -100% Highest)
	The *total* sustainability scores are grouped into four recognition levels. (4: Platinum (min: 85%), 3: Gold (min: 65%), 2: Silver (min: 45%), and 1: Bronze (min: 25%) (Highest:4- Platinum, Lowest: 1- Bronze)
Academics (AC)	Sustainability in curriculum and research (0% Lowest -100% Highest)
Engagement (EN)	Sustainability in campus & public engagement (0% Lowest -100% Highest)
Operations (OP)	Sustainability in air & climate, buildings, energy, food & dining, grounds, purchasing, transportation, waste, and water (0% Lowest -100% Highest)
Planning & Administration (PA)	Sustainability in coordination & planning, diversity & affordability, investment & finance, and wellbeing & work (0% Lowest -100% Highest)
Innovation & Leadership (IN)	Sustainability in innovation & leadership (0% Lowest -100% Highest)
Control & Independent Variables:	
Reporting cycles	The reporting cycle or the year the report was issued includes "three reporting cycles." (3: Recent/Last cycle, 2: Last-1, and 1: Last-2)
Country	1: USA, 2: Canada
State/Provinces	North American States (1: AL - 40: WI- American States) (41: Can-ON- 47: Can-AB- Canadian Provinces)
Institutional Characteristics:	
Institutional Control	Type of education 1: Baccalaureate, 2: Doctoral/Research, 3: Master, 4: Associate
Institutional Type	Type of institution 1: Private for non-profit and 2: Public (Private for profit: n/a)
Full-time Equivalent (FTE) Enrollment	Range of the number of full-time students' enrollment (1: less than 5,000, 2: 5,000-9,999, 3: 10,000-19,999, and 4: more than 20,000)

Source: created by the author.

Table 2- Sample Descriptives: Breakdown of the Institutional Types

Country	Institutional Type	Frequency	Percentage
1- USA	1- Private for non-profit	250	37.8
	2- Public	411	62.2
	Total	661	100
2- Canada	2- Public	82	100

Source: created by the author.

Table 3- Sample Descriptives: Breakdown of the Institutional Control

Country	Institutional Control	Frequency	Percentage
1-USA	1-Baccalaureate	116	17.5
	2-Doctoral/Research	358	54.2
	3- Masters	169	25.6
	4- Associate	18	2.7
	Total	**661**	**100**
2-Canada	1-Baccalaureate	7	8.5
	2-Doctoral/Research	47	57.3
	3- Masters	5	6.2
	4- Associate	23	28
	Total	**82**	**100**

Source: created by the author.

Table 4- Sample Descriptives: Breakdown of the FTE Enrollment

Country	FTE Enrollment	Frequency	Percent
1-USA	1- less than 5,000	191	28.9
	2- 5,000-9,999	124	18.8
	3- 10,000-19,999	137	20.7
	4- more than 20,000	209	31.6
	Total	661	100
2-Canada	1- less than 5,000	7	8.5
	2- 5,000-9,999	9	11
	3- 10,000-19,999	31	37.8
	4- more than 20,000	35	42.7
	Total	82	100

Source: created by the author.

Table 5- Top Performers* in the *Last Reporting Cycle*

HEIs in the USA	St.	Total Score	AC	EN	OP	PA	IN	Inst. Contr.	Inst. Type	FTE Enroll.
Arizona State	AZ	91	99	91	75	86	100	Doct.	Public	>20,000
Colorado State	CO	88	100	97	63	86	100	Doct.	Public	>20,000
State University of New York College of Environmental Science and Forestry	NY	87	100	92	63	84	100	Doct.	Public	<5,000
Cornell University	NY	86	99	96	62	79	100	Doct.	Private	>20,000
University of New Hampshire	NH	86	100	93	62	78	100	Doct.	Public	10,000-19,999
Stanford University	CA	86	97	87	71	72	100	Doct.	Private	10,000-19,999
University of California Merced	CA	86	93	88	69	79	100	Doct.	Public	5,000-9,999

HEIs in Canada	St.	Total Score	AC	EN	OP	PA	IN	Inst. Contr.	Inst. Type	FTE Enroll.
Université de Sherbrooke	QC	93	98	98	74	93	100	Doct.	Public	>20,000
Université Laval	QC	88	100	78	72	87	100	Doct.	Public	>20,000
McGill University	QC	86	99	89	64	85	100	Doct.	Public	>20,000
Thompson Rivers	BC	86	95	89	74	81	50	Mast.	Public	10,000-19,999
University of Victoria	BC	86	92	89	68	83	100	Doct.	Public	10,000-19,999

Legend: *: Top performers (the platinum level) **St**: State and **Doct.**: Doctoral/Research & **Mast**.: Master. **Source**: created by the author.

Table 6- Descriptive Statistics of Stars® Ratings

Country	Stars Ratings	N	Minimum	Maximum	Mean	Std. Deviation
1-USA	Total Rating	661	25.13	91.10	60.70	13.25
	AC	661	5.35	100	67.68	16.97
	EN	661	6.73	100	65.58	16.99
	OP	661	5.77	75.45	45.68	12.16
	PA	661	3.13	86.13	55.18	12.93
	IN	661	0.00	100.00	79.52	31.74
2-Canada	Total Rating	82	33.58	92.73	64.40	12.55
	AC	82	28.10	99.95	73.50	15.40
	EN	82	29.44	98.32	67.10	14.29
	OP	82	20.54	74.25	48.93	12.64
	PA	82	19.31	92.88	57.31	14.75
	IN	82	0.00	100	86.51	26.40

Source: created by the author.

Table 7- Mean of Sustainability (sub)scores, State by State, *across three reporting cycles*

State	Total	AC	EN	OP	PA	IN
AL	46.1	58.3	51.3	27.9	40.1	71.4
AZ	73.4	85.6	76.2	57.8	62.0	87.5
CA	65.1	68.5	68.8	51.7	62.0	85
CO	65.4	71.7	71.6	52.4	57.9	73.2
CT	64.3	73.2	66.7	48.6	60.7	77.3
FL	58	67.1	66.3	41.4	47.4	78.4
GA	54.5	62.7	60	37.7	51.8	71.9
HI	31.3	46.7	35.9	11.9	37.9	30.0
IA	68.7	83.8	75.7	46.9	59.0	85.2
ID	61.2	71.9	56.2	48.2	54.5	87.5
IL	55.5	61.3	65.7	41.5	45.8	71.2
IN	59.8	66.4	68.9	42.6	52.7	87.5
KS	46.6	48.1	56.0	34.9	36.2	83.3
KY	61.6	61.3	73.9	43.7	61.8	94.8
MA	61.3	65.3	66.6	48.0	56.2	80.9
MD	59	56.8	65.0	48.1	58	85.4
ME	65	72.7	74.2	52.3	48.4	79.7
MI	60.9	71.2	70.4	39.5	57.2	79.3
MN	66.1	74.2	70.7	47.7	62.6	97.9
MO	66.3	59	81.8	55	59.4	100
MT	62.3	78.3	57.4	46.5	54.1	81.3
NC	58.1	67.7	61.7	42.2	52.8	74.7
NE	55.3	66.4	62.6	36.3	51.4	71
NH	65.4	71.6	69.1	50.5	63.2	75
NJ	57.1	64.9	50.8	44.3	56.4	86.8
NY	63.6	71.2	67.6	48.7	57.4	80.5
OH	64.9	73.8	75.4	44.6	57.5	91.3
OK	59.7	68.5	67.9	47.7	45.2	58.3
OR	67.8	71.4	71.2	53.8	62.3	96
PA	58.2	62.9	63.0	46.1	53.3	69.1
RI	45.2	58.0	46.4	29.7	43.7	41.3
SC	56.6	67.3	62.4	40	45.7	83
SD	42.5	51.8	43.6	31.2	34.6	59.4
TN	50.3	59.3	56.1	37.4	44.5	41.9
TX	54.4	65.3	57.8	38.1	47.5	74
UT	57.5	60.8	64.1	44.9	50.5	80.3
VA	64.3	72.5	71.8	46.5	55.4	96.6
VT	66.8	69.9	70.9	54	61.4	92.7
WA	63.9	71.7	61.9	50.1	61	89
WI (Reference Cat.)	57.5	65.1	59.5	43.6	54.6	67.8
Mean USA:	60.7	67.7	65.6	45.7	55.2	79.5

Legend: in alphabetical order. Source: created by the author.

Province	Total	AC	EN	OP	PA	IN
Can-BC	64.6	70.7	67.2	50.8	59.1	90
Can-MB	62.2	67.3	68.1	46.7	54.9	96.9
Can-NS	71.9	80.6	78.5	58.6	59.6	100
Can-ON	61.8	70.3	63.9	47.8	54	81.3
Can-QC	67.9	79.5	68.9	50.2	63.1	85.6
Can-SK	59.7	71.1	65.5	41.8	46.1	100
Can-AB (reference cat.)	64.7	81.9	79.5	39.8	48.1	93.8
Mean Canada:	64.4	73.5	67.1	48.9	57.3	86.5

Legend: in alphabetical order. Source: created by the author.

Table 8- Correlations

	Total Rating	Country	Inst. Control	Inst. Type	FTE Enrollment	State
Total Rating	1					
Country	0.09**	1				
Inst. Control	-0.19***	0.16***	1			
Inst. Type	0.05	0.25***	0.33***	1		
FTE Enrollment	0.26***	0.16***	0.09**	0.50***	1	
State	-0.03	0.49***	0.01	.10***	-0.02	1

: Sig at 5% level, *: Sig at 1% level, Source: created by the author.

Table 9- State, Year, Country Fixed Effects Regression for the Dependent Variables of **Total** Rating, **Academics** Rating, and **Engagement** Rating

Variables	Model 1 For Total Rating	Model 2 For AC Rating	Model 3 For EN Rating
Institutional Control (H_1) (reference category: Doctoral/Research Institution)			
Associate	-10.98***	-17.89***	-10.18***
	(2.70)	(3.64)	(3.59)
Baccalaureate	-1.38	-1.01	-4.99*
	(2.11)	(2.85)	(2.80)
Masters	-6.36***	-6.14***	-7.18***
	(1.44)	(1.95)	(1.92)
Institutional Type (H_2) (reference category: Public Institution)			
Private	0.29	-0.70	2.56
	(1.31)	(1.77)	(1.74)
FTE Enrollment (H_3) (reference category: Institution with FTE Enrollment of more than 20,000)			
less than 5,000	-6.70***	-5.79**	-4.83*
	(2.11)	(2.85)	(2.80)
5,000-9,999	-4.77***	-2.28	-7.57***
	(1.60)	(2.15)	(2.12)
10,000-19,999	-2.07	-0.17	-0.70
	(1.37)	(1.84)	(1.81)

Country (reference category: Canada)			
USA	-6.00	-13.91	-8.90
	(12.42)	(16.74)	(16.47)
States of the USA (reference category: State# 40: Wisconsin-WI)			
[State=1: AL]	-8.01	-2.99	-7.16
	(7.65)	(10.32)	(10.15)
[State=2: AZ]	11.42	21.71**	7.30
	(7.67)	(10.34)	(10.17)
[State=3: CA]	9.89***	6.17	8.12
	(3.98)	(5.37)	(5.28)
[State=4: CO]	5.94	4.50	7.77
	(5.95)	(8.03)	(7.90)
[State=5: CT]	6.14	10.05	1.92
	(5.98)	(8.06)	(7.94)
[State=6: FL]	-0.29	4.88	-1.34
	(5.45)	(7.35)	(7.24)
[State=7: GA]	-9.94	-14.03	-12.70
	(6.84)	(9.22)	(9.08)
[State=8: HI]	-17.85***	-5.92	-19.17**
	(6.71)	(9.04)	(8.90)
[State=9: IA]	10.09	18.17*	10.40
	(7.67)	(10.33)	(10.17)
[State=10:ID]	10.24	20.60	8.23
	(12.34)	(16.64)	(16.37)
[State=11: IL]	-3.56	-6.54	-2.76
	(6.34)	(8.54)	(8.41)
[State=12: IN]	-2.01	-2.19	-0.44
	(5.42)	(7.31)	(7.19)
[State=13: KS]	4.71	8.85	9.53
	(12.57)	(16.94)	(16.67)
[State=14: KY]	3.43	-2.15	10.63
	(9.07)	(12.22)	(12.03)
[State=15: MA]	4.73	2.41	1.92
	(4.67)	(6.30)	(6.20)
[State=16: MD]	-0.11	-12.41	1.50
	(6.82)	(9.20)	(9.05)
[State=17: ME]	16.16**	17.74*	15.82*
	(6.93)	(9.34)	(9.20)
[State=18: MI]	3.55	6.90	5.37
	(5.23)	(7.05)	(6.94)
[State=19: MN]	11.20**	14.02*	9.71
	(5.46)	(7.35)	(7.24)
[State=20: MO]	4.50	-17.70	8.93
	(12.37)	(16.67)	(16.41)
[State=21: MT]	5.16	11.48	-5.16
	(12.31)	(16.60)	(16.33)
[State=22: NC]	-0.02	3.39	-2.91
	(5.07)	(6.84)	(6.73)

[State=23: NE]	4.06	6.12	6.44
	(6.89)	(9.29)	(9.14)
[State=24: NH]	2.58	-2.15	1.87
	(9.05)	(12.20)	(12.00)
[State=25: NJ]	-0.04	6.75	-12.82
	(6.36)	(8.57)	(8.44)
[State=26: NY]	6.73	7.78	4.00
	(4.21)	(5.67)	(5.58)
[State=27: OH]	2.29	5.54	5.96
	(5.67)	(7.64)	(7.52)
[State=28: OK]	0.36	5.72	3.57
	(12.31)	(16.59)	(16.33)
[State=29: OR]	11.67*	8.35	9.62
	(6.36)	(8.57)	(8.43)
[State=30: PA]	4.84	2.53	5.12
	(4.45)	(5.99)	(5.90)
[State=31: RI]	-10.93	-7.05	-18.01*
	(7.74)	(10.43)	(10.26)
[State=32: SC]	3.82	5.43	3.85
	(7.62)	(10.27)	(10.11)
[State=33: SD]	-15.86**	-13.70	-19.53**
	(6.89)	(9.29)	(9.14)
[State=34: TN]	-8.94	-8.74	-8.24
	(6.83)	(9.21)	(9.06)
[State=35: TX]	-4.18	-0.29	-6.46
	(4.80)	(6.47)	(6.37)
[State=36: UT]	2.44	-0.95	4.48
	(6.32)	(8.52)	(8.39)
[State=37: VA]	6.16	8.72	6.81
	(5.25)	(7.08)	(6.97)
[State=38: VT]	16.10**	12.23	16.07*
	(6.89)	(9.29)	(9.14)
[State=39: WA]	6.05	5.67	-2.41
	(5.08)	(6.84)	(6.74)
Provinces of Canada (reference category: State #47: Alberta-AB)			
[State=41: ON]	2.87	-2.48	-4.55
	(12.39)	(16.71)	(16.44)
[State=42: QC]	5.97	2.45	-0.59
	(12.57)	(16.94)	(16.67)
[State=43: BC]	-0.70	-11.81	-5.33
	(12.57)	(16.94)	(16.67)
[State=44: MB]	1.09	-8.94	-0.48
	(14.65)	(19.75)	(19.44)
[State=45: NS]	14.73	16.68	11.38
	(16.93)	(22.81)	(22.45)
[State=46: SK]	-2.35	-1.14	-6.45
	(16.79)	(22.64)	(22.28)
Year/reporting cycle (reference category: 3 = last/recent reporting cycle)			

[Reporting cycle=1]	-10.36	-25.00	-5.44
	(16.66)	(22.46)	(22.10)
[Reporting cycle=2]	-3.01	-4.90	18.05
	(16.66)	(22.46)	(22.10)
Intercept	69.68***	85.53***	76.13***
	(12.02)	(16.21)	(15.95)
Observations:	743	743	743
R-Square:	0.357	0.284	0.292
Adj-R Square:	0.206	0.116	0.125
F-Value:	2.364***	1.692***	1.755***

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.10. Source: Created by the author.

Table 10- State, Year, Country Fixed Effects Regression for the Dependent Variables of **Operations** Rating, **Planning & Administration** Rating, and **Innovation & Leadership** Rating

Variables	**Model 4 For OP Rating**	**Model 5 For PA Rating**	**Model 6 For IN Rating**
Institutional Control (H_1) (reference category: Doctoral/Research Institution)			
Associate	-4.80**	-10.47***	-6.42
	(2.45)	(2.65)	(6.56)
Baccalaureate	0.96	-0.67	-3.62
	(1.91)	(2.07)	(5.13)
Masters	-4.31***	-6.07***	-15.36***
	(1.31)	(1.41)	(3.50)
Institutional Type (H_2) (reference category: Public Institution)			
Private	1.35	-2.60**	-0.85
	(1.19)	(1.28)	(3.18)
FTE Enrollment (H_3) (reference category: Institution with FTE Enrollment of more than 20,000)			
less than 5,000	-7.48***	-4.86**	-14.94***
	(1.91)	(2.07)	(5.12)
5,000-9,999	-4.71***	-3.88***	-8.24**
	(1.45)	(1.56)	(3.87)
10,000-19,999	-2.96**	-2.38*	-11.43***
	(1.24)	(1.34)	(3.32)
Country (reference category: Canada)			
USA	-2.33	8.36	-25.36
	(11.24)	(12.17)	(30.13)
States of the USA (reference category: State# 40: Wisconsin-WI)			
[State=1: AL]	-11.31*	-15.34**	23.15
	(6.93)	(7.50)	(18.57)

[State=2: AZ]	9.58	5.02	8.19
	(6.94)	(7.51)	(18.61)
[State=3: CA]	11.33***	8.98**	27.53***
	(3.60)	(3.90)	(9.66)
[State=4: CO]	6.99	0.66	21.31
	(5.39)	(5.83)	(14.44)
[State=5: CT]	3.79	4.67	21.36
	(5.41)	(5.86)	(14.51)
[State=6: FL]	-1.90	-8.97*	17.92
	(4.94)	(5.34)	(13.23)
[State=7: GA]	-6.68	-6.40	1.32
	(6.19)	(6.70)	(16.60)
[State=8: HI]	-24.84***	-10.67	-27.82*
	(6.07)	(6.57)	(16.27)
[State=9: IA]	4.49	1.58	23.03
	(6.94)	(7.51)	(18.60)
[State=10:ID]	4.32	-0.31	31.04
	(11.17)	(12.09)	(29.94)
[State=11: IL]	-3.12	-6.07	26.41*
	(5.74)	(6.21)	(15.38)
[State=12: IN]	-3.40	-5.56	21.07
	(4.91)	(5.31)	(13.15)
[State=13: KS]	1.88	-12.78	40.66
	(11.37)	(12.31)	(30.49)
[State=14: KY]	0.84	2.52	31.11
	(8.20)	(8.88)	(22.00)
[State=15: MA]	7.69*	0.59	21.87**
	(4.23)	(4.58)	(11.34)
[State=16: MD]	6.29	1.99	17.48
	(6.17)	(6.68)	(16.55)
[State=17: ME]	16.95***	3.98	31.09*
	(6.27)	(6.79)	(16.82)
[State=18: MI]	-2.13	1.85	22.70*
	(4.73)	(5.12)	(12.68)
[State=19: MN]	6.08	10.00*	37.25***
	(4.94)	(5.35)	(13.24)
[State=20: MO]	15.71	5.49	35.09
	(11.19)	(12.12)	(30.00)
[State=21: MT]	2.60	4.50	34.24
	(11.14)	(12.06)	(29.87)
[State=22: NC]	0.11	-7.43	21.17*
	(4.59)	(4.97)	(12.31)
[State=23: NE]	-2.32	5.35	25.46
	(6.24)	(6.75)	(16.72)
[State=24: NH]	4.92	6.85	-0.88
	(8.19)	(8.86)	(21.95)
[State=25: NJ]	-2.62	1.28	31.58**
	(5.75)	(6.23)	(15.43)
[State=26: NY]	6.85*	2.34	23.10**
	(3.80)	(4.12)	(10.20)
[State=27: OH]	-1.65	-4.36	19.00

	(5.13)	(5.55)	(13.75)
[State=28: OK]	3.18	-12.32	-27.20
	(11.14)	(12.06)	(29.86)
[State=29: OR]	12.42**	9.41	31.67**
	(5.75)	(6.23)	(15.42)
[State=30: PA]	6.89*	-1.94	25.25**
	(4.02)	(4.36)	(10.78)
[State=31: RI]	-12.08*	-6.20	-4.53
	(7.0)	(7.58)	(18.77)
[State=32: SC]	5.74	-9.83	28.12
	(6.89)	(7.46)	(18.48)
[State=33: SD]	-12.12**	-22.38***	-1.68
	(6.23)	(6.75)	(16.71)
[State=34: TN]	-7.34	-14.64**	2.81
	(6.18)	(6.69)	(16.57)
[State=35: TX]	-4.68	-9.74**	12.00
	(4.34)	(4.70)	(11.64)
[State=36: UT]	3.78	-5.09	33.10**
	(5.72)	(6.19)	(15.33)
[State=37: VA]	3.48	0.16	25.87**
	(4.75)	(5.14)	(12.74)
[State=38: VT]	19.24***	7.84	38.28**
	(6.24)	(6.75)	(16.72)
[State=39: WA]	7.37	7.67	31.80***
	(4.59)	(4.97)	(12.32)
Provinces of Canada (reference category: State #47: Alberta-AB)			
[State=41: ON]	6.57	11.73	-0.34
	(11.21)	(12.14)	(30.07)
[State=42: QC]	6.36	20.45*	-5.31
	(11.37)	(12.31)	(30.49)
[State=43: BC]	6.11	10.27	-1.24
	(11.37)	(12.31)	(30.48)
[State=44: MB]	7.24	6.94	-1.47
	(13.26)	(14.36)	(35.55)
[State=45: NS]	16.90	15.15	15.30
	(15.31)	(16.58)	(41.06)
[State=46: SK]	-1.62	-4.61	8.88
	(15.19)	(16.45)	(40.74)
Year/reporting cycle (reference category: 3 = last/recent reporting cycle)			
[reporting cycle=1]	-5.23	-1.85	-0.001
	(15.07)	(16.32)	(40.41)
[reporting cycle=2]	-15.48	-3.44	12.50
	(15.07)	(16.32)	(40.41)
Intercept	49.52***	52.9***	102.55***
	(10.88)	(11.78)	(29.17)
Observations:	743	743	743
R-Square:	0.387	0.377	0.323

Adj-R Square:	0.243	0.230	0.164
F-Value:	2.69***	2.574***	2.032***

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.10. Source: Created by the author.

Table 11: Paired Sample Statistics

STARS (Sub-)Ratings	**Mean**	**N**	**Std. Dev.**	**Std. Error Mean**
Last **Total** Rating	66.35	250	10.63	0.67
Prior **Total** Rating	61.03	250	12.50	0.79
Last AC Rating	75.61	250	13.55	0.86
Prior AC Rating	67.91	250	15.85	1.00
Last EN Rating	69.56	250	13.87	0.88
Prior EN Rating	66.47	250	15.75	1.00
Last OP Rating	50.62	250	10.55	0.67
Prior OP Rating	46.33	250	11.44	0.72
Last PA Rating	58.10	250	11.85	0.75
Prior PA Rating	54.09	250	13.38	0.85
Last IN Rating	89.60	250	19.94	1.26
Prior IN Rating	80.15	250	32.01	2.02

Legend: The ratings are all reported based on a 100 % scale (0- lowest and 100%-highest). Source: Created by the author

Table 12: Paired Samples Correlation

STARS (Sub-)Ratings	**N**	**Correlation**	**p-value**
Last **Total** & Prior **Total** Ratings	250	0.87	<0.001***
Last AC & Prior AC Ratings	250	0.77	<0.001***
Last EN & Prior EN Ratings	250	0.73	<0.001***
Last OP & Prior OP Ratings	250	0.82	<0.001***
Last PA & Prior PA Ratings	250	0.77	<0.001***
Last IN & Prior IN Ratings	250	0.61	<0.001***

***: Sig at 1 percent level. Source: Created by the author.

Table 13: Analyses of Paired Sample T-tests and Effect Sizes

Variance in (Sub)Ratings (H_4)	**Mean**	**Std. Dev**	**df**	**t**	**p-value**	**Cohen's d**
Last **Total** - Prior **Total** Rating	5.32	6.25	249	13.48	<001***	0.85
Last AC - Prior AC Rating	7.71	10.15	249	12.01	<001***	0.76
Last EN - Prior EN Rating	3.09	10.94	249	4.47	<001***	0.28
Last OP - Prior OP Ratings	4.29	6.70	249	10.13	<001***	0.64
Last PA - Prior PA Rating	4.01	8.71	249	7.28	<001***	0.46
Last IN - Prior IN Rating	9.45	25.26	249	5.92	<001***	0.37

***: Sig at 1 percent level. **Source**: Created by the author.

The heterogenous impact of energy subsidy reform: The ill targeted nature of energy subsidies in Mongolia

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Abstract

The Mongolian energy sector faces mounting difficulties, with infrastructure dating back to the Soviet era and increasing energy demand surpassing installed capacity. The Government of Mongolia has begun implementing energy sector reforms, including significant electricity tariff increases. However, there is a lack of studies assessing the impact of these changes on inflation and household living costs. This study fills this void by using a microsimulation model based on the 2023 Household Socio-Economic Survey and the 2019 Input-Output Table to analyze the heterogeneous impact of energy subsidy removal on inflation and household living costs. Our findings reveal that current subsidies disproportionately benefit wealthier households, with complete subsidy removal increasing household expenditures by 2.0% on average. The poorest decile faces a 2.4% burden compared to 1.4% for the richest decile. Eliminating these subsidies could increase poverty rates and economic inequality. Interestingly, the government's policy of moderately increasing household electricity prices, shifting some of the burden to the industrial sector, and maintaining subsidies for heating and briquettes imposes a similar burden on household expenses. Although this policy framework reduces the financial burden on low-income populations, it unfairly impacts the livelihoods of rural populations, particularly herders, who do not benefit from energy subsidies, by fueling overall inflation. To mitigate these adverse effects, we recommend targeted support measures for vulnerable populations.

Key words: energy subsidies, household heterogeneity, direct and indirect welfare effect, electricity price elasticities, Mongolia

JEL classification:

Email???

1. Introduction

The Mongolian energy sector is currently experiencing significant challenges. Much of the infrastructure, dating back to the Soviet era, urgently requires modernization. Additionally, with Mongolia's economy growing at an annual rate of 6% over the past 18 years, energy demand has surged. This has led to electricity consumption exceeding the country's installed capacity, necessitating imports from neighboring Russia and China.

Mongolia faces significant challenges in delivering essential public utilities due to its harsh climate, vast territory, and sparse population. Between 2005 and 2023, national electricity consumption increased 3.4 times, with the industrial sector accounting for 62% of total consumption and the residential sector 24%. Currently, 81.6% of households have centralized electricity, and 49.6% have centralized heating. In urban areas, 98.8% of households are connected to the electric grid, compared to 45.5% in rural areas, where many rely on small-scale renewable energy sources like solar panels.

Making matters worse, state-owned energy companies have accumulated substantial losses, limiting their capacity for expansion and productivity improvements. Their reliance on subsidies from the government is increasing and the energy sector has increasingly become a constraint on economic growth and dependent on imports.

This unfortunate combination of increasing demand, limited capacity, increasing subsidies and lack of modernization and funding pose significant risk to the sustainability of the energy sector. It necessitated an increase in electricity tariffs and the prices of its alternative energy sources. Any increase in energy tariffs and prices will have a deep impact on household consumption and the quality of life. In this study, we assess the impact of subsidy removal or energy price increase on household expenditure.

Household energy consumption accounts for up to 7% of total household spending. This encompasses various energy forms such as electricity, heating, and other fuels. Due to its substantial impact on household livelihoods, the government has periodically subsidized energy consumption to prevent cost-push inflation and protect the livelihoods of households

Moreover, thermal energy production doubled for the last 18 years, with the residential sector consuming 36%, trade and services 35%, and the industrial sector 25%. In the capital city of Ulaanbaatar, where half of the country's population resides, 53.0% of households live in detached homes and yurts, who face significant heating challenges during harsh winters. Alternative fuels like gas are limited and expensive, making them impractical for most households. Electricity, despite being heavily subsidized, is not a viable option for home heating due to its supply capacity constraints and high costs. Consequently, households depend on coal for heating, which is a primary contributor to the air pollution in the capital city, making it one of the worst air polluted cities in the world.

Fossil fuel subsidies in Mongolia are provided through state budget, coal price regulation, and off-budget transfers. Direct subsidies to households were around Togrog 400 billion (1.7% of GDP) in 2016 (Freije & Yang, 2018). Residential electricity prices were significantly lower than their costs, resulting in substantial

subsidies and sector losses. Thermal coal prices are also set low, leading to losses for coal mines. Off-budget financial support from state-owned mining companies to households further subsidized the sector.

Despite the significance of subsidies' effect on household expenditure, comprehensive studies measuring the extent of energy subsidies and their impacts in Mongolia remain limited. By examining the impact of subsidy reform under various scenarios, this study aims to identify the heterogenous impact of the subsidy removal or energy price increase. The use of the 2023 Household Socio-Economic Survey (HSES) and the Input-Output Table 2019 provides a robust data foundation for our analysis.

In this study we estimate two scenarios of subsidy removal and its impact on household expenditure. The first scenario analyzes the heterogenous impact of full removal of subsidies on households. This scenario will shed light on how complete removal of subsidies, which leads to an increased revenue for energy sector, affect the household living cost. The second scenario analyzes the heterogenous impact of a moderate increase in electricity prices, which reflects an electricity tariff adjustment implemented by the government in November 2024. This scenario will show us the impact of this policy on inflation and hence, on household living costs, which can also be called an indirect effect. This is particularly of interest to us because increasing energy prices lead to an increased cost of production in other sectors, which will lead to a broader increase in prices or inflation. Also, this energy price increase will directly increase household living cost similarly to the first scenario, which we call direct effect. Combining direct and indirect effects, we estimate the full heterogenous impact of this policy on household living costs. It should be noted, to accommodate households' response to price increase, we will adjust household energy demand by the energy price elasticities in both scenarios.

Our findings show that both the complete removal of subsidies and the existing policy framework lead to an estimated nationwide increase in household spending of around 2.0%. However, the impact on different income groups varies notably, with the current policy being less burdensome for lower-income households.

This paper is structured as follows. Section 2 reviews the empirical findings on the distributional impact of subsidy reform. Section 3 presents the data and methodology used in the study. Section 4 discusses the main findings, comparing the direct and indirect distributional impacts of subsidy reforms across two scenarios and different urban and rural groups. Finally, the conclusion is presented.

2. Literature Review

Since 2010s, international organizations such as the World Bank and International Monetary Fund have increasingly focused on energy subsidy policies in developed and developing countries. Studies by these organizations highlight the significant fiscal burden, market distortions, increased inequality, and environmental harm associated with these subsidies. Despite these challenges, these comprehensive studies emphasize the importance of carefully considering the economic, social, and environmental implications of energy subsidies and implementing well-designed reform strategies (Bacon, Ley, & Kojima, 2010; Clements, et al., 2013).

As micro data availability has improved and energy transition has received greater attention, much empirical research has been done on the heterogenous impact of energy subsidy reform in developing countries. The primary reason for providing fossil fuel subsidies is to support poor households. While supporting poorer households is a common political justification, studies suggest that most of these subsidies favor wealthier households over poorer ones in terms of disposable income (Klaiber, Rentschler, & Dorband, 2023). However, the literature on the impact of fossil fuel-subsidy removal has found varying results. While some studies find deterioration in household welfare and poverty increases, some studies find positive welfare effects and highlight the favorable impact on fiscal burden and opportunity for promoting renewable energy.

Saboohi (2001) estimated the effect of reducing energy subsidies in Iran and argued that the living costs of an average urban household would be increased by 28.7% due to the removal of subsidies. Also, Vecchi and Andriamihaja (2007) estimated the effect of the rise in petroleum prices on the living standards in Madagascar with an Input-Output model. They found that a 17% rise in oil prices would result in 1.75% increase on average in household expenditures (1.5% for high-income households, 2.1% for poor households). Rentschler (2016) assesses the poverty effects of fossil fuel subsidy reform in Nigeria at the regional level. They find that uncompensated subsidy removal would be detrimental to welfare as it would increase the national poverty rate by 3-4%. Heterogenous impacts at regional level are found as some states are particularly vulnerable to price shocks. Giuliano et al. (2020) analyzed the distributional effects of energy subsidy reform in Argentina. They found that while the social tariff introduced to protect vulnerable households is relatively pro-poor, there are still targeting errors. Despite the reform, energy subsidies in Argentina continue to disproportionately benefit wealthier households. Lin and Kuang (2020) investigate the heterogeneous impacts of eliminating energy subsidies on households in China. They found that removing energy subsidies, particularly for electricity and gas, negatively impacts poor households more than rich households. They also found that households with lower income and a higher proportion of consumption to disposable income experience a greater indirect impact from subsidy removal.

However, some studies hold different views, which argue that subsidies reform has a greater negative impact on high-income households. Song et al. (2012) estimated the distribution effect of rising product oil prices in USA. The findings revealed that the impact of higher gasoline and diesel prices mainly affected high-income families, while higher kerosene prices might have a greater impact on poor families. Jiang et al. (2015) found that the distributional impacts of removing subsidies in China vary by fossil fuels, and

Government price controls can reduce the negative impact of energy subsidy reform. Moreover, Freund and Wallich (2016) assessed the welfare effects of energy subsidy reform in Poland and found that the welfare losses of the non-poor caused by rising energy prices are about 2% higher than those of the poor. Amin et al. (2018) investigates the impact of fossil fuel subsidy removal on Bangladesh economy, which is a small, oil-importing country. They find a positive impact on household welfare even when the subsidy is not compensated. They also find improvement in the fiscal burden of the country. Ilias et al. (2022) found that a rise in the prices of electricity causes a significant decrease in the real expenditure of households in all expenditure quintiles. However, the decline is greater for the relatively affluent households than the relatively poor households. They also found that the indirect effect of subsidy removal is far greater as compared to the direct effect.

In addition, some recent studies investigated mitigation measures for negative impacts of subsidy removal. Using Pakistan as a case study, Khalid and Salman (2019) uses a uniform and non-uniform price increase to determine the optimal level of electricity subsidies. Employing a micro-model technique for the calculation of deadweight and welfare losses and introducing a targeted subsidy approach, they identified that the targeted subsidy approach not only generates fiscal savings but also improves the welfare of the vulnerable in society. Antimiani et al. (2023) studies the impact of EU carbon neutrality policy and find that the simultaneous implementation of all instruments under the EU climate strategy including the removal of subsidies to fossil fuels and the reuse of revenues to foster the technological transition of the energy system is a win-win solution.

The issue of energy subsidies reform in Mongolia has not been paid enough attention compared to international studies.

Following Lustig and Higgins (2013), Freije and Yang (2018) used the NSO Household Socio-Economic Survey (HSES) 2016 data to analyze the income distribution effects of energy price subsidies in Mongolia. They found that regulated central heating tariffs were a highly regressive subsidy, with 59% of subsidies benefiting the top three deciles of the population. In contrast, electricity subsidies were less unequal, with 39% going to the top three deciles.

Narantungalag et al (2022) investigates the effectiveness of large electricity subsidies to reduce the consumption of dirty energy and improve ambient air quality. They find that households receiving electricity subsidies increase their (total of subsidized and un-subsidized) electricity expenditure by at least 17 percent more than those who have not received any such benefit. This is an important positive outcome for reducing air pollution, indicating that households change their behavior of daytime and non-winter season electricity consumption, when they do not receive any subsidy.

Using Input-Output 2019 table, Urgamalsuvd and Altanzul (2024) estimated the direct and indirect impacts of electricity price changes on other sector products and the overall price level. They found that a 28% increase in electricity prices for industrial consumers would lead to a 0.7% increase in the general price level. Additionally, a 44.9% increase in coal prices for thermal power plant electricity generation would result in a 0.2% increase in the general price level.

3. Data and Methodology

3.1. Data

To assess the heterogeneous impacts of energy subsidy removal on household welfare, this study utilizes a microsimulation model based on the 2023 Household Socio-Economic Survey (HSES) data. The HSES is a nationally representative and publicly available dataset conducted by the National Statistics Office with methodological support from the World Bank. The sampling design of the HSES employs stratified random sampling, ensuring that households are selected with equal probability. The 2023 HSES includes a total sample size of 8,551 households. Furthermore, additional estimations utilizing HSES data from 2018-2020 will be discussed below in this section.

Table 1 provides descriptive statistics on household energy expenditures, disaggregated by location and dwelling type, offering crucial insights into the varying financial burdens associated with energy consumption across different segments of the Mongolian population.

Table 1. Household energy consumption

		Annual average expenditure, thousand TOGROG				Energy consumption	
	Obs.	Total	Electricity	Coal	Heating	Electricity (kWh/month)	Coal (tonne/year)
Total	**8,551**	**21,068**	**447.1**	**509.0**	**277.1**	**268.7**	**3.7**
By location							
Capital city	2,635	22,868	496.2	562.0	251.8	292.1	3.9
Provincial center	2,299	19,843	397.3	535.6	343.5	249.7	4.1
Rural district	2,016	17,124	361.7	499.3	365.8	219.1	3.7
Countryside	1,600	20,168	329.5	355.2	-	207.1	2.9
By main type of dwelling							
Traditional home	3,078	17,879	328.3	430.8	-	203.4	3.2
Apartment	2,229	25,868	422.4	-	270.5	242.9	-
Detached houses	3,116	19,758	542.5	579.0	449.6	333.6	4.2

Source: Authors' calculation based on HSES 2023 micro data.

As shown in Table 1, households in Ulaanbaatar have the highest average electricity expenditure (Togrog 496.2 thousand or around USD 141 per year) as their electricity consumption per month is 292.1 kWh, the highest, while those in the countryside have the lowest expenditures (Togrog 329.5 thousand or 94 USD) and consumption (207.1 kWh/month). Regarding the centralized heating, apartments have the highest average heating expenditure (Togrog 267.5 thousand or USD 78), whereas traditional dwellings (ger or yurt) and countryside households report no expenditure on heating as all those households are not connected to the centralized heating system. These households rely on coal or wood burning for heating. It should be noted that coal briquettes are used only in the capital city of Ulaanbaatar and raw coal for the rest of the country. The average annual expenditure for households in traditional dwellings or yurts (Togrog 430.8 thousand) is lower than that of households in detached houses (Togrog 579.0 thousand). When considering location, households in the capital city exhibit the highest average annual coal expenditure

(Togrog 562 thousand), while those in rural areas demonstrate the lowest (Togrog 355.2 thousand). For a detailed distribution of household electricity and coal consumption, please refer to Figure A1 in the Appendix.

3.2. Policy simulations

This study employs two distinct simulation scenarios to investigate the effects of energy subsidy reform. The first scenario analyzes the impact of a complete removal of residential energy subsidies across electricity, centralized heating, and briquette fuels. This full removal is projected to result in price increases of 61% for residential electricity, 85% for centralized heating, and 62% for briquette. The second scenario, which is similar to the current policy change, examines the consequences of a partial reduction in residential electricity subsidies, leading to an average price increase of 45% for residential electricity consumers. To mitigate potential adverse effects on household livelihoods, this scenario incorporates a simultaneous 30% increase in electricity tariffs for industrial consumers, while maintaining substantial subsidies for centralized heating and briquette.

As highlighted in the existing literature (Ilyas, Hussain, Ullah, & Xue, 2022; Lin & Kuang, 2020), the removal of energy subsidies affects household cost of living through direct and indirect channels. First, households directly experience higher energy expenditure due to the increased prices resulting from subsidy removal. Second, the cost of other goods and services increases as elevated electricity prices raise production costs and raw material prices thereby increasing overall inflation. As a result, households face higher inflation and elevated expenditures, which we call an indirect effect.

Thus, our first simulation assesses the direct impact of residential energy price increases under complete subsidy removal. In contrast, the second simulation estimates both the direct and indirect impacts of energy price hikes, as it incorporates impacts of simultaneous electricity tariff increases for both residential and industrial consumers.

3.3. Estimating the direct impact of energy price increases

To estimate the direct distributional impact of removing energy tariff subsidies, we use the price-gap approach comparing reference prices with end user prices for consumers. In other words, we calculated the actual costs associated with the production and distribution of electricity, heating, and briquette and used it as the actual effective tariff. Electricity and centralized heating tariffs and costs were obtained from the Energy Regulatory Committee and were calculated at the regional level for greater accuracy.

The electricity tariffs and costs associated with producing and delivering electricity vary accross five regions: Western, Altai-Uliastai, Central, Southern and Eastern. Currently, the cost of electricity is Togrog 222 per kWh in the Central region, where 90% of the electricity is sold. In the Western region, where electricity is fully imported from Russia and accounts for 3% of total electricity sales, the cost is Togrog 309 per kWh. In contrast, the costs are Togrog 258 per kWh in Altai-Uliastai, Togrog 272 per kWh in the Southern region, and Togrog 209 per kWh in the Eastern region. On the other hand, consumer unit price in the Central region is Togrog 141 for residential and Togrog 250 for entities while in the Western region it is Togrog 133 for residential and Togrog 230 for entities (ERC, 2023). In addition to the main electricity

subsidy, there is a separate subsidy for households on the outskirts of Ulaanbaatar, which is in the Central region. This subsidy provides a 50% to 100% discount on nighttime electricity consumption (between 9 PM and 6 AM). However, as this consumption is not separately reported in the household survey, we used the daytime tariff for electricity consumption in our analysis.

The cost of the coal briquette, which is used only in the city of Ulaanbaatar, is calculated based on the balance sheet of Tavan Tolgoi Tulsh LLC which is the only producer of briquette.

Energy consumption data was derived from the energy bills of households connected to centralized electricity, heating, and briquette services, as reported in the household survey.

The full or partial removal of energy subsidies and the subsequent price increase may prompt households to reduce their energy consumption to mitigate the impact on household living costs. The extent of this reduction depends on the price elasticity of households' energy demand. Currently, there is a lack of studies that specifically assesses the price elasticity of electricity and coal demand of households. Therefore, we will quantify this elasticity to evaluate the direct effects of reducing energy price subsidies.

To estimate the elasticity, we construct synthetic panel data from cross-sectional household surveys and estimate the following equation of household energy consumption demand:

$$ln(cons_{ict}) = \beta_0 + \beta_1 \cdot ln(price_{ict}) + \beta_2 \cdot ln(income_{ct}) + \beta_3 \cdot ln(cross\ price_{ict}) + \\ + \gamma \cdot X_{ct} + \alpha_c + \theta_t + \epsilon_{ct} \quad (1)$$

where, $ln(cons_{ict})$ - logarithm of average consumption of energy source i for cohort c at time t, $ln(price_{ict})$ - logarithm of average price of energy source i for cohort c at time t, $ln(income_{ct})$ - logarithm of average household income for cohort c at time t, $ln(cross\ price_{ict})$ logarithm of average price of substitute energy for energy source i, cohort c at time t, X_{ct} - vector of control variables for cohort c at time t (e.g., average household head age, family size, house area etc,), α_c - cohort specific fixed effects (captures time-invariant cohort characteristics), θ_t – time fixed effects, ϵ_{ct} is error term, β_1 is the electricity price elasticity of electricity consumption (our primary interest), β_2 is income elasticity of energy consumption), β_3 is substitute price elasticity of energy consumption, and γ is coefficient for control variables.

It should be noted the time t will take two values 0 and 1 representing before and after tariff increase, whereas i represents electricity or coal. In other words, we estimate demand for both electricity and coal. Coal includes briquettes for only the city of Ulaanbaatar, and regular thermal coal for the rest of the country.

Synthetic cohort data involves tracking the average behavior of groups (cohorts) over time, rather than individual households. In our case, each cohort represents a group of households with similar characteristics. This approach is useful when we lack true panel data but have repeated cross-sectional data. Deaton (1985) proposed treating cohort means as if they were panel data points. While acknowledging that these cohort means contain measurement errors, Verbeek and Nijman (1992)

demonstrated that the inherent grouping of the data can only be reliably disregarded when cohorts are sufficiently large, typically exceeding 100 members.

Cohort definition in this analysis adhered to two primary criteria: homogeneity in energy consumption characteristics within cohorts and sufficiency of number of observations per cohort. Based on the available variables, "province" and "type of housing" were selected as the stratification variables. In other words, these variables were used as the main criteria for creating cohorts. That is if households were in the same “province” while residing in the same “type of housing”, we included them in the same cohort.

With regards to “province”, Mongolia comprises 21 provinces, with the capital city, Ulaanbaatar, further divided into 6 central and 3 remote districts. To ensure adequate and balanced cohort sizes, Govisumber, a small province, was merged with the geographically proximate Dornogovi province, and the three remote districts of Ulaanbaatar were aggregated with the neighboring Tuv province. With regards to the “type of housing”, three primary housing types were identified: *ger* or traditional dwelling, apartments, and detached houses, while other less common housing categories (e.g., public dormitories, non-living quarters) were excluded from the analysis.

To address cases of small cohort sizes for apartment and dwellers and traditional-dwelling households in certain rural provinces, households residing in apartments and traditional-dwelling across 2-3 adjacent rural provinces were combined into single cohorts. For electricity demand analysis, this cohort construction process resulted in a final analytical sample of 66 cohorts, where the minimum cohort size was 102 and the average cohort size was 261. Similarly, for coal demand analysis, this cohort construction process resulted in a final analytical sample of 46 cohorts, where the minimum cohort size was 105 and the average cohort size was 253.

This study utilizes the HSES data from three waves conducted between 2018 and 2020 to analyze the impact of an energy price increase by comparing cohort-level changes in energy consumption before and after the price adjustment. The pooled household data were segmented into two periods: pre-September 2019 and post-September 2019, the latter representing the period when the electricity tariff increase was reflected in household expenditures.

Electricity prices in Mongolia are strictly regulated, with adjustments typically occurring every few years. In July 2019, the Energy Regulatory Committee (ERC) implemented a significant tariff increase, raising electricity prices by 21.8% to 27.7% across five regional grids. Since then, electricity prices have remained unchanged for five years.

In contrast, coal briquette price regulation has been limited to the capital city, Ulaanbaatar, where raw coal was banned since 2019 to mitigate air pollution. The government introduced subsidized coal briquettes as a cleaner alternative for household heating. During the COVID-19 lockdowns in 2021, the government further reduced briquette prices by 75% from their already heavily subsidized levels to alleviate household financial burdens. After the pandemic, briquette prices returned to pre-2021 levels. However, raw coal prices in other cities and rural areas remain unregulated.

In this study, demand elasticities of centralized heating, the sole source for apartment heating, is assumed to be zero. Centralized heating operates on a fixed payment system based on apartment area, independent

of actual consumption due to the absence of individual heat meters. Consequently, changes in heat prices are not expected to affect its consumption levels.

3.4. Estimating indirect impact of energy price increases

To assess the potential indirect effects of electricity price increase for industrial consumers, we estimated the secondary price increases in other goods that might result from the initial electricity tariff rise. For this analysis, we utilized Mongolia's 32x32 input-output table, which provides insights into the interdependencies among various economic sectors.

The price increase in the energy sector would lead to higher prices in other sectors, as energy is a key input for many industries. These secondary price increases would then propagate through the economy as input costs rise in other sectors, creating a chain effect. The total indirect price effect can be estimated using the Leontief input-output price model as shown in Equation (2).

$$\begin{bmatrix} \Delta P_1 \\ \Delta P_2 \\ \vdots \\ \Delta P_{k-1} \\ \Delta P_{k+1} \\ \vdots \\ \Delta P_n \end{bmatrix} = (I - A_{n-1}^T)^{-1} \cdot \begin{bmatrix} a_{k1} \\ a_{k2} \\ \vdots \\ a_{k,k-1} \\ a_{k,k+1} \\ \vdots \\ a_{k,n} \end{bmatrix} \cdot \Delta P_k \quad (2)$$

where, ΔP_i is the price change of i-th sector product, $a_{i,j}$ is the direct consumption coefficient in the Input-Output table *A,* which is the matrix of direct intermediate consumption of domestic products per unit of output, I is the identity matrix and $(I - A_n^T)^{-1}$ is inverse Leontief matrix. In this model, the economy has a total of n sectors. However, to estimate the effect of price change in k-th sector (e.g. energy sector) on other sectors' prices, k-th row and k-th column of matrices and vectors are removed in Equation (2).

To assess the indirect impact of energy price increases on household consumption expenditure, we first calculated the price changes in other sectors' products by using the Input-Output price model (2). Then, using the corresponding relationships between consumption expenditure and economic sectors (see Table A1 in Appendix) and the sectors' weights in value added, we estimated the final indirect impact of consumer price increases induced by energy price increases for industrial sectors.

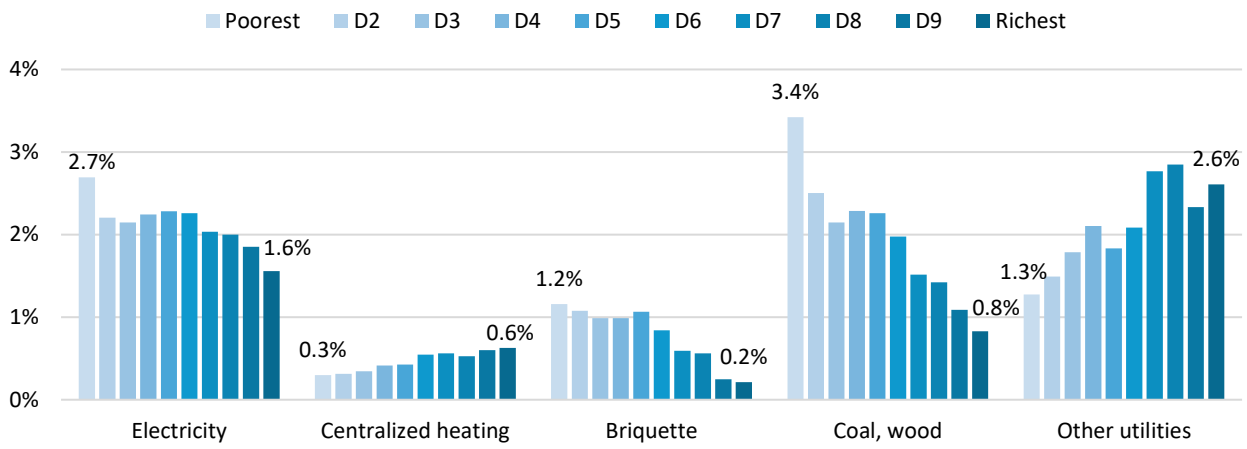
4. Research findings

4.1. Distribution of Fossil Fuel Subsidies

We categorize households into income groups. We used per capita income adjusted for household size using the OECD equivalence scale. This scale assigns a value of 1 to the first adult household member (aged 14 years and over), 0.7 to each additional adult member, and 0.5 to each child. To generalize the study findings into the national scale, we use household survey weight.

Figure 1 illustrates the distribution of electricity and heating costs across different income groups. Notably, households in the lowest income bracket tend to have a higher proportion of their expenditure on electricity and fuels like briquettes, coal, and firewood. In contrast, centralized heating and other utility costs are more prevalent among higher-income households.

Figure 1. Share of electricity and heating costs in household expenditure by income decile



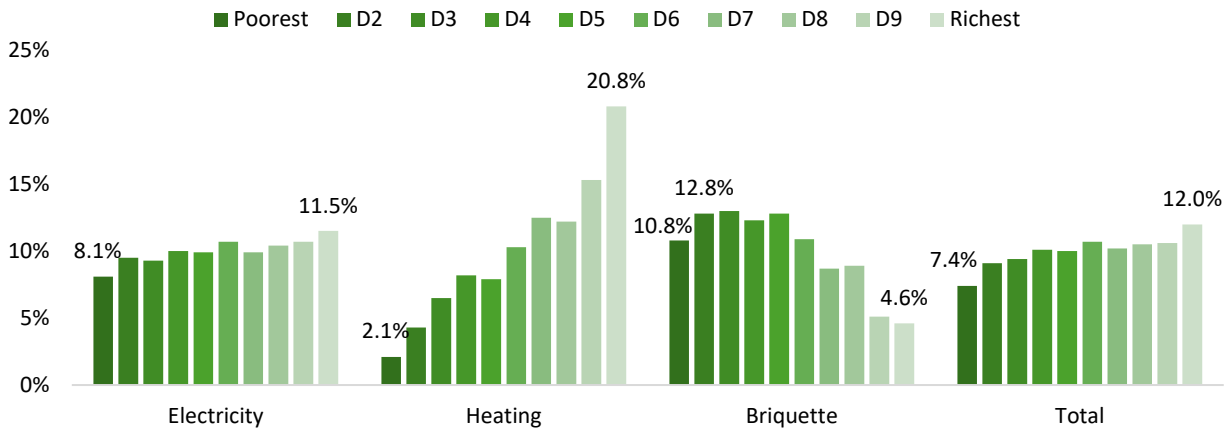
Source: researchers' calculations based on data from HSES 2023

The subsidy for electricity and heating is determined through the price-gap approach, which involves comparing the actual tariffs with the production costs. By quantifying the difference between these two factors and multiplying it by the volume of electricity consumed, the level of subsidies can be calculated.

In our calculation, energy subsidy policies tend to benefit richer households more significantly. In terms of electricity subsidies, 8.1% of the total subsidy is allocated to the poorest decile, whereas the richest decile receives 11.5%. The variation is greater for centralized heating subsidies, with the wealthiest 3 deciles receiving 48.3% of the total subsidy, while only 12.9% being allocated to the poorest 3 deciles. These findings align closely with the research conducted by Freije and Yang (2018). For briquette, the distribution of subsidy is in opposite to centralized heating, with the poorest 3 deciles receiving 36.6% of the total subsidy, while 18.6% being allocated to the wealthiest 3 deciles. It is related to the fact that households residing in apartments connected to the centralized heating have significantly higher income than those who live in detached houses and yurts (see Figure A2 in Appendix). In other words, richer households living

in apartments benefit more from electricity and heating subsidies while poorer households living in detached households in Ulaanbaatar benefit more from briquette subsidies.

Figure 2. Distribution of energy subsidy in income groups



Source: Researcher's estimation based on data from HSES 2023 data

During Covid-19, between November 2020 to June 2022, the government decided to assume responsibility for the electricity and heating bills of households to provide income support. It was established that the support will be the same amount of bill paid during the previous year. Therefore, the richer households benefitted even more from these additional subsidies. During the pandemic, the price of improved briquettes for households in *ger* (yurt) areas was reduced by 75% from its subsidized level. This support was, however, more beneficial to poor and middle-income households. Therefore, in 2021 and 2022, total subsidies were distributed more equally due to the additional supportive measures namely briquette subsidies for the outskirts area of the capital city. Poor and middle-income households receive more subsidies because those households in the capital city tend to live in ger (yurt) or detached houses and use briquettes.

4.2. Household Energy Demand Elasticities

The energy demand estimation results of equation (1) are presented in Table 2. The dependent variables are specified as monthly electricity consumption (in kWh) for electricity demand and annual coal/briquette consumption (in tons) for coal demand. The regressors include energy prices and household income, along with several control variables: housing characteristics (living area in square meters and number of rooms), household demographics (number of members, number of children, and the age and marital status of the household head), and time dummies.

To determine the appropriate estimation method, we conducted Hausman specification tests. For electricity demand, the test results ($\chi^2 = 16.9$, $p = 0.076$) support the use of a random effects model. In contrast, for coal demand, the test ($\chi^2 = 24.8$, $p = 0.002$) indicates that a fixed effects approach is more appropriate.

For electricity, the estimated own-price elasticity (β_1) is −0.379 (statistically significant at the 5% level) for all households, indicating that, on average, a 1% increase in electricity price leads to a 0.38% decrease in electricity consumption. However, price elasticities vary across household groups. For instance, the coefficient is −0.043 (statistically insignificant) for apartment dwellers but −0.447 (significant at the 10% level) for those living in *gers* (yurts) and detached houses. These estimates align with the range reported in international studies. For example, Pereira *et al.* (2019), in their review of over 20 empirical studies, found short-term price elasticities of electricity ranging from −0.02 to −0.84 across various countries and methodologies. Similarly, Jia and Xu (2021) reported a range of short-term price elasticities from −0.07 to −2.64 in their review of over 30 empirical studies.

Table 2. Estimated price and income elasticities of household energy demand

	Electricity			Coal		
	All	Apartment	Ger/House	All	Ger	House
β_1	-0.379**	-0.043	-0.447*	-0.339***	-0.223	-0.527***
	(0.188)	(0.273)	(0.253)	(0.081)	(0.143)	(0.177)
β_2	0.141*	0.131	0.126	0.128*	-0.014	0.121
	(0.085)	(0.116)	(0.132)	(0.070)	(0.148)	(0.154)
β_3	-0.001	-0.004**	0.039	0.169	0.133	0.393
	(0.002)	(0.002)	(0.065)	(0.142)	(0.179)	(0.290)
House size	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	Yes	Yes	Yes	Yes	Yes	Yes
Period fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R^2 adj.	0.688	0.677	0.644	0.311	0.244	0.490
Obs	132	40	92	92	44	48

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors estimation based on NSO's HSES 2018-2020 primary data.

Similarly, for coal, the own-price elasticity (β_1) is −0.339 (significant at the 1% level). Disaggregated by dwelling type, the coefficient is −0.223 (insignificant) for *ger* residents but −0.527 (significant at 1%) for those in detached houses.

The income elasticity of energy consumption (β_2) exhibits a positive coefficient, as expected, in most cases. However, the values are small (0.13–0.14) even when statistically significant, suggesting that electricity and coal consumption are relatively income-inelastic. A 1% increase in household income corresponds to only a 0.13–0.14% rise in energy consumption.

Regarding cross-price elasticities (β_3), the results for coal align with expectations. The coefficient is 0.169 for all households, implying that a 1% increase in electricity price induces a 0.17% rise in coal consumption as households substitute coal for heating and cooking. This effect varies by dwelling type, with detached-house residents exhibiting a higher elasticity (0.393), compared to *ger* residents (0.133). In contrast, electricity's cross-price elasticity shows a negligible negative value, contrary to expectations but economically insignificant.

To verify the robustness of these results, we estimated several specifications for electricity demand, including pooled OLS and panel regression models with different control variables. The results are

presented in Table A2 in the Appendix. From this analysis, the own price elasticity consistently shows the expected negative sign, indicating that electricity demand decreases as prices increase. However, the elasticity is inelastic across all specifications, with the coefficient β_1 ranging from -0.15 to -0.38. Conversely, the income elasticity is positive and also inelastic for all specifications, with the coefficient β_2 ranging from 0.14 to 0.39. For coal price (cross-price) elasticity, the results indicate a value of 0 across all specifications, suggesting no significant substitution effect between electricity and coal.

4.3. Impact of Removing Energy Subsidies

To assess the impact of removing or reducing household energy subsidies we consider two simulations: 1) Full removal of household energy subsidies; 2) Moderate increase in electricity prices for residentials and shift some of burden to industries by increasing prices for entities.

Simulation 1

In the first simulation, we eliminated all household energy subsidies, encompassing electricity, heating, and briquette. This resulted in a substantial price increase on average: residential electricity prices rose by 61%, centralized heating price by 85%, and briquette prices by 62%.

The simulation results for the complete removal of subsidies are presented in Table 3. On average, the removal of electricity subsidies imposed a burden of 1.2% on household expenditures, while heating and briquette subsidies each accounted for 0.4%. Overall, the elimination of energy subsidies led to a 2.0% increase in household expenditures, even when accounting for the decrease in energy demand based on own and cross prices elasticities.

Table 3. Increases in living cost of after fully removing all energy subsidies for residential, %

Income group	Total impact	Electricity			Heating		Briquette	
		All	Urban	Rural	All	Ulaanbaatar center	All	Ulaanbaatar ger area
Poorest	2.4	1.6	2.1	1.2	0.2	1.6	0.6	2.7
D2	2.1	1.3	1.7	0.6	0.2	1.3	0.6	2.2
D3	2.2	1.3	1.5	0.7	0.3	1.3	0.6	2.1
D4	2.2	1.3	1.5	0.8	0.3	1.2	0.6	1.9
D5	2.2	1.3	1.5	0.8	0.4	1.1	0.4	2.1
D6	2.0	1.2	1.3	0.7	0.4	1.0	0.4	1.5
D7	1.9	1.1	1.3	0.8	0.4	0.9	0.3	1.5
D8	1.8	1.1	1.1	1.0	0.5	0.8	0.2	1.4
D9	1.5	0.9	1.0	0.5	0.5	0.8	0.2	1.1
Richest	1.4	0.8	0.9	0.6	0.5	0.7	0.1	0.8
All	**2.0**	**1.2**	**1.4**	**0.8**	**0.4**	**1.1**	**0.4**	**1.7**

Source: Authors' calculation based on simulation

However, these average impacts vary significantly across different household groups. Overall, poorer households experience a disproportionately higher burden if the government were to eliminate all residential energy subsidies. For instance, the burden on living costs amounts to 2.4% of household expenditure for the poorest decile, compared to 1.4% for the richest decile.

When examining individual energy sources, the burden of electricity subsidy removal is particularly pronounced, with the poorest decile facing a 1.6% increase in costs compared to only a 0.8% increase for the richest decile. Given that urban households have greater access to central electricity grids, the removal of electricity subsidies has a more significant negative impact on urban households than on rural ones. Specifically, urban households experience a 1.4% increase in expenditures, while rural households face a 0.8% increase. However, the disproportionate burden across income groups is similar in both urban and rural areas. The poorest decile in urban areas bears a 2.1% burden, compared to 1.2% for rural areas. Conversely, the richest decile in urban areas faces a 0.9% burden, while rural households in the richest decile experience only a 0.6% increase.

For briquette, the disparity in the impact of subsidy removal is pronounced, with the poorest decile bearing a 0.6% burden compared to 0.1% for the richest. This analysis encompasses all households. However, when focusing solely on households residing in the Ulaanbaatar outskirts that utilize briquette for heating and receive the briquette subsidy, the calculated expenditure burden of removing this subsidy is significantly higher, averaging 1.7%. Moreover, the burden varies considerably across income groups within this specific population. The poorest decile households residing in Ulaanbaatar's ger areas face a substantial 2.7% burden, while the richest decile households experience a 0.8% increase.

In contrast to the regressive impact of electricity and briquette subsidy removal, the elimination of heating subsidies exhibits a generally progressive effect, with the poorest decile facing a 0.2% increase in costs and the richest decile experiencing a 0.5% increase. This progressive pattern can be attributed to the tendency of wealthier households to reside in dwellings connected to centralized heating systems, thereby benefiting more from heating subsidies. However, it's crucial to remember that the total value of heating subsidies is typically lower than those for electricity and briquette across all income levels. Consequently, the complete elimination of energy subsidies would still result in a regressive policy, disproportionately affecting poorer households. Moreover, if we focus exclusively on households residing in the capital city's central areas, who constitute the vast majority of heating subsidy beneficiaries, the regressive nature of the policy becomes apparent. The poorest decile in the Ulaanbaatar central areas faces a 1.6% burden, while the richest decile experiences only a 0.7% increase in household expenditure.

Simulation 2

In the second simulation, we modelled a scenario with moderate electricity price increases compared to Simulation 1, which reflects recently adjusted electricity tariff. Specifically, we assessed the impact on household living costs stemming from an average 45% increase in residential electricity prices and a 30% increase for industrial consumers. Unlike Simulation 1, this analysis maintained the assumption that government subsidies for briquette and heating would continue.

This policy scenario has a less detrimental direct impact on household finances due to the relatively modest electricity price increases and the continuation of subsidies for briquette and heating. Households are also expected to adapt behaviorally by reducing their electricity consumption, although the extent of this reduction may be limited. However, the increased energy prices for industrial consumers are likely to elevate production costs across various economic sectors, as electricity and heating are essential inputs. These higher industrial costs can contribute to inflationary pressures (See Table A3 in Appendix). Given the varying energy intensity among sectors, the resulting increases in final product prices will also differ. Consequently, these indirect, cost-driven price effects will ultimately impact households heterogeneously, depending on their specific consumption patterns.

Simulation result of this policy is presented in Table 4. The direct impact stems from increased residential energy prices adjusted by own and cross price elasticities of energy sources, while the indirect impact results from higher inflation caused by increased industrial energy costs. On average, the total impact of the increase in electricity and heating prices is less than in the previous scenario, with households experiencing a 2.0% expenditure burden. The direct effect is greater than the indirect effect, with a 1.2% burden from household electricity tariff changes and a 0.8% burden from industrial electricity tariff changes.

Table 4. Impact of the current policy shock on household living costs, %

Income	All households			Urban			Rural		
group	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect
Poorest	2.1	1.4	0.7	2.7	1.9	0.7	1.5	0.8	0.7
D2	2.1	1.3	0.8	2.6	1.8	0.8	1.2	0.4	0.7
D3	2.0	1.2	0.8	2.3	1.5	0.8	1.2	0.5	0.8
D4	1.9	1.1	0.8	2.3	1.5	0.8	1.3	0.6	0.8
D5	2.1	1.3	0.8	2.5	1.6	0.8	1.3	0.5	0.8
D6	2.0	1.2	0.8	2.2	1.3	0.9	1.3	0.5	0.8
D7	2.1	1.2	0.9	2.4	1.5	0.9	1.4	0.6	0.8
D8	2.0	1.1	0.9	2.2	1.3	0.9	1.4	0.6	0.8
D9	1.8	0.9	0.9	1.9	1.0	0.9	1.1	0.3	0.8
Richest	1.8	0.9	0.9	1.9	1.0	0.9	1.4	0.6	0.8
All	2.0	1.2	0.8	2.3	1.5	0.8	1.3	0.5	0.8

Source: Authors' calculation based on simulation

The overall impact of the policy measure exhibits slight regressivity across income deciles, with the lowest decile incurring a 2.1% burden compared to 1.8% for the highest decile. However, the direct and indirect effects demonstrate distributional heterogeneity. Specifically, increases in residential electricity prices display a regressive pattern, imposing a 1.4% burden on the poorest decile and 0.9% on the wealthiest. Conversely, the indirect effects stemming from increased industrial electricity prices are slightly progressive, resulting in a 0.7% burden for the lowest income decile and 0.9% for the highest.

Due to variations in electricity expenditure shares, urban households experience a more substantial impact from the price increases (2.3%) than their rural counterparts (1.3%). This difference in cost shares also underlies distinct direct and indirect effects for these groups. In urban areas, the direct effect of

energy price hikes contributes 1.5% to household budgets, while the indirect effect adds 0.8%. In contrast, rural households experience more burden from indirect effect with a 0.8% increase in expenditure than direct effect with 0.5%. The direct impact of the policy is more regressive in urban settings compared to rural areas. Conversely, the indirect impact demonstrates a marginally progressive effect in both urban and rural contexts.

Given the concentration of residential energy subsidies in the capital city, it is essential to examine the impact of electricity price increases on households residing in Ulaanbaatar. Table 5 presents the effects of electricity price increases on living costs by household groups. We divide Ulaanbaatar into central and outskirt areas.

On average, the impact of the policy measure on households in the Ulaanbaatar outskirts is much more than in central areas, with a 2.8% and 2.0% cost burden, respectively. Moreover, this burden is distributed unevenly across income groups in these two areas. Specifically, the poorest decile households in the central area face a 2.6% burden, while the richest decile households experience a 1.6% burden. In contrast, households in the outskirt areas exhibit a less pronounced variation, with the poorest decile facing a 3.1% burden and the richest decile facing a 2.9% burden.

When decomposing the total impact, the uneven distribution can be primarily attributed to the direct impact of increased residential electricity prices. The poorest decile households in the central area face a 1.7% burden directly from increasing electricity costs, compared to 0.6% for the richest decile households. Households in the outskirt areas exhibit a less pronounced variation, with the poorest decile facing a 2.4% burden and the richest decile facing a 2.1% burden.

Regarding the indirect impact, price increases across all products and services due to the industrial electricity price increase have a relatively even effect on household income groups. However, the indirect impact is slightly higher among higher-income groups in the central area compared to lower-income groups in that area and all income groups in the outskirts.

Table 5. Impact of the current policy shock on household living costs in Ulaanbaatar, %

Income group	Central area			Outskirts		
	Total	Direct	Indirect	Total	Direct	Indirect
Poorest	2.6	1.7	0.9	3.1	2.4	0.7
D2	2.3	1.4	0.9	2.8	2.0	0.8
D3	2.2	1.3	0.9	2.8	2.1	0.8
D4	2.0	1.1	0.9	2.3	1.5	0.8
D5	2.0	1.0	0.9	2.4	1.6	0.8
D6	1.8	0.9	0.9	2.9	2.1	0.8
D7	1.7	0.8	0.9	2.6	1.8	0.8
D8	1.7	0.8	1.0	3.3	2.4	0.8
D9	1.7	0.7	1.0	2.8	2.0	0.8
Richest	1.6	0.6	1.0	2.9	2.1	0.8
Total	2.0	1.1	0.9	2.8	2.0	0.8

Source: Authors' calculation based on simulation

A comparative analysis of the two policy simulations reveals that the average impact on national household expenditures is remarkably similar. Both the full subsidy removal scenario (Simulation 1) and the current tariffs (Simulation 2) result in an estimated additional expenditure burden of approximately 2.0% for households nationwide. This convergence in average impact occurs despite the intention of the current policy (Simulation 2) to reallocate some direct costs from households to businesses while maintaining subsidies for centralized heating and processed coal briquettes. Our analysis suggests that the indirect financial burden imposed on households through consequent inflation effectively matches the burden shifted to businesses as the policy retained heating and briquette subsidies.

Despite the comparable average impact, the distributional consequences differ significantly. The current policy exhibits a less regressive effect compared to the scenario involving complete energy subsidy removal. This outcome is primarily attributable to several factors within the current policy framework. Firstly, Simulation 2 maintains the targeted subsidy for processed coal briquettes, which predominantly benefits lower-income households residing in the *ger* (yurt) districts of Ulaanbaatar, thereby introducing a progressive element. Although the fiscal cost of the briquette subsidy is substantial, potentially exceeding that of the centralized heating subsidy, its targeted nature contrasts with the heating subsidy for apartment dwellers, which also remained unchanged but is generally considered regressive. Furthermore, the recent adjustment to the residential electricity tariff, establishing a three-tiered tariff to regulate the electrical system overload, enhances the overall progressivity of energy pricing under the current policy compared to a scenario with no subsidies and simpler tariffs. This structure imposes significantly higher marginal rates on consumption exceeding 150 kWh and particularly 300 kWh per month, further mitigating the burden on low-consumption households.

However, the implementation of the current policy presents distinct challenges for specific demographic groups, particularly rural and herder households. These populations experience an increased financial burden primarily through indirect inflationary effects rather than direct changes in energy costs. Herder households derive minimal direct benefit from the major energy subsidy programs, as they typically reside off-grid, lacking connections to centralized electricity and district heating networks. Their energy needs are often met through independent solar PV systems for basic electricity and biomass fuels (such as firewood and animal dung) or raw coal purchased at market prices for heating and cooking. Crucially, the subsidized briquette program is geographically restricted to Ulaanbaatar, excluding rural consumers. Consequently, policy measures that reduce energy costs for beneficiaries connected to centralized systems can inadvertently shift the economic burden, via inflation, onto non-beneficiary population like herders. This raises significant equity considerations regarding the distribution of costs and benefits associated with national energy subsidy reforms.

These findings underscore the necessity for a carefully designed and sequenced energy subsidy reform strategy that explicitly accounts for the heterogeneous impacts across different socio-economic groups and minimizes adverse macroeconomic consequences. Effective reform should prioritize measures beyond simple cost reallocation.

5. Conclusion

Mongolia's fossil fuel subsidy policies are regressive, disproportionately benefiting wealthier households while burdening poorer ones. Despite being moderate by global standards, these subsidies, particularly for centralized heating, may exacerbate income inequality. Although briquette subsidies primarily benefit poorer households, they contribute significantly to air pollution in Ulaanbaatar, necessitating long-term alternative strategies.

In our microsimulation analysis, both the full subsidy removal scenario and the current policy framework result in an estimated additional expenditure burden of approximately 2.0% for households nationwide. However, the distributional consequences differ significantly, with the current policy being less regressive.

The analysis also indicates that while the current energy policy framework offers the notable advantage of mitigating the immediate financial burden on low-income households compared to a full subsidy elimination scenario, it presents several significant drawbacks that challenge its long-term viability and overall economic efficiency. Firstly, the current policy continues substantial ongoing fiscal costs, maintaining significant budgetary commitments by retaining subsidies for centralized heating and processed coal briquettes, alongside implicit subsidies within the lower tiers of the electricity tariff structure. Secondly, the strategy of reallocating direct energy costs from households to the industrial sector fails to decrease the average household expenditure burden due to counteracting inflationary pressures resulting from increased operational costs for businesses. Thirdly, raising electricity tariffs for industrial consumers may adversely impact business competitiveness, investment, and overall economic activity.

Effective reform should prioritize measures beyond simple cost reallocation. Key policy recommendations include targeted subsidy reform, tariff rationalization, demand-side management, supply-side efficiency, and cost reduction. Addressing these aspects concurrently is crucial for navigating Mongolia's energy transition effectively, ensuring that subsidy reforms contribute to long-term fiscal sustainability, economic efficiency, and social equity.

Thus, any decision to reform or eliminate fossil fuel subsidies in Mongolia should be carefully considered, with a focus on mitigating the negative impacts on vulnerable households and implementing targeted support measures to ensure a just transition. Redirecting savings from subsidy elimination to support vulnerable families through direct cash transfers, food vouchers, or expanded education and health programs can help achieve this goal.

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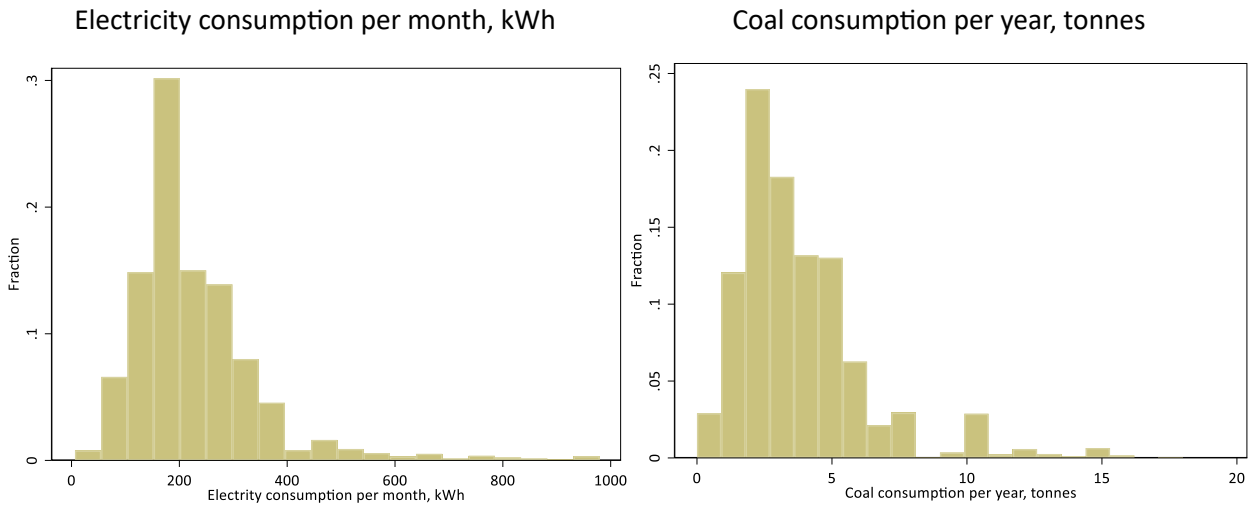
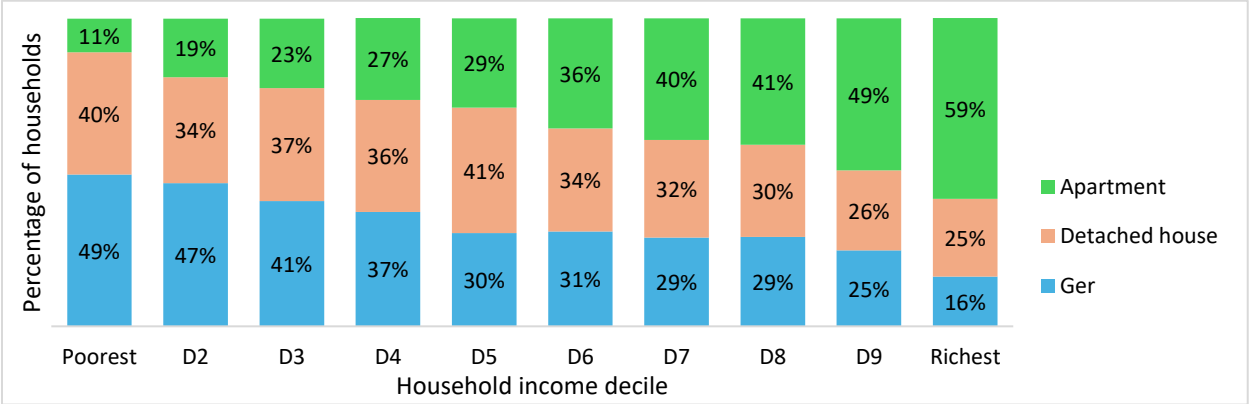
Appendix

Figure A1. Household energy consumption distributions



Source: Authors' calculation based on HSES 2023

Figure A2. Type of house and income



Source: Authors' calculation based on HSES 2023

Table A1. The corresponding relations between household expenditure and economic sector

Expendire items	Production sectors
Food	Crop production, related service activities; Animal production, hunting; Forestry and fishing; Manufacture of food products;
Beverages and tobacco	Manufacture of beverages and tobacco
Clothes	Manufacture of textiles; wearing apparel; leather and related products
Residence	Mining of coal, crude petroleum and metal ores, and other mining; Manufacture of other non-metallic mineral products and metal products; Other manufacturing; Other manufacture; Construction
Medicine and medical services	Human health and social work activities
Education	Education; Manufacture of wood, paper and related products; printing and reproduction of recorded media
Electricity and heating	Electricity, gas, steam and air conditioning supply
Water supply; sewerage, waste management	Water supply; sewerage, waste management and remediation activities
Finance and insurance services	Financial and insurance activities
Information and communication services	Information and communication
Hotel and restaurant services	Accommodation and food service activities
Traveling and transportation services	Transportation and storage; Manufacture of coke and refined petroleum products; chemicals and chemical products; Manufacture of machinery and equipment; Wholesale and retail
Entertainment services	Arts, entertainment and recreation
Other	Real estate activities; Professional, scientific and technical activities; Administrative and support service activities; Public administration and defense; compulsory social security; Other service activities

Table A2. Estimated price and income elasticites of household electricity demand

Dependent variable – Log(electricity consumption)	(1)	(2)	(3)	(4)	(5)
Log(electricity price)	-0.147	-0.374***	-0.264***	-0.276***	-0.379**
	(0.166)	(0.076)	(0.078)	(0.082)	(0.188)
Log(real income)	0.214***	0.391***	0.175**	0.146*	0.141*
	(0.081)	(0.063)	(0.071)	(0.078)	(0.085)
Log(coal price)	-0.002	-0.001	-0.001	-0.001	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Log(house area)	0.117		0.181**	0.173**	0.175**
	(0.086)		(0.085)	(0.087)	(0.087)
Number of room	0.193***		0.202***	0.203***	0.203**
	(0.067)		(0.068)	(0.078)	(0.080)
Family size	0.159*			0.105	0.112
	(0.096)			(0.072)	(0.077)
Number of children	-0.016			-0.035	-0.050
	(0.177)			(0.103)	(0.106)
Age of household head	-0.221			-0.331	-0.329
	(0.257)			(0.225)	(0.224)
Age square of household head	0.002			0.003	0.003
	(0.003)			(0.002)	(0.002)
Household head married	0.036			-0.015	-0.028
	(0.282)			(0.205)	(0.211)
Period 2 (Period 1 = 0)	-0.029				0.022
	(0.047)				(0.045)
constant	6.527	0.712	2.692***	10.760*	11.319*
	(6.597)	(0.868)	(0.980)	(5.546)	(5.902)
Adjusted R^2	0.709	0.522	0.656	0.670	0.688
Obs	132	132	132	132	132

Note: Specification (1) refers to a Pooled OLS medel. Specification (2) to (6) are estimated using random effect panel regressions and differ only in the controls used.

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A3. Price changes of other sectors product when industrial electricity price increased by 30%

#	Economic sector	Price change
1	Crop production, related service activities	0.8%
2	Animal production, hunting	0.2%
3	Forestry and fishing	1.3%
4	Mining of coal and crude petroleum	0.5%
5	Mining of metal ores	0.8%
6	Other mining and quarrying	0.4%
7	Mining support service activities	0.4%
8	Manufacture of food products	0.4%
9	Manufacture of beverages and tobacco	1.7%
10	Manufacture of textiles; wearing apparel; leather and related products	0.8%
11	Manufacture of wood, paper and related products; printing and reproduction of recorded media	1.1%
12	Manufacture of coke and refined petroleum products; chemicals and chemical products	0.4%
13	Manufacture of other non-metallic mineral products and metal products	2.8%
14	Manufacture of machinery and equipment	0.8%
15	Other manufacturing	1.6%
16	Water supply; sewerage, waste management and remediation activities	4.2%
17	Construction	1.2%
18	Wholesale and retail trade; repair of motor vehicles and motorcycles	0.8%
19	Transportation and storage	0.4%
20	Accommodation and food service activities	1.0%
21	Information and communication	1.3%
22	Financial and insurance activities	0.6%
23	Real estate activities	0.4%
24	Professional, scientific and technical activities	0.9%
25	Administrative and support service activities	2.1%
26	Public administration and defence; compulsory social security	0.7%
27	Education	2.1%
28	Human health and social work activities	1.4%
29	Arts, entertainment and recreation	3.2%
30	Other service activities	1.6%
31	Other activities	0.0%

Source: Authors' calculation based on Input-Output table of Mongolia 2019

The impact of citizenship on intermarriage: evidence from Italy*

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Abstract

Acquiring citizenship is associated with better economic and social opportunities for immigrants. This paper examines how, in a country with a large fraction of migrants, marriage decisions respond to a change in the legal status of foreign residents. The variation in the relationship between citizenship status and the propensity for mixed marriages could be influenced by the dominance of either the assimilation hypothesis or the status exchange hypothesis. Using individual-level data from the populated municipality of Modena, Emilia-Romagna (Italy), we find that the assimilation hypothesis prevails: the more immigrants integrate into host countries, the more likely they are to marry natives. Specifically, our results show that acquiring citizenship not only increases the likelihood of marriage but also significantly boosts the formation of mixed couples.

Keywords: Citizenship; intermarriage; foreign population; administrative data.

JEL: J12; J15; O15.

*The usual caveat applies. The views expressed here are those of the authors and do not reflect those of the institutions with which the authors are affiliated.

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1 Introduction

In recent decades, migration flows and the proportion of foreign-born populations have increased significantly, not only in traditional immigration countries such as Australia, Canada, and the United States but also in other developed economies. As a result, many European countries now host a substantial foreign-born population, a trend that is expected to persist over time (Choi et al., 2012).

Historically a country of emigration, Italy has undergone a profound transformation in recent decades, emerging as a major destination for immigrants from various regions of the world (Azzolini and Guetto, 2017). This shift has not only altered the demographic composition of the population but has also had significant implications for the labor market and social policies.

The increasing presence of foreign-born residents has fueled extensive academic and political debates in Italy, with particular attention to immigrants' integration into the labor market, their contribution to the economy, the requirements for citizenship acquisition, and the social tensions arising from rapid demographic changes. While immigration has been associated with economic growth and demographic rejuvenation, it has also raised concerns about its potential effects on native workers' employment and wages, as well as on the welfare system (Zaiceva and Zimmermann, 2016). Moreover, immigrant integration remains a key issue on the political agenda.

Without effective economic, political, and social integration, immigrants risk marginalization and may not fully benefit from the opportunities provided by the host country. From the host country's perspective, the failure to integrate immigrants poses significant challenges, ranging from fiscal burdens to ghettoization and social tensions, particularly if immigrants are poorly integrated or perceived by natives as a threat to jobs, housing, or cultural traditions. Integration, in all its dimensions, depends on immigrants' preferences and choices but is also strongly influenced by the opportunities provided by the host country to facilitate and promote this process. These opportunities are, in part, shaped by policies designed to support immigrants' inclusion, among which access to citizenship plays a crucial role. Citizenship represents the most significant privilege a host country

can grant to its immigrant population. Acquiring it not only fosters immigrants' integration by encouraging them to invest in their future in the host country but also shifts their reference models and reduces discrimination from native citizens.

Citizenship acquisition is widely recognized in the literature as a key factor in reducing the social distance between immigrants and natives. From an economic perspective, citizenship provides immigrants with greater security and long-term stability in the host country (Sajons, 2016), improving their access to the labor market through higher employment rates (Fougère and Safi, 2009; Corluy et al., 2011), entry into more prestigious jobs, and higher wages (Chiswick, 1978; Kogan, 2003; Gathmann and Keller, 2014). However, the impact of citizenship extends beyond the labor market. From a socio-cultural perspective, citizenship increases the likelihood that immigrants will develop stronger ties with natives due to a greater sense of belonging to the host country (Bloemraad et al., 2008) and higher civic participation (De Rooij, 2012). Additionally, an improved legal status can contribute to reducing deviant behaviors (Mastrobuoni and Pinotti, 2015).

To the best of our knowledge, the formation of mixed marriages remains a relatively underexplored topic, particularly in the Italian context. From a theoretical standpoint, the relationship between citizenship status and the propensity to enter mixed marriages may be influenced by either the assimilation hypothesis or the status-exchange hypothesis. According to the former, the more immigrants integrate into the host country, the more likely they are to marry native citizens. However, the status-exchange hypothesis suggests that in contexts of low integration, immigrants might use marriage as a means to improve their prospects for inclusion in the host country. In this case, higher levels of integration would reduce the likelihood of immigrants entering mixed marriages.

In addition to investigating the relationship between citizenship and couple formation, this study also focuses on another potential effect that obtaining local citizenship may have on both demographic and economic decisions within the couple's life. Among the wide range of possible decisions, and given the nature of the data used in this analysis, we focus on fertility behavior among couples in which at least one partner acquires Italian citizenship. The underlying assumption is that citizenship acquisition, as a mechanism of integration, may lead naturalized immigrants to adopt fertility patterns more closely

aligned with those of native Italians. Since fertility rates have been steadily declining among Italian couples (ISTAT, 2023), while foreign-born individuals generally exhibit higher fertility levels often due to cultural factors (Mussino and Ortensi, 2019), we investigate whether obtaining citizenship is associated with a reduction in fertility among naturalized immigrants. The existing literature has primarily focused on the relationship between migration background and fertility rates, highlighting how, upon arrival in the host country, the country of origin and the type of residence permit influence the decision to have children (Mussino and Strozza, 2012).

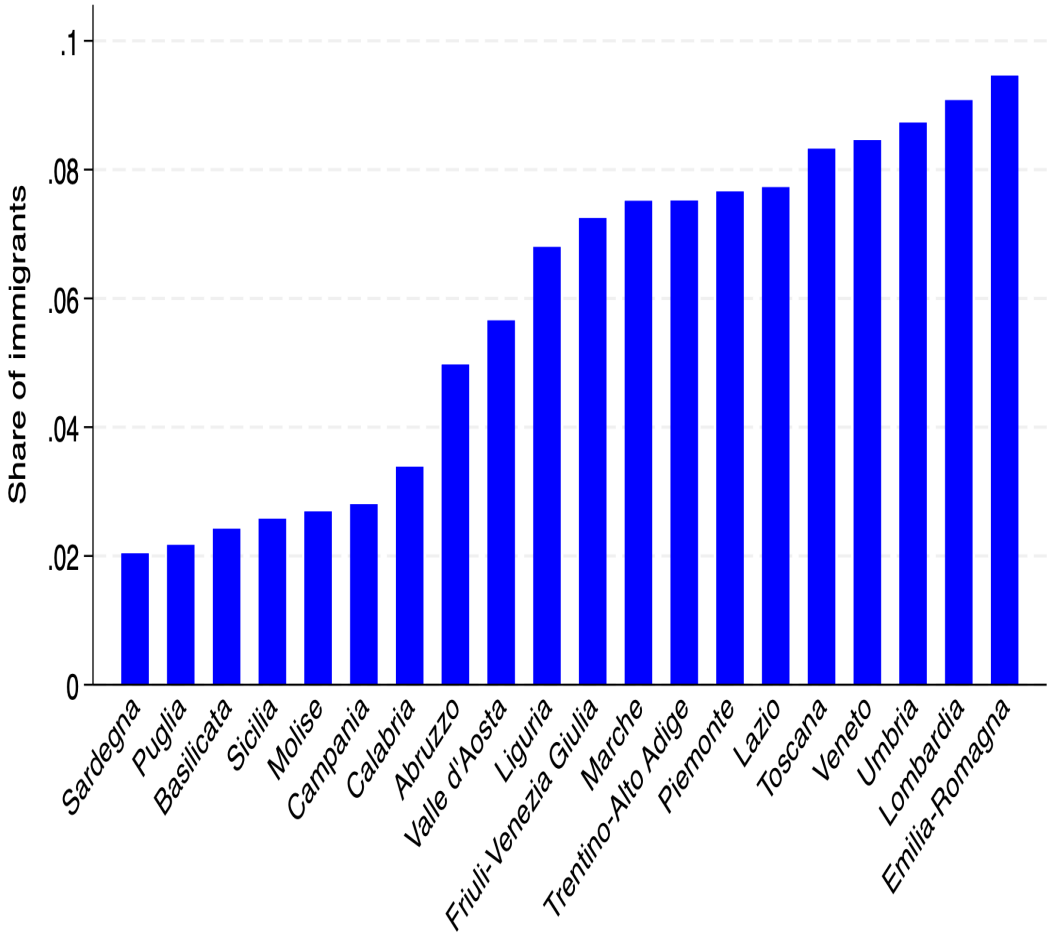
This study focuses on the Italian case as an interesting context and provides causal evidence on the relationship between integration and mixed marriages by analyzing an exogenous change in immigrants' legal status: citizenship acquisition. Furthermore, it contributes to the literature on the effects of citizenship on fertility, expanding the understanding of cultural assimilation mechanisms.

The remainder of the paper is organized as follows: Section 2 presents the case study; Section 3 discusses the data and sample; Section 4 outlines the empirical approach and identification strategy; the main results are reported in Section 5, while Section 6 includes robustness checks; Section 7 presents the results on fertility choices; finally, Section 8 concludes the paper.

2 The case study

As of January 1, 2023, approximately 5 million foreign citizens reside in Italy, accounting for 8.7% of the total population. However, the distribution of the foreign population is not uniform across the national territory. The majority of foreign residents are concentrated in the regions of Central and Northern Italy, where the economic and social fabric has historically created a greater attraction for migratory flow. Among these regions, Emilia-Romagna stands out as the one with the highest proportion of foreign residents relative to the total population, reinforcing its role as a particularly relevant area for studying migratory dynamics (Figure 1).

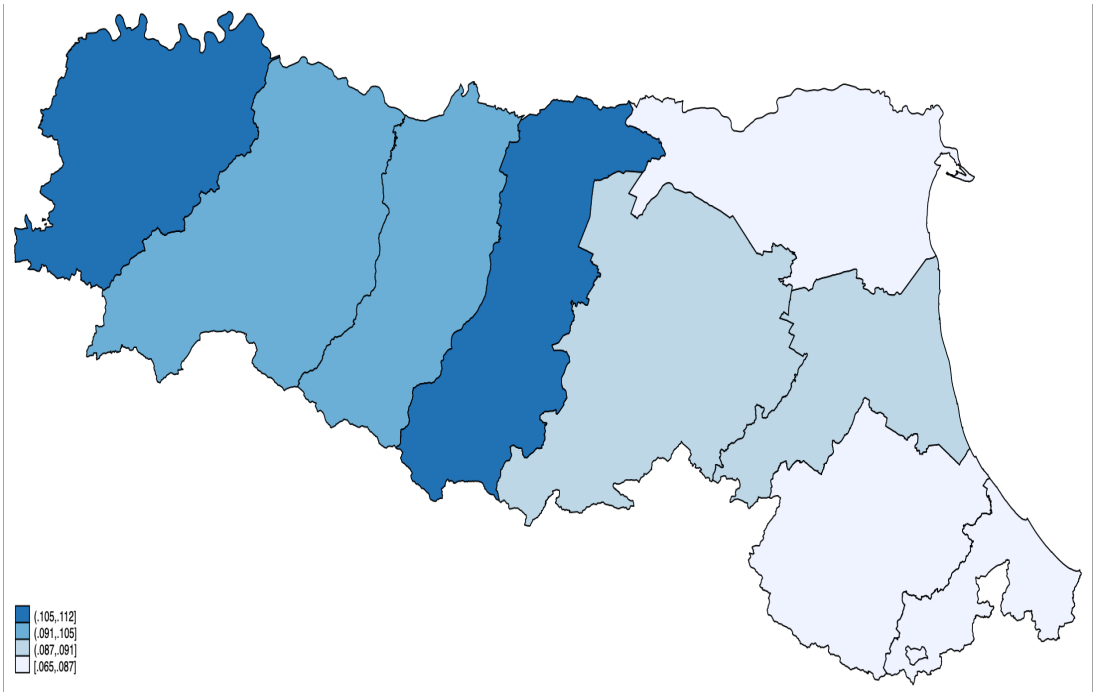
Figure 1: Distribution of immigrant population among Italian regions



Source: Elaborations of the authors on ISTAT data.

Within Emilia-Romagna, the province of Modena stands out as a particularly interesting case study. As shown in Figure 2, Modena ranks among the provinces with the highest percentage of foreign residents relative to the total population, making it an ideal context for analyzing dynamics related to integration and citizenship acquisition.

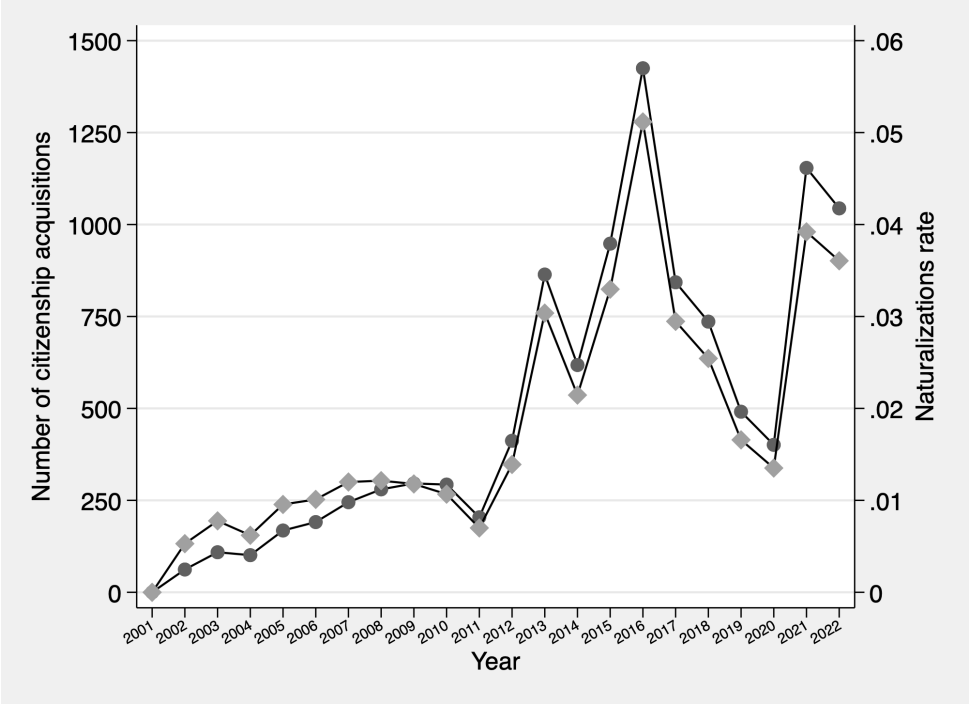
Figure 2: Distribution of the immigrant population in Emilia-Romagna



Source: Elaborations of the authors on ISTAT data.

Italian citizenship law is primarily governed by Law No. 91/1992, uniformly applied across the entire national territory. Article 9 of this law specifically regulates the acquisition of citizenship by concession. The fundamental requirement is a period of continuous and current legal residence at the time of application. This period varies: at least ten years for non-EU citizens and four years for EU citizens. Only residence with a valid permit is considered, excluding periods of mere registry residence without proper authorization. Figure 3 illustrates trends in citizenship acquisitions and naturalization rates in the Municipality of Modena.

Figure 3: Acquisitions of citizenship and naturalization rate in the city of Modena



Source: Elaborations of the authors on data from the population registers of Modena.

The decision to focus the analysis on a single municipality, rather than on the entire Italian territory, is also motivated by methodological considerations. By studying the municipality of Modena, we can adopt a more targeted approach, leveraging the availability of detailed administrative individual-level data. This allows us to account for specific local factors that are often overlooked in analyses conducted at the national level.

Therefore, Modena represents an emblematic example of the socio-demographic transformations characterizing Central and Northern Italy, both in terms of the composition of the foreign population and the evolution of their integration processes. Focusing the analysis on Modena not only enables us to capture these dynamics in greater detail but also provides an opportunity to derive insights applicable to similar contexts in other areas of the country.

3 Data and sample

To analyze the causal effect of citizenship acquisition on the formation of mixed couples, we utilize administrative data from the population registers of the municipality of Modena.[1] These data represent an innovative resource for research, as they allow us to track each individual from the moment they become a resident in Modena-either through relocation or by birth-until they move to another municipality or pass away. The dataset includes various individual characteristics, such as gender, year of birth, and electoral section (i.e. a territorial level below that of neighborhoods, where around 1,000 individuals live per area). However, the most relevant variables for our analysis are citizenship and marital status. The initial sample covers the period 2001-2022 and counts about 4.2 million observations, thus about 190 thousand individuals per year.

Regarding citizenship, the data specify not only whether an individual is Italian or foreign but also, in the case of foreigners, their country of origin, current citizenship, and any potential acquisition of Italian citizenship during their residency in Modena. Concerning marital status, the dataset records whether an individual is single, married, divorced, or widowed. The marriage event is identified as a change of the value of the marital status variable from one year to another.

Each individual is also assigned a family identification code based on shared residence, enabling us to reconstruct couples. Couples were identified by matching individuals of different genders within the same household who share the same year of marriage. To ensure the accuracy of the couple construction, we excluded families with more than two individuals sharing the same year of marriage (2,825 observations eliminated) and individuals who experienced the marriage event but were the sole members of their household (158,566 observations eliminated). Additionally, we excluded individuals who were perpetually married since 2001, for whom it was impossible to determine the year of marriage (1,607,123 observations eliminated). The citizenship of each partner allows us to classify marriages into three categories: Italian, if both spouses hold Italian citizenship; foreign, if both spouses hold foreign citizenship; and mixed, if the spouses have different citizenship

[1]The data were provided to us by the Municipality of Modena for the implementation of the Welfare Data Lab, which is included in the wider project called *Osservatorio Sostenibilità Territoriale*.

(i.e. one spouse is an Italian citizen and the other one is a foreign citizen).

Once the couples were constructed, we excluded families with more than six members (78,861 observations eliminated) to avoid including social or elder care facilities in our analysis. Moreover, since our unit of analysis is the individual over time, we excluded individuals who did not maintain continuous residency in the municipality of Modena (174,569 observations eliminated).

As marriage represents a censored event, individuals exit the sample once they are married.[2] While the initial sample covers the years 2001–2022, the analysis is conducted for the period 2012–2022 only. This methodological choice allows us to account for the ten years required to acquire Italian citizenship and then significantly reduce potential endogeneity biases.

Finally, we restricted our analysis to individuals aged between 25 and 54 years (209,599 observations eliminated). The lower age limit ensures the exclusion of individuals who might still be engaged in the educational system, thus avoiding a further source of heterogeneity within the analyzed sample.

Table 1 presents the descriptive statistics dividing the sample into categories of unmarried, married to foreigners, and mixed marriages, while Table A.1 in the Appendix reports the same descriptive statistics for the entire sample.

[2] In Section 6.2, we present the results using an alternative methodology without imposing this condition.

Table 1: Descriptive statistics dividing the sample into unmarried, foreign marriage and mixed married individuals

Unmarried[a]				Foreign marriage			Mixed marriage		
Variables	Obs	Mean	Std. dev.	Obs	Mean	Std. dev.	Obs	Mean	Std. dev.
Age	7791	32.489	4.627	155	34.432	3.976	76	34.395	4.358
Age square	7791	1076.938	304.642	155	1201.284	268.577	76	1201.737	293.995
Sex									
Male	7791	0.531	0.499	155	0.613	0.489	76	0.408	0.495
Female	7791	0.469	0.499	155	0.387	0.489	76	0.592	0.495
Continent									
Africa	7791	0.253	0.435	155	0.387	0.489	76	0.250	0.436
America	7791	0.068	0.252	155	0.013	0.113	76	0.145	0.354
Asia	7791	0.110	0.313	155	0.135	0.343	76	0.105	0.309
Europe	7791	0.569	0.495	155	0.465	0.500	76	0.500	0.503
Neighborhood									
Centro storico	7791	0.183	0.386	155	0.213	0.411	76	0.092	0.291
Crocetta-Albareto	7791	0.168	0.374	155	0.213	0.411	76	0.171	0.379
Modena Est/San Damaso	7791	0.051	0.220	155	0.019	0.138	76	0.079	0.271
San Lazzaro	7791	0.115	0.319	155	0.116	0.321	76	0.053	0.225
Santa Agnese	7791	0.159	0.365	155	0.148	0.357	76	0.224	0.419
Buon Pastore	7791	0.089	0.284	155	0.077	0.268	76	0.092	0.291
San Faustino/Baggiovara/Cittanova	7791	0.167	0.373	155	0.142	0.350	76	0.224	0.419
Madonnina/Quattro Ville	7791	0.069	0.254	155	0.071	0.258	76	0.066	0.250
Year	7791	2018.642	2.808	155	2018.065	2.969	76	2018.197	3.183
Time for the first child				2.360	1.655932	0.9350726	1,185	0.249789	0.6902203

[a] *Unmarried* refers to individuals who have never married during the observation period.

Source: Elaborations of the authors on data from the population registers of Modena.

4 Empirical strategy

We begin by examining whether obtaining citizenship causes an increase in the probability of getting married. To conduct this analysis, we estimate a probit model which can be formulated as follows:

$$Y_{it} = \beta_1 Citizenship_{it} + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_i + \phi_s + \epsilon_{it} \tag{1}$$

where i denotes individuals and t denotes time (year). Y_{it} represents the outcome variable, which is a binary variable equal to 1 if the individual is married and 0 if the individual is not married. $\mathbf{X}_{it}$ is a vector of time-varying individual characteristics, including age and the square of age, while $\mathbf{Z}_i$ is a vector of time-invariant individual characteristics,

including gender and continent of birth. Finally, ϕ_s represents the set of spatial fixed effects, referring to the neighborhood of residence within the municipality of Modena, while ϵ_{it} denotes the idiosyncratic error term.

The key independent variable in the model specification is $Citizenship_{it}$, which is a binary indicator. Citizenship may be correlated with both observable and unobservable factors that simultaneously influence the propensity for intermarriage (Zimmermann et al., 2009). Compared to immigrants without citizenship, immigrants who possess the host country's citizenship are likely to have spent more years in the host country, acquired better language proficiency, and developed broader social networks. To address these issues of endogeneity, the independent variable $Citizenship_{it}$ takes the value of 1 if an individual has acquired Italian citizenship, regardless of their years of residence in the municipality of Modena. To obtain citizenship, individuals must meet certain requirements, including 10 years of continuous residence in Italy, which may not necessarily all be within the municipality of Modena. The individual could indeed have resided in other Italian municipalities before moving to Modena.[3] Conversely, $Citizenship_{it}$ takes the value of 0 if the individual has been a resident of Modena for at least 10 years but has not acquired Italian citizenship. Thus, we exclude those individuals who have not obtained Italian citizenship and have resided in Modena for less than 10 years.

Therefore, the focus of the first part of the analysis is the estimate of the coefficient β_1, which captures the effect of citizenship acquisition on the likelihood of marriage. Subsequently, we examine how citizenship acquisition influences the type of marriage. In this case, our empirical analysis relies on the estimation of multinomial logistic models specified as follows:

$$Y_{it} = \beta_1 Citizenship_{it} + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_i + \phi_s + \epsilon_{it} \tag{2}$$

where i denotes individuals and t denotes time (year). Y_{it} represents the outcome variable, which is a categorical variable with three categories: 0 if the individual is not married, 1 if the individual marries and the marriage is between foreign individuals, and 2 if the

[3]The regulation of citizenship is primarily governed by Law No. 91/1992.

individual marries and the marriage is between individuals with different citizenship (i.e. mixed marriage). The other variables retain the same meaning as in Equation 4. In Equations 4 and 2, standard errors are clustered at the individual level.

It has to be noted that we apply the 10-year residence rule in Italy to both EU and non-EU citizens to ensure equal treatment. However, as described in Section 2, EU citizens require a shorter period of continuous and current legal residence for the Italian citizenship acquisition (i.e., 4 years instead of 10 years for non-EU citizens). As a sensitivity analysis, we then replicated the results of the main analysis splitting foreign citizens into EU and non-EU groups and adjusting the citizenship variable according to their respective requirements. Specifically, while for the non-EU citizens the empirical setting remains the same described above, as for the EU citizens the variable $Citizenship_{it}$ takes the value of 1 if an individual has acquired Italian citizenship and 0 if the individual has been a resident of Modena for at least 4 years but has not acquired Italian citizenship. Moreover, in the case of EU citizens, we do not apply the 10-year residence rule as before but a 4-year residence one. Results of this sensitivity analysis, presented in Tables A.2 and A.3 in the Appendix, overall confirm that this methodological decision does not seem to affect the outcomes highlighted from the main analysis.

5 Results

In the following subsection, we present the estimates related to Equation 4, which examines the probability of marriage, and the estimates from Equation 2, which focus on the type of marriage. We consider the entire sample as described in Section 3, along with three sub-samples based on gender, age, and continent of birth to account for differentiated effects.

5.1 Baseline results

Marginal effects from a probit model are reported in Table 2. The results show that acquiring Italian citizenship increases the probability of marriage for those who have ob-

tained it. Specifically, foreign residents who have acquired Italian citizenship, compared to foreign nationals residing in the municipality of Modena for at least 10 years but who have not obtained Italian citizenship, have a 1.1% higher probability of getting married.

Table 2: Probit marginal effects

	(1)
	Likelihood of marriage
Citizenship	0.0106***
	(0.00392)
Observations	8,417
Controls	YES
Neighborhood FE	YES

*Notes: The results are derived from the estimation of a probit model using individual-level data. The dependent variable is a binary 0–1 indicator for married/not married. Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

The marginal effects from the multinomial logistic regressions are reported in Table 3. The results highlight how the acquisition of Italian citizenship influences the type of marriage, showing that foreigners who acquire Italian citizenship have a lower probability of not marrying, approximately -1.2%, and a higher probability of marrying an Italian citizen, i.e., entering into a mixed marriage, approximately 0.8%.

Table 3: Multinomial Logistic Marginal Effects. Dependent variable: Type of marriage

	Coefficient	Standard Error
Citizenship		
Unmarried	-0.0121**	(0.00471)
Foreign marriage	0.00430	(0.00380)
Mixed marriage	0.00782***	(0.00277)
Observations	8417	
Controls	Yes	
Neighborhood FE	Yes	

*Notes: The results are derived from the estimation of a multinomial logistic regression using individual-level data. The dependent variable is a categorical variable with three categories: 0 if the individual is not married, 1 if the individual marries and the marriage is between foreign individuals and 2 if the individual marries and the marriage is between individuals with different citizenships (mixed marriage). Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

These findings appear to support the assimilation theory rather than the status exchange theory. Specifically, the acquisition of citizenship, being the most important privilege a host country can offer to its immigrant population, seems to facilitate integration by encouraging mixed marriages, that is, marriages between foreign nationals who have become Italian citizens and native Italians. This supports the idea that citizenship is a powerful tool for social integration, as it allows immigrants to form intimate relationships with native citizens, thereby fostering their participation in social life.

5.2 Heterogeneity analysis

Individual characteristics play a crucial role in determining the effect of citizenship acquisition on the likelihood of marriage and the formation of mixed couples. According to the literature, foreign women are more likely to marry Italian men, not necessarily as a result of an integration process but rather as an expression of status exchange (Guetto and Azzolini, 2015). This phenomenon is particularly evident among foreign women employed in the domestic sector, often under irregular contracts, for whom marriage may represent an opportunity to improve their socio-economic conditions.

However, gender is not the only relevant factor in the "bargaining" process that occurs during the formation of couples between migrants and natives. Age also plays a significant role. A younger age, particularly for women, can be perceived as an indicator of physical attractiveness and a higher likelihood of having children-both factors that positively influence the propensity to marry. On the other hand, for men, an older age can signal financial stability and a well-established socio-economic status (Guetto and Azzolini, 2015). In line with these dynamics, the literature highlights a normative preference for marriages between individuals of similar ages, although cases of age imbalances in mixed marriages often favor the native partner.

Finally, another key factor influencing the propensity to marry natives is the continent of birth, as diverse cultural backgrounds can shape the formation of couples (Guetto and Azzolini, 2015).

To account for these factors, the sample is divided based on gender, age, and continent of birth. Specifically, in addition to distinguishing between men and women, individuals are categorized into two age groups: the first includes those aged 25 to 30, while the second comprises individuals aged 31 to 40. Finally, the sample is classified by continent of birth, distinguishing between Europe, Africa, and Asia-America. This segmentation allows for a detailed examination of how each of these individual characteristics influences marital dynamics, offering a more nuanced understanding of the factors contributing to the formation of mixed couples. Table 4 presents the marginal effects of the probit model for the three subsamples, while Table 5 reports the marginal effects of a multinomial logistic regression for the same subsamples.

Table 4: Marginal effect of the probability of marriage by gender, age group, and continent

	Gender		Age Group		Continent		
	Male	Female	25-30	31-40	Europe	Africa	Asia and America
Citizenship	0.0155***	0.00777	-0.00197	0.0217***	0.00219	0.0217**	0.00784
	(0.00546)	(0.00572)	(0.00440)	(0.00580)	(0.00426)	(0.00866)	(0.0111)
Observations	4,527	3,890	3,436	4,981	4,738	2,166	1,513
Controls	YES	YES	YES	YES	YES	YES	YES
Neighborhood FE	YES	YES	YES	YES	YES	YES	YES

*Notes: The results are derived from the estimation of a probit model using individual-level data. The dependent variable is a binary 0–1 indicator for married/not married. Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

Table 5: Multinomial Logistic Marginal Effects by Gender, Age Group, and Continent. Dependent variable: Type of marriage

	Gender		Age Group		Continent		
	Male	Female	25-30	31-40	Europe	Africa	Asia and America
Citizenship							
Unmarried	-0.0167***	-0.00927	0.00239	-0.0239***	-0.00541	-0.0259***	-0.0239*
	(0.00603)	(0.00807)	(0.00462)	(0.00701)	(0.00639)	(0.00968)	(0.0140)
Foreign married	0.00938*	-0.00201	-0.00269	0.0106*	-0.00252	0.0183**	0.0102
	(0.00526)	(0.00597)	(0.00382)	(0.00564)	(0.00553)	(0.00846)	(0.00840)
Mixed married	0.00730**	0.0113**	0.000305	0.0133***	0.00793**	0.00765	0.0137
	(0.00294)	(0.00541)	(0.00261)	(0.00411)	(0.00318)	(0.00467)	(0.0110)
Observations	4,527	3,890	3,436	4,981	4,738	2,166	1,513
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Notes: The results are derived from the estimation of a multinomial logistic regression using individual-level data. The dependent variable is a categorical variable with three categories: 0 if the individual is not married, 1 if the individual marries and the marriage is between foreign individuals and 2 if the individual marries and the marriage is between individuals with different citizenships (mixed marriage). Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

The results presented in Table 4 show that acquiring Italian citizenship increases the likelihood of marriage for specific categories, such as men, adults, and individuals originating from Africa.

Consistent with the results presented in Table 4, Table 5 highlights that acquiring Italian citizenship reduces the likelihood of remaining unmarried for men, adults, and individuals born in Africa, Asia, and America.

Regarding the type of marriage, the findings in Table 5 suggest that acquiring Italian citizenship has a positive effect on the probability of mixed marriages for both men and women. Specifically, the increase is 1.1% for women and slightly lower, at 0.7%, for men. In line with the observed effects on the general probability of marriage, citizenship acquisition has a significant impact on mixed marriages among adults. Furthermore, within this group, there is also an increase in marriages between foreign individuals, likely associated with better access to institutions and marriage-related rights.

However, the results differ substantially when considering the continent of origin. While citizenship acquisition increases the likelihood of marriage for individuals from Africa, its effect on mixed marriages is more pronounced for those born in Europe. This finding may reflect cultural or socio-economic differences across regions of origin, which may have implications for integration and citizenship policies.

Overall, these results emphasize the importance of considering individual characteristics and cultural contexts when analyzing the impact of citizenship on marriage behavior, highlighting how the effects can vary by gender, age, and continent of birth.

6 Robustness

6.1 Lagged treatment

From a theoretical perspective, the relationship between citizenship status and the propensity for mixed marriages can be interpreted through two main hypotheses: the assimilation hypothesis and the status exchange hypothesis. The former suggests that acquiring citizenship promotes the social integration of immigrants by breaking down cultural and social barriers, thereby increasing the likelihood of forming mixed couples. The latter, however, posits that mixed marriages are primarily driven by opportunities for social and economic advancement, implying that obtaining citizenship would reduce their oc-

currence.

The results obtained thus far seem to confirm the predominance of the assimilation hypothesis, showing that acquiring Italian citizenship leads to an increase in the formation of mixed couples. This finding highlights how citizenship can act as a catalyst for social integration, fostering closer connections between immigrants and native Italians.

To further substantiate this theory, in this section we propose an additional analysis. We replicate the estimates presented earlier, but with a focus on citizenship acquisition in the previous year. This approach allows us to test the robustness of the observed effect over time and to gain deeper insights into the mechanisms through which citizenship influences marital behaviors.

The marginal effects derived from a probit model are presented in Table 6. These results indicate that acquiring Italian citizenship in the preceding year has no significant effect on the probability of getting married.

Table 6: Probit marginal effects with lagged treatment

	(1)
	Likelihood of marriage
Citizenship	0.00276
	(0.00471)
Observations	5,962
Controls	YES
Neighborhood FE	YES

*Notes: The results are derived from the estimation of a probit model using individual-level data. The dependent variable is a binary 0–1 indicator for married/not married. Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

The marginal effects from the multinomial logistic regressions, as shown in Table 7, highlight that acquiring Italian citizenship in the preceding year significantly increases the likelihood of forming mixed couples. This finding aligns with the assimilation hypothesis, which posits that obtaining citizenship reduces social and cultural barriers, facilitating

closer relationships between immigrants and native citizens. By gaining access to the rights and privileges associated with citizenship, immigrants are likely to experience improved social integration and acceptance, which in turn enhances opportunities for forming mixed marriages. Moreover, the positive effect observed in the context of mixed couples suggests that citizenship plays a key role not only in granting formal inclusion but also in fostering informal social interactions. This outcome reinforces the idea that citizenship acquisition serves as a powerful tool for advancing the social integration of immigrants, thereby strengthening their ability to build intimate and lasting connections within the host society.

Table 7: Multinomial Logistic Marginal Effects with lagged treatment. Dependent variable: Type of marriage

	Coefficient	Standard Error
Citizenship		
Unmarried	-0.00125	(0.00575)
Foreign marriage	-0.00548	(0.00494)
Mixed marriage	0.00674**	(0.00296)
Observations	5,962	
Controls	Yes	
Neighborhood FE	Yes	

*Notes: The results are derived from the estimation of a multinomial logistic regression using individual-level data. The dependent variable is a categorical variable with three categories: 0 if the individual is not married, 1 if the individual marries and the marriage is between foreign individuals and 2 if the individual marries and the marriage is between individuals with different citizenships (mixed marriage). Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

6.2 Alternative identification strategy

To strengthen the robustness of our conclusions, we conducted an alternative analysis using a Two-Way Fixed Effects (TWFE) model. For this analysis, we focused on a balanced panel of individuals residing in the municipality of Modena from 2011 to 2022, aged between 25 and 45 years. Specifically, we estimate the following model:

$$Y_{it} = \beta_1 Citizenship_{it} + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_i + \phi_s + \phi_y + \epsilon_{it} \quad (3)$$

where i denotes individuals and t denotes time (year). The variables $\mathbf{X}_{it}$, $\mathbf{Z}_{it}$ $Citizenship_{it}$ and ϕ_s retain the same definitions discussed in Section 4, with the addition of year fixed effects ϕ_y. The dependent variable Y_{it} represents the outcome of interest, for which we consider three binary variables. The first variable, *Married*, equals 1 if the individual is married and 0 otherwise. The second variable, *Foreign married*, equals 1 if the individual is married to another foreigner and 0 if unmarried. Finally, the third variable, *Mixed married*, equals 1 if the individual is married to an Italian (indicating the formation of a mixed couple) and 0 if unmarried.

Thus, the objective remains to estimate the coefficient β_1, which captures the effect of citizenship acquisition on the likelihood of marriage and the type of marriage.

This approach allows for controlling unobserved, time-invariant individual characteristics and time-varying factors common to all individuals. The inclusion of individual and temporal fixed effects ensures that the estimated effect of citizenship is free from these potential confounding influences.

The results in Table 9 show that acquiring citizenship increases both the likelihood of getting married and the likelihood of marrying an Italian citizen. Conversely, it decreases the probability of marrying another foreigner.

Table 8: Two-Way Fixed Effect model results

	(1) Married	(2) Mixed marriage	(3) Foreign marriage
Citizenship	0.0939***	0.152***	-0.0707***
	(0.0100)	(0.0145)	(0.0141)
Observations	175,325	46,340	46,340
Number of individuals	24,714	5,691	5,691
R^2	0.088	0.119	0.271
Controls	YES	YES	YES
Neighborhood FE	YES	YES	YES
Year FE	YES	YES	YES

*Notes: Each column shows estimates from separate regression, estimated using individual level data. Controls include age, the square of age, gender and continent of origin. Standard errors are clustered at the individual level. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

Table 9: Two-Way Fixed Effect model results

	(1) Married	(2) Foreign marriage	(3) Mixed marriage
Citizenship	0.0939***	-0.0707***	0.152***
	(0.0100)	(0.0141)	(0.0145)
Observations	175,325	46,340	46,340
Number of individuals	24,714	5,691	5,691
R^2	0.088	0.271	0.119
Controls	YES	YES	YES
Neighborhood FE	YES	YES	YES
Year FE	YES	YES	YES

*Notes: Each column shows TWFE estimates from separate regression, estimated using individual level data. Controls include age, the square of age, gender and continent of origin. Standard errors are clustered at the individual level. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

Compared to the main analyses, the TWFE model produces qualitatively similar results, confirming the significance of the effect of citizenship on marriage choices. However, the TWFE approach allows for a more precise capture of intra-individual variations over time, enhancing the robustness of the estimates and reducing the risk of bias stemming from unobserved factors.

7 Additional Effects of Citizenship Acquisition

In this section, we address an important aspect that citizenship acquisition may influence but has been largely overlooked in the literature: the decision to have a child. Specifically, we aim to examine the time elapsed between the formation of a couple and the birth of the first child, assessing how the type of couple-mixed or composed of two foreign partners- and citizenship acquisition affect these timelines.

To investigate this relationship, we estimate the following model:

$$Y_{it} = \beta_1 Citizenship_{it} * Marriage_{it} + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_i + \phi_s + \epsilon_{it} \tag{4}$$

where i denotes individuals and t denotes time (year). The variables $\mathbf{X}_{it}$, $\mathbf{Z}_{it}$ and ϕ_s retain the same definitions discussed in Section 4. The outcome variable Y_{it} measures the time between the couple's formation, defined as the year of marriage, and the birth of the first child. It is a categorical variable that takes the value of 0 if the couple has not had children, 1 if they had children before marriage, 2 if they had children within the first five years of marriage, and 3 if they had children more than five years after marriage. The main independent variable is $Citizenship_{it} * Marriage_{it}$ which represents the interaction between citizenship acquisition (equal to 1 if the individual has obtained citizenship and 0 otherwise) and the type of couple (mixed or composed of two foreign partners). This interaction can take four values: 0 if both partners are foreign and neither has obtained citizenship, 1 if both partners are foreign and one of them has acquired citizenship, 2 if the couple is mixed and the foreign partner has not acquired citizenship, 3 if the couple is mixed and the foreign partner has obtained Italian citizenship. The coefficient of interest is β_1 which captures the joint effect of citizenship acquisition and marriage type on the timing of the first child's birth.

The results are reported in Table 10.

Table 10: Multinomial Logistic Marginal Effects. Dependent variable: Time for the first child

	Coefficient	Standard Error
Foreign marriage without citizenship	*Base Outcome*	
Foreign marriage with citizenship		
No child	0.237***	0.0486
Child before marriage	-0.0974***	0.0375
Child within 5 years of marriage	-0.0818*	0.0435
Child after 5 years of marriage	-0.0576*	0.0316
Mixed marriage without citizenship		
No child	0.726***	0.0371
Child before marriage	-0.212***	0.0321
Child within 5 years of marriage	-0.384***	0.0332
Child after 5 years of marriage	-0.131***	0.0290
Mixed marriage with citizenship		
No child	0.799***	0.0317
Child before marriage	-0.244***	0.0289
Child within 5 years of marriage	-0.392***	0.0316
Child after 5 years of marriage	-0.163***	0.0259
Observations	5,962	
Controls	Yes	
Neighborhood FE	Yes	

*Notes: The results are derived from the estimation of a multinomial logistic regression using individual-level data. Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

Compared to foreign couples in which neither partner has acquired Italian citizenship, both mixed couples where the foreign partner obtains citizenship and foreign couples in which at least one partner becomes an Italian citizen show a lower likelihood of having children, particularly before and within the first years of marriage. Among foreign couples in which at least one partner acquires Italian citizenship, the probability of not having children increases by 23.7 percentage points, while the likelihood of having a child before

marriage decreases by 9.74 percentage points and that of having a child within five years of marriage drops by 8.18 percentage points. A similar pattern is observed in mixed couples where the foreign partner does not acquire citizenship. In these cases, the probability of not having children is even higher, increasing by 72.6 percentage points, while the probability of having a child before marriage and within five years decreases by 21.2 and 38.4 percentage points, respectively. This trend is even more pronounced in mixed couples where the foreign partner acquires citizenship, with the likelihood of not having children increasing by 79.9 percentage points, and the probability of childbirth before marriage and within five years decreasing by 24.4 and 39.2 percentage points.

These results suggest that acquiring citizenship is associated with a postponement of family formation rather than an increase in childbearing. This could be explained by the fact that obtaining Italian citizenship often coincides with improved economic stability and career opportunities, which may lead individuals to delay parenthood. Furthermore, the strong negative effects on early childbirth among mixed couples, regardless of whether the foreign partner acquires citizenship, indicate that integration into the native population plays a key role in shaping reproductive behavior. Being in a relationship with an Italian citizen likely facilitates greater exposure to native fertility patterns, which tend to favor later childbearing and lower overall fertility. This suggests that both legal status and cultural integration influence family planning decisions, potentially leading to a different balance between career and family life.

8 Conclusion

Many theoretical and empirical studies explain the growth of mixed marriages as the result of two primary mechanisms: the assimilation of immigrants into host societies or a status exchange. For instance, Azzolini and Guetto (2017) emphasize the role of status exchange in the formation of mixed marriages in Italy. Their findings show that the 2004 and 2007 European Union enlargements led to a significant decrease in mixed marriages between women from the new EU member states and Italian men. This result suggests that, in a context such as Italy—characterized by limited socio-economic integration of immigrants

and stringent naturalization requirements—marriage with Italian citizens may represent an opportunity to improve one's social status. Contrary to these findings, our study argues that the link between citizenship and the formation of mixed marriages is better explained by assimilation theory rather than status exchange. Thus, acquiring citizenship appears to be a crucial tool for the integration of foreign nationals. Using individual-level data from the population registers of the municipality of Modena, we demonstrate that obtaining Italian citizenship not only significantly increases the probability of marriage but also fosters the formation of mixed marriages. This form of social cohesion is particularly relevant for a country like Italy, which hosts a significant proportion of foreign nationals. Greater social integration not only encourages immigrants' active participation in political life—contributing to a more inclusive and representative society—but also facilitates their inclusion in the economic fabric. This process, in addition to improving immigrants' individual opportunities, strengthens the overall economy by expanding the workforce, increasing productivity, and enhancing cohesion among diverse communities. A more detailed analysis, which segments the sample by gender, age, and continent of birth, provides further insights. Our results show that citizenship acquisition has a particularly strong impact on men and adults, for whom we observe an increase in both the likelihood of marriage and the formation of mixed marriages. However, the impact varies by continent of birth: while citizenship increases the probability of marriage among African immigrants, the formation of mixed marriages is more common among European immigrants. These differences highlight that social inclusion remains an ongoing process and appears to be more pronounced for European immigrants, whose cultural background is closer to that of Italians. A crucial aspect of our analysis is the construction of the citizenship variable, which addresses endogeneity issues. Specifically, we included individuals who had resided in Modena for more than ten years but had not acquired Italian citizenship, allowing for a more precise identification of the causal effect of citizenship. Moreover, robustness tests considering citizenship acquisition in the preceding year confirm the main results and further reinforce the validity of assimilation theory. These findings underscore that citizenship is not merely a legal recognition but also a powerful instrument for promoting the social integration of immigrants. Finally, we also examined another aspect related

to citizenship: its effect, in combination with the type of couple, on the timing of the birth of the first child. Specifically, we analyzed the time elapsed between the formation of the couple, defined as the year of marriage, and the birth of the first child. Our results indicate that both citizenship acquisition and the type of couple significantly influence this timing. In particular, compared to couples formed by two foreigners without Italian citizenship, mixed couples in which the foreign partner obtains citizenship and foreign couples in which at least one partner acquires citizenship show a lower probability of having children both before marriage and in the early years afterward. This effect is also observed in mixed couples in which the foreign partner has not acquired citizenship, suggesting that merely being in a relationship with an Italian is an indicator of a broader integration process that affects reproductive choices. In conclusion, by leveraging detailed administrative individual-level data, this study—unique in the Italian context to the best of our knowledge—demonstrates that acquiring Italian citizenship is a fundamental vehicle for social integration, fostering stronger ties between immigrants and Italian citizens. The implications of our findings go beyond theoretical contributions. This study enriches the debate on the role of citizenship, highlighting its positive impact not only on the legal dimension but also on social and economic cohesion. Policymakers should recognize the significant impact of citizenship on socio-economic well-being and actively work to simplify and expedite the naturalization process. Doing so could strengthen the integration of immigrant communities and promote their participation in social, economic, and political spheres. Additionally, targeted initiatives aimed at reducing cultural barriers and fostering mutual understanding between immigrants and Italian citizens could amplify the benefits of naturalization. The results of our study emphasize the importance of continuously expanding and deepening research on the multidimensional effects of citizenship to inform more inclusive and effective policies, as well as to better understand demographic dynamics and intergenerational integration processes.

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9 Appendix

Table A.1: Descriptive Statistics

Variable	Description	Obs	Mean	Std. dev.
Marital status	A binary 0-1 indicator denoting whether the individual is married	8,417	0.024	0.153
Type of marriage	Categorical variable indicating the type of marriage (mixed or between foreigners)	8,417	0.036	0.231
Age	Continuous variable indicating the individual's age in each year	8,417	32.488	4.583
Square of age	Square of the age variable	8,417	1,076.461	301.648
Sex	A binary 0-1 indicator denoting the individual's gender			
Male		8,417	0.538	0.499
Female		8,417	0.462	0.499
Continent	Categorical variable indicating the continent from which individuals originate			
Africa		8,417	0.257	0.437
America		8,417	0.066	0.248
Asia		8,417	0.114	0.318
Europe		8,417	0.563	0.496
Neighborhood	Disaggregation of neighborhoods in the municipality of Modena			
1		8,417	0.181	0.385
2		8,417	0.172	0.378
3		8,417	0.050	0.219
4		8,417	0.113	0.317
5		8,417	0.159	0.366
6		8,417	0.089	0.285
7		8,417	0.166	0.372
10		8,417	0.069	0.253
Year	Indicates the years	8,417	2018.53	2.839
Time for the first child	Years between the year of marriage and the year of birth of the first child	3,545	1.185896	1.086872

Source: Elaborations of the authors on data from the population registers of Modena.

Table A.2: Probit marginal effects of likelihood to marry

	(1)	(2)
	EU	NO EU
Citizenship	-0.0102	0.0122**
	(0.00778)	(0.00475)
Observations	4,947	6,276
Controls	YES	YES
Neighborhood FE	YES	YES

*Notes: The results are derived from the estimation of a probit model using individual-level data. The dependent variable is a binary 0–1 indicator for married/not married. The first column refers to EU foreign nationals, for whom the residence requirement is 4 years, while the second column pertains to non-EU foreign nationals, for whom the residence requirement is 10 years. Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

Table A.3: Multinomial Logistic Marginal Effects. Dependent variable: Type of marriage

	EU	EXTRA EU
Citizenship		
Unmarried	0.0185	-0.0144***
	(0.0115)	(0.00555)
Foreign married	-0.0287***	0.00896*
	(0.0102)	(0.00464)
Mixed married	0.0102*	0.00547*
	(0.00554)	(0.00305)
Observations	4,947	6,276
Controls	Yes	Yes
Neighborhood FE	Yes	Yes

*Notes: The results are derived from the estimation of a multinomial logistic regression using individual-level data. The dependent variable is a categorical variable with three categories: 0 if the individual is not married, 1 if the individual marries and the marriage is between foreign individuals, and 2 if the individual marries and the marriage is between individuals with different citizenships (mixed marriage). Controls include age, the square of age, gender, and continent of origin. Standard errors are clustered at the individual level. *** p-value<0.01, ** p-value<0.05, * p-value<0.1.* Source: Elaborations of the authors on data from the population registers of Modena.

Do Households Understand the Consequences of Monetary Policy Changes?*

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Incomplete (please do not circulate)

May 2025

Abstract

An econometric investigation of the Korean household survey suggests that the answer to this question is "No." In response to exogenous monetary policy tightening, free of output and price puzzles, households lower price expectations but become more optimistic about the economic and labor market outlook and increase their consumption plan. This supply-shock interpretation of monetary policy shocks is in sharp contrast to the demand-shock interpretation of professional forecasters in response to the same shock. Moreover, low-income households seem more confused (i.e., having a more supply-side view of monetary policy) than high-income households in understanding the consequences of monetary policy changes. While these findings are at odds with the theoretical prediction of any standard macroeconomic model, they can be rationalized if households link higher inflation to worsening economic conditions. Supporting this hypothesis, the puzzling response of the economic outlook largely disappears when we focus on a group of young households with limited exposure to the stagflation experience during the Asian Financial Crisis in 1998.

JEL codes: E21; E32; E44; F52; G21

Keywords: Monetary policy; Household survey; Professional forecasters; Stagflationary view

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I. INTRODUCTION

Do households understand the consequences of monetary policy changes? In other words, do households correctly anticipate a decline in inflation and economic activity following exogenous monetary policy tightening? Although the macroeconomic effects of monetary policy shocks are well understood by academics and policymakers, it does not necessarily imply that households are equally capable of understanding the effects of monetary policy shocks. In particular, a recent strand of the literature has found a significant deviation in the way households form expectations from the so-called full-information rational expectation (FIRE) framework embedded in most macroeconomic models (Coibion and Gorodnichenko, 2015; Angeletos et al., 2020; Weber et al., 2022).

Our study is motivated by the recent evidence from household surveys that households and professionals seem to have dramatically different views on the nature of shocks hitting the economy (e.g., Candia et al., 2020). This puzzling behavior of households can be best explained by their predominant reliance on inflation in perceiving current and expecting future economic conditions. In other words, households could attribute high inflation as a negative signal of economic conditions and therefore have a supply-side view of economic fluctuations. We take one step further and test whether households correctly understand the consequences of monetary policy changes via shifting aggregate demand. To this end, we utilize a large-scale monthly household survey in Korea (Consumer Survey Index) conducted by the Bank of Korea since 2008M9[1] and compare the response of household expectations with that of professional expectations obtained from Consensus Economics.

We estimate a standard monetary VAR model including a measure of the short-term interest rate, prices, and economic activity, which is augmented by expectations of these variables. To make sure the endogeneity of monetary policy changes does not drive our findings, we use the newly constructed monetary policy shock series by the Bank of Korea staff (Ahn et al., 2022), which follows a high-frequency approach pioneered by Kuttner (2001), Gürkaynak et al. (2005), and Gertler and Karadi, 2015). Since they use changes in Treasury bond yields in a short-time window (10 minutes

[1] Prior to 2008, Consumer Survey Index was available at a quarterly frequency and in a somewhat different format.

before and 20 minutes after the announcement of the policy rate) surrounding monetary policy decisions by the Bank of Korea, such changes can be seen as largely exogenous to economic conditions.

Our empirical findings are striking. Although this exogenous monetary policy shock well behaves in our VAR model (i.e., free of price and output puzzles) and professional forecasters (correctly) expect a decline in both inflation and output following monetary tightening, household expectations are consistent with neither a theoretical prediction nor actual responses from data. While households correctly expect a decline in future prices, they expect improvement in economic conditions and a better labor market outlook. As a result, they also increase planned spending. This is the first main finding of our paper.

We further exploit demographic heterogeneity to sharpen the identification of this puzzling finding. Although we do not have individual-level survey data, the responses in the Korean household survey are disaggregated over several demographic dimensions (e.g., gender, age, income, and housing status). As widely documented in the literature on heterogeneity in inflation expectations across demographic groups (e.g., Madeira and Zafar, 2015; D'Acunto et al., 2019; D'Acunto et al., 2021), the responses of their price expectations to monetary policy tightening are also heterogeneous.

More importantly, however, those who expect a larger decline in future prices (i.e., those who believe that monetary tightening is more powerful) expect a better economic outlook and plan to increase their spending more. This is the case for low-income households when compared to high-income households and suggests that low-income households are more confused about the consequences of monetary policy changes, which is the second key finding of our paper. From a theoretical point of view within the FIRE framework, this finding is even more puzzling than the first finding and is unlikely to be driven by other confounding factors not included in the VAR system (i.e., omitted variable bias), as we look at *differential* effects.

Then why do Korean households view monetary policy shocks as supply shocks, not demand shocks? We take a hint from the Phillips curve of the Korean economy. While the Phillips curve is

alive well, there is an outlier in this relationship, which is the Asian Financial Crisis in 1998. The Asian Financial Crisis, characterized by a sharp increase in both inflation and unemployment, traumatized Korean people who enjoyed the so-called "growth miracle" over the past decades. To the extent that this single but extreme event is overweighted when individuals characterize how the economy works, it is possible that households form expectations in a way driven by a supply-side view. To test this hypothesis, we re-estimate the effects of monetary policy shocks on a group of young households with limited exposure to the crisis episode. Interestingly, we do not find an upward revision in their expectations of future economic conditions, which is the third finding of the paper.

The remainder of the paper is organized as follows. In Section II, we discuss data and econometric methodology, after which Section III presents our main findings and discussion of the findings. Section IV concludes.

II. Data and Empirical Methodology

A. Bank of Korea Consumer Survey

Data on household expectations are extracted from the Korean Consumer Survey, which has been conducted monthly by the Economic Statistics Department of the Bank of Korea since September 2008. Korean Consumer Survey covers 2,200 households, which are sampled from a population group that covers over 90% of the entire Korean population by using a mixture of stratified sampling and systematic sampling methods. The Bank of Korea asks such households about their expectations on various economic variables in a qualitative manner, which includes both (i) aggregate variables, such as the overall economic conditions, price level (inflation),[2] labor market conditions, interest rate, wage level, and housing prices; and (ii) variables specific to each respondent, such as household income, household consumption, household saving, and household debt.

For all of such variables, the households answer multiple choice questions with five options of "very positive", "positive", "moderate", "negative", and "very negative" where "very positive"

[2] While the Bank of Korea also asks household expectations of future "inflation" in a quantitative manner, the answer to this question is not available at demographic levels.

means a better situation or huge increase depending on the context. Based on the results, Consumer Survey Index for each variable is calculated with the following equation:

$$CSI = \frac{\text{very positive} \times 1 + \text{positive} \times 0.5 - \text{negative} \times 0.5 - \text{very negative} \times 1}{\text{The total number of respondents}} \times 100 + 100.$$

Thus, the Consumer Survey Index can have a value between 0 and 200, where a value over 100 implies that the number of households with positive expectations is greater than that of households with negative expectations. One useful feature of the Consumer Survey from the Bank of Korea is that it provides not only average data but also separate data on each group of various demographic characteristics, including gender (male and female), age (below 40, 40-49, 50-59, 60-69, and over 70), income level (below 1 million, 1-2 million, 2-3 million, 3-4 million, 4-5 million, and over 5 million won), house ownership (owner and rent), and residential area (Seoul, major metropolitan cities, and small cities). Such a demographic disaggregation helps discover potential heterogeneity in household responses to monetary policy shocks and alleviates concern for omitted variable bias when differences in expectations across demographic groups are used in estimation.

B. Consensus Economics Forecasts

Following a practice in the literature on professional forecasts (Ball et al., 2015; Coibion and Gorodnichenko, 2015; Baker et al., 2020), we use Consensus Economics forecasts as a measure of professional forecasts of the Korean economy. Consensus Economics solicits individual forecasts from professional forecasters: banks and financial firms, leading industrial companies, consulting firms, think tanks, and research groups.

Consensus Economics provides country-specific forecasts for key macroeconomic variables, including GDP, personal consumption, business investment, corporate profits, industrial production, producer prices, consumer prices, wages, car sales, housing starts, unemployment, current account balance, short- and long-term interest rates, and federal budget balances.

Since Consensus Economics forecasts are based on fixed-event rather than fixed-horizon (i.e., each survey refers to a specific calendar year, so the forecast horizon depends on the time in which the survey is collected), we adjust the raw series to obtain the fixed-horizon forecast following

Dovern et al. (2012) and Choi et al. (2022). In particular, we take the weighted average of the forecasts for the current calendar year and the next calendar year to compute one-year-ahead forecasts where the weight is determined by their share in the forecasting horizon:

$$\pi^e_{1Y} = \frac{12-m+1}{12}\pi^e_{CY} + \frac{m-1}{12}\pi^e_{NY},$$

where π^e_{CY} is the fixed-event inflation forecast for this calendar year; π^e_{NY} is the fixed-event inflation forecast for the next calendar year; and m is the current calendar month.

C. High-frequency Measure of Korean Monetary Policy

We use a new measure of Korean monetary policy shocks recently constructed by the Bank of Korea staff (Ahn et al., 2021) employing a high-frequency approach of Kuttner (2001), Gürkaynak et al. (2005), and Gertler and Karadi (2015). Ahn et al. (2021) first identify unexpected interest rate futures surprises (S_t) with data on changes in returns on three-year Korean government bonds (R) that occur between $\tau - 10$ minutes and $\tau + 20$ minutes where τ denotes the moment of an announcement on the policy rate by the Bank of Korea. Then, S_t can be expressed as the sum of m_t, a component that captures the effect of monetary policy, and η_t, which reflects the noise factor. Since η_t is not related to other macroeconomic or financial phenomena, and its value is trivial due to its small variance by construction, S_t itself can be regarded as a monetary policy shock.

To address the remaining concern of the so-called central bank information effect (Nakamura and Steinson, 2018), Ahn et al. (2021) further decompose m_t into pure monetary policy shock (MP_t) and central bank information shock (CBI_t) by using the methodology utilized by Jarociński and Karadi (2020). Ahn et al. (2021) impose two assumptions to isolate two different types of shocks:

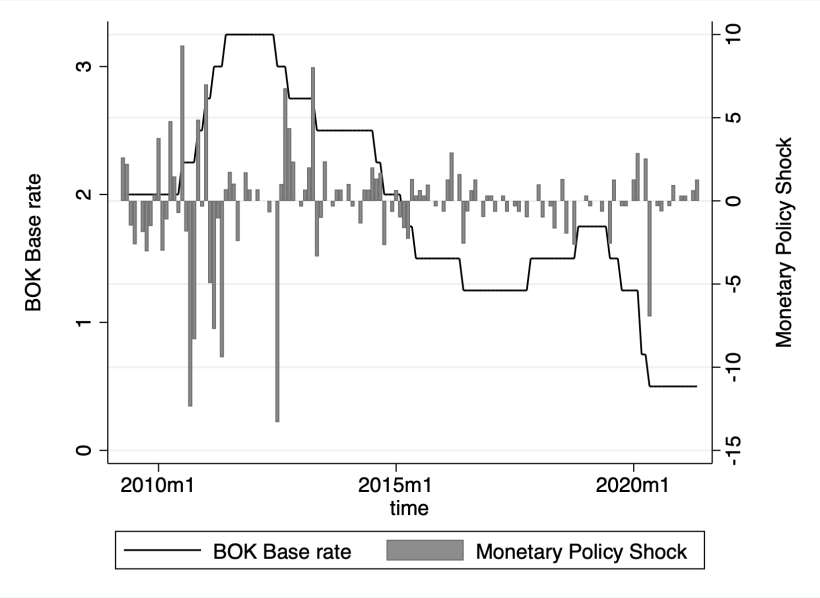
(i) S_t is affected only by the central bank's monetary policy announcement shocks.

(ii) Identification of exogenous MP_t and CBI_t follows pre-determined sign restrictions; MP_t is associated with an interest rate increase and a decline in stock prices, while CBI_t is associated with an increase in both interest rates and stock prices.

As shown later, we do not have a price puzzle or output puzzle using m_t as a measure of monetary policy shocks. Thus, we use standard Cholesky identification for baseline analysis without

disentangling the central bank information effect, in order to ease comparison with earlier studies. Figure 1 shows the level of the short-term policy rate and our baseline measure of monetary policy shocks m_t during the period under study.

Figure 1. Short-term policy rate (left axis) and high-frequency monetary policy shock (right axis)



D. Vector Autoregression Model

This subsection briefly describes the main empirical framework used in our analysis. We employ a standard monetary VAR model to estimate the responses of both standard macroeconomic variables (prices and output) and expectations of these variables. The baseline VAR model includes (i) the exogenously identified monetary policy shock series described earlier; (ii) the short-term nominal interest rate, consumer prices, and a measure of output; and (iii) professional or household expectations of prices and output.

The following general representation summarizes the structural VARs used in this study:

$$Ay_t = c + \sum_{k=1}^{p} F_k y_{t-k} + u_t, \tag{1}$$

where y_t is an $n \times 1$ vector of the aforementioned variables ($n = 6$ in the baseline model augmented with expectation variables). c denotes an $n \times 1$ vector of constants and linear time trends. F_k are $n \times n$ matrices of coefficients, and u_t is an $n \times 1$ vector of structural shocks. The lag p for the analysis is three, which is determined by what the Akaike and Bayesian information criteria suggest. We identify the simultaneous relations of structural shocks by assuming that A is a lower triangular matrix (i.e., recursive identification):

$$A = \begin{pmatrix} 1 & 0 & ... & 0 \\ a_{21} & 1 & ... & 0 \\ ... & ... & ... & 0 \\ a_{n1} & ... & a_{nn-1} & 1 \end{pmatrix}.$$

A reduced-form model can be obtained from (1):

$$y_t = A^{-1}c + \sum_{k=1}^{p} B_k y_{t-k} + A^{-1}\Sigma\epsilon_t, \qquad \epsilon_t \sim N(0, I_n), \tag{2}$$

where $B_k = A^{-1}F_k$ for $k = 1, 2, \ldots, p$, and

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & ... & 0 \\ 0 & \sigma_2 & ... & 0 \\ ... & ... & ... & 0 \\ 0 & ... & 0 & \sigma_n \end{pmatrix},$$

where σ_i denotes the standard deviation of each structural shock. Since the monetary surprise m_t is constructed using a tight window around the Bank of Korea's announcements, it should be contemporaneously exogenous concerning the macroeconomic environment. We, therefore, identify the monetary policy shock using a Cholesky decomposition with m_t ordered first in the vector of endogenous variables. In other words, we incorporate m_t as an internal instrument as suggested by Plagborg-Møller and Wolf (2021). The Cholesky ordering of the baseline model is exogenous monetary policy shock series, one-year government bond yields, consumer prices, industrial

production, professional or household expectations of future prices, and their expectations of future economic conditions.

III. Empirical Findings

A. Main Results

Before presenting the main results, Figure 2 shows the results of estimating a standard monetary VAR model without expectation variables. In response to monetary policy tightening, one-year government bond yields increase, and both consumer prices and industrial production decline, which is consistent with the standard theoretical prediction of monetary tightening. Consistent with the evidence presented by Ahn et al. (2021), our VAR model with high-frequency identification does not suffer from a price puzzle or output puzzle, so we conclude that monetary policy shocks are properly identified.

Figure 2. Effects of high-frequency monetary policy shocks

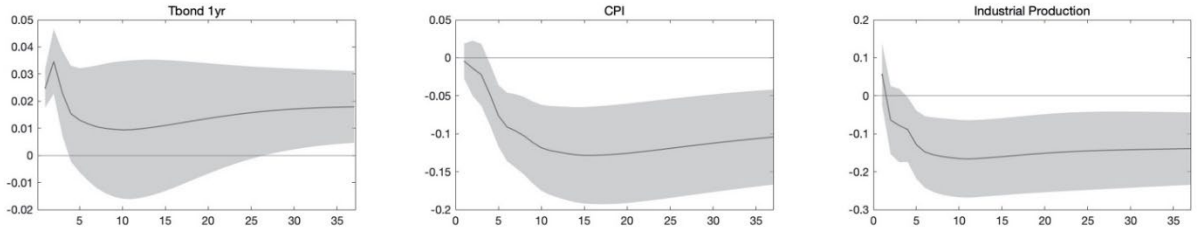
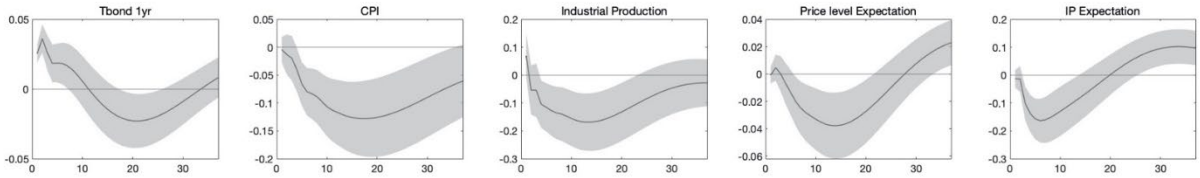


Figure 3 shows the response of both macroeconomic variables and professional forecasts of macroeconomic variables to the monetary policy shock. In response to monetary tightening, professional forecasters sharply revise down their expectations of CPI inflation and industrial production.[3] This finding can be interpreted in two ways. First, professional forecasters do understand the consequence of monetary policy changes given that monetary policy shocks are correctly identified, and their behavior is consistent with what economic theory would suggest.

[3] We obtain similar findings when forecasts of industrial production are replaced with those of real GDP.

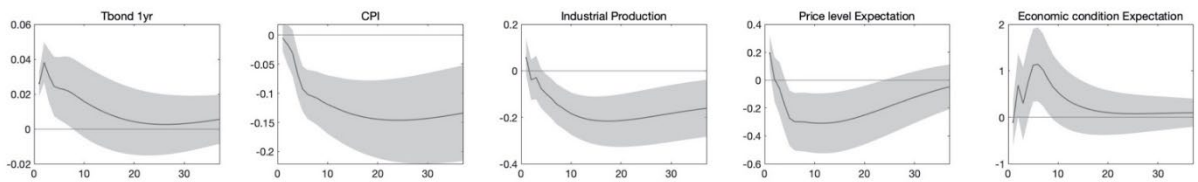
Second, monetary policy shocks are correctly identified if professional forecasters have rational expectations. For example, Jarociński and Karadi (2020) present the response of Consensus Economics forecasts of inflation and GDP growth to confirm that their high-frequency identification of U.S. monetary policy shocks is successful. Regardless of the interpretations, the literature has often assumed the response of professional forecasters to be representative of other economic agents.

Figure 3. Effects of high-frequency monetary policy shocks (professional expectations)



However, the results in Figure 4 challenge this view and cast serious doubt on the practice of using the expectations of professional forecasters to learn the effectiveness of monetary policy. While households (correctly) lower their expectations of future price levels, they expect better economic conditions in general. Compared to the persistent response of realized output, their expectation revisions are transitory though probably because they observe worse economic conditions over time. Nevertheless, there is no significant downward revision of the economic outlook over the three-year horizon. This finding is clearly odd in the prediction of standard economic models and implies that households interpret a monetary policy shock as a supply shock, not a demand shock.

Figure 4. Effects of high-frequency monetary policy shocks (household expectations)

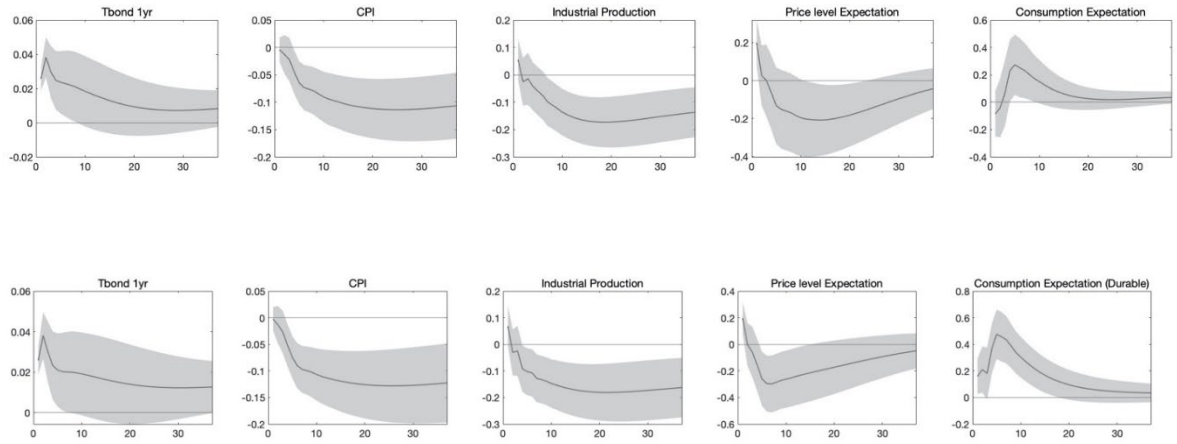


Can we generalize this puzzling finding that households misunderstand the consequences of monetary policy changes to other countries? At first glance, our findings seem contradictory to the euro-area evidence of Geiger et al. (2023), who use a similarly identified euro-area high-frequency monetary policy shock of Altavilla et al. (2019) and the Joint Harmonized EU Programme of Business and Consumer Surveys to answer a similar question. By estimating a panel VAR model of euro-area monthly data from 2003M1 to 2019M4, they found a decline in inflation expectations and an increase in unemployment expectations in response to exogenous monetary tightening and concluded that consumers form expectations in a way that is broadly consistent with empirical and theoretical models of the monetary transmission mechanism. However, they also documented significant heterogeneity in the responses of unemployment expectations across countries, unlike the relatively homogenous responses of inflation. Interestingly, household expectations of future unemployment are revised down following monetary tightening in periphery countries like Italy and Greece, which experienced a financial crisis. In the next section, we also discuss our findings in the context of the crisis experience of Korean households.

Another key variable of interest is household planned consumption. One of the most important channels through which monetary policy changes affect the real economy is consumption which accounts for the dominant share of GDP. Figure 5 shows the response of household planned consumption (total consumption in the top panel and durable consumption in the bottom panel). In contrast to the theoretical prediction of consumption Euler equation, households increase their spending plan following a monetary tightening and this response is stronger for durable consumption.

This finding is even more puzzling because the Fisher equation would suggest a strong increase in the real interest rate due to falling inflation expectations. The only plausible explanation for this response is that households mistakenly expect better economic conditions in the future. Using the euro-area consumer expectation survey, Duca-Radu et al. (2019) also find heterogeneity in the effect of household inflation expectation revisions on planned consumption. Interestingly, such a link is also weaker in periphery countries like Greece, Italy, Portugal, and Spain that experienced the financial crisis.

Figure 5. Effects of high-frequency monetary policy shocks (household expectations, consumption)



Taken together, our findings may provide a potential rationale for why the literature has not reached a consensus on the effect of household inflation expectations on their consumption decisions (e.g., Bachmann et al., 2015; Coibion et al., 2019; Binder and Brunet, 2022). Moreover, to the extent that household inflation expectations are associated with expectations of future economic conditions through a supply-side view, inflation expectations as a policy tool (Coibion et al., 2020) may not achieve the intended outcomes.

B. Robustness Checks

In this section, we provide robustness checks of the main finding of our paper that household expectations differ from professionals' expectations and are not consistent with the theoretical prediction.

First, we replace industrial production (actual outcomes) and household expectations of general economic conditions with the unemployment rate and household expectations of labor market conditions, respectively. This exercise is to guard against the concern that the household interpretation of "general" economic conditions is not well defined. Second, we change the ordering in Cholesky ordering in which household expectation variables are placed before actual economic outcomes to reflect the fact that households are unlikely to observe current economic conditions

when they are asked to provide their expectations of the future state of the economy. Third, we extend the lag structure of the VAR system to six lags to fully account for persistence in variables. Figures 6, 7, and 8 confirm that our main findings are robust to these alternative specifications.

Figure 6. Effects of high-frequency monetary policy shocks: labor market expectations

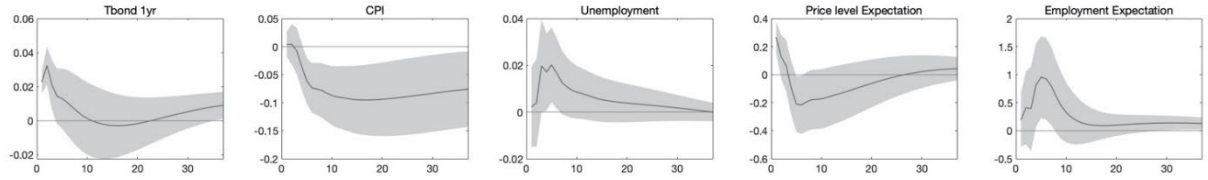


Figure 7. Effects of high-frequency monetary policy shocks: alternative ordering

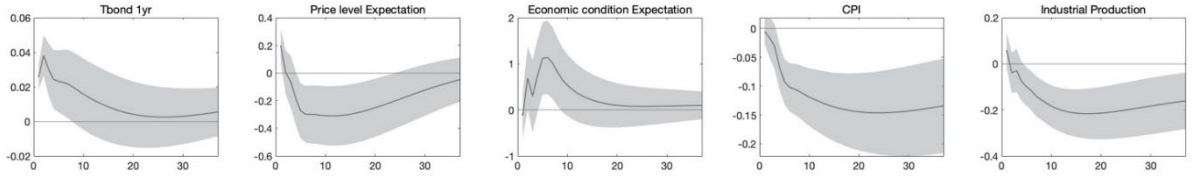
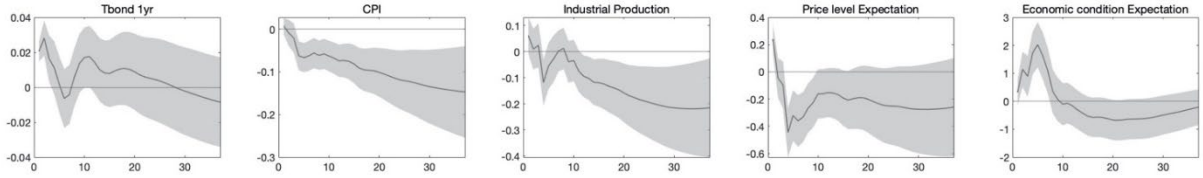


Figure 8. Effects of high-frequency monetary policy shocks: using six lags

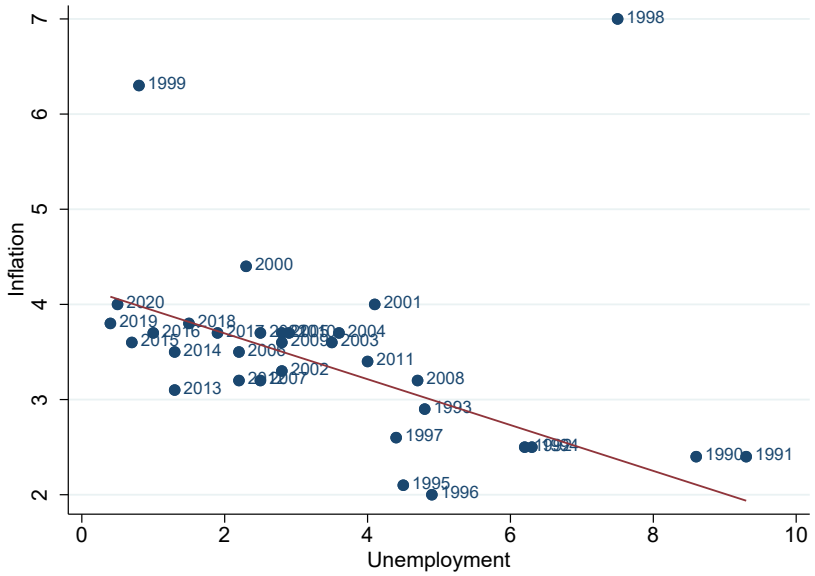


C. Discussion

We discuss the rationale for the anomaly documented in the way households form their expectations. We first look at the Phillips curve of the Korean economy using the CPI inflation and the unemployment rate from 1990 and 2021 at an annual frequency. We restrict the sample period from 1990 because consistent unemployment data is available from this year and the Korean

economy was unlikely in a steady state prior to 1990.[4] As shown in Figure 9, the theoretical negative relationship between the two is apparent and this relationship is highly statistically significant.[5] This stylized fact suggests no reason for Korean households to form expectations through a supply-side view. However, there is an outlier in this relationship, which is the Asian Financial Crisis in 1998. To the extent that this single but extreme event is overweighted when individuals characterize how the economy works, it is possible that households form expectations in a way driven by a supply-side view. The fact that Baker et al. (2020) found that large, unexpected shocks induce immediate and synchronized updating of information for inattentive agents implies the plausibility of this hypothesis.

Figure 9. Phillips curve of the Korean economy



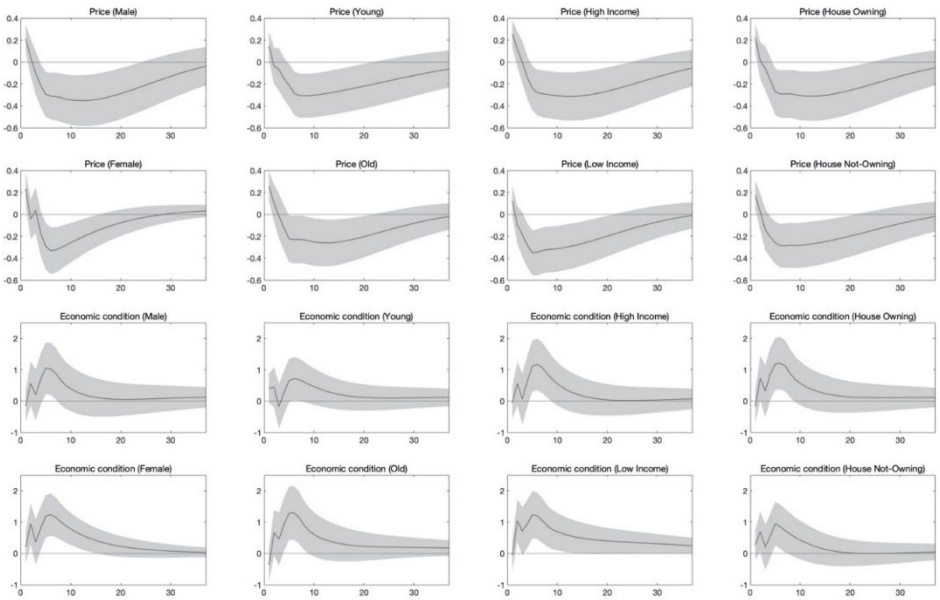
Keeping this caveat in mind, we further proceed with exploiting demographic heterogeneity in the answers in the Korean Consumer Survey. We repeat the baseline analysis but do it separately

[4] We obtain the same conclusion using real GDP growth instead of the unemployment rate for the period between 1980 and 2022.

[5] Without the observation of 1998, $\pi_t = 9.35(1.90) - 1.79(0.54) \times u_t$, where numbers in the parenthesis are robust standard errors. With this observation, $\pi_t = 5.60(2.59) - 0.63(0.76) \times u_t$, indicating that the experience of the Asian Financial Crisis is highly influential on the slope of the Phillips curve.

for each demographic group (e.g., male vs. female; young vs. old; high-income vs. low-income; housing owners vs. renters). To save space, we only present the responses of expectation variables. Figure 10 shows the responses of price expectations (upper panel) and those of output expectations (lower panel) for different groups and Figure 11 shows whether their responses are statistically different.

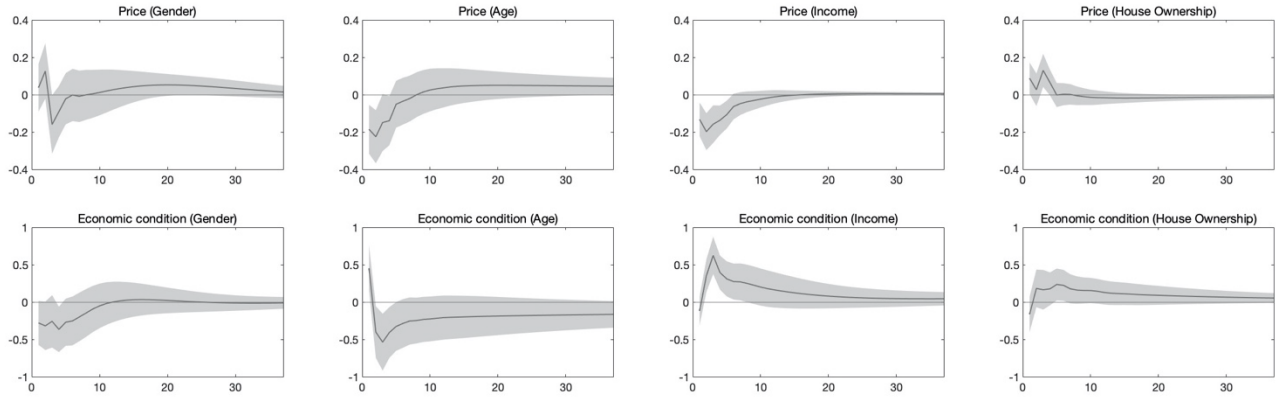
Figure 10. Heterogeneous effects of high-frequency monetary policy shocks



There are some interesting results worth discussing. First, not all demographic characteristics are important in determining household expectations after monetary policy shocks. For example, gender and housing status do not seem to be crucial in shaping expectations of future prices and economic conditions. Second, unlike other demographic groups, young households do not raise their expectations of the future economic outlook following a monetary tightening. In other words, they are the group with a relatively better understanding of the consequences of monetary policy shocks. The fact that they actually have a stronger downward revision of future price expectations than old households implies that they have a more demand-side view of economic fluctuations than the old. Such an interpretation is consistent with the findings by Heim et al. (2022), using the Michigan Survey of Consumers, that individuals who recall co-moving inflation

and unemployment from experience are more apt to adjust their inflation expectations in line with supply shocks.

Figure 11. Heterogeneous effects of high-frequency monetary policy shocks: differences



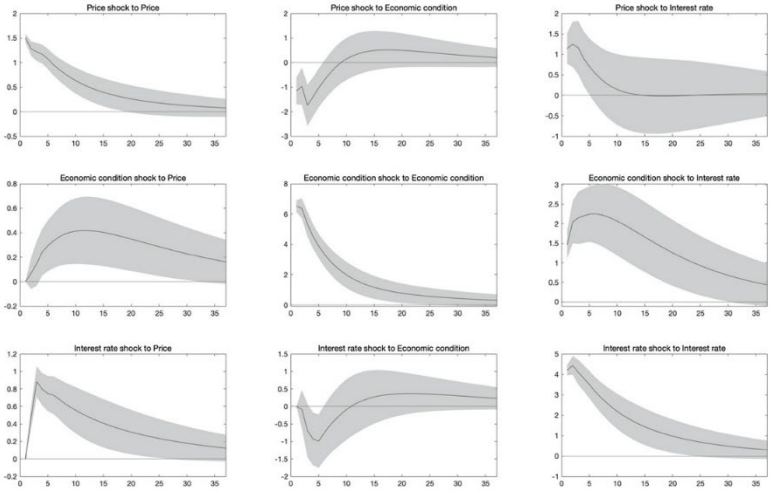
Third, a statistically significant difference in the response to monetary tightening is observed when we divide groups by income. Households with income below the median income (i.e., low-income) lower their price expectations more than high-income households. At the same time, they expect a better economic outlook, suggesting that changes in expectations of low-income households following a monetary policy shock are more aligned with a supply-side view (therefore they are more confused about the consequences of monetary policy changes) than high-income households. The relatively better ability of high-income households to form theory-consistent expectations is aligned with the findings of Armantier et al. (2015).

Another possibility to investigate is that households simply do not even understand how the central bank responds to changes in economic conditions (i.e., the Taylor rule). If this is the case, it is not surprising that they also misunderstand the consequences of monetary policy changes. By estimating the trivariate VAR model akin to Stock and Watson (2001) but all variables are replaced with their expectation counterparts, we test whether households generally understand the Taylor rule. As shown in the last column in Figure 12, households change their expectations of future interest rates in a way consistent with changes in their expectations of future prices and economic

outlook (i.e., revise up future interest rates when they expect higher prices or better economic conditions in the future).

This finding is consistent with micro evidence from the U.S. economy (Carvalho and Nechio, 2014) and the misunderstanding of the Taylor rule cannot be an answer to the misunderstanding of the consequence of monetary policy changes. Moreover, the response of expectations of future economic conditions to a shock to expectations of future prices (shown in the first row and the second column) further confirms that households form expectations in a way consistent with the supply-side view of economic fluctuations.

Figure 12. Estimation of small-scale monetary VARs with expectation variables



IV. Conclusion

TBA

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Online Appendix.

A. Example of Korean Household Consumer Survey Questionnaire

The survey will be conducted between 2021. 01. 11 and 2021. 01. 18, so please answer the following questions during the given period.

Respondent's Information

The survey form should be filled out by the householder himself.

Date Responded: 2021 Jan ___

Name: _____

Date of Birth (Year and Month): _____

Gender: □Male □Female

Number of household members (including yourself): ___

Phone Number: Cellular phone (required) _____ Residence Telephone _____

Residence Address: _____

E-mail Address: _____

Current Occupation: □Regular Workers □Temporary or Daily Workers □Self-employed □Others (Unemployed, Housework, Students, etc.)

Please indicate the occupation that accounts for the main source of household income.

Regular workers are those with employment contract periods over 1 year.

Residential State: □Own House □Long-term Rent[6] □Monthly Rent □Other (Free housing, etc.)

Household Income (Monthly Average):

□Less than 1 Million won □1 to less than 2 Million Won □2 to less than 3 Million Won □3 to less than 4 Million Won

□4 to less than 5 Million Won □5 to less than 6 Million won □6 to less than 7 Million Won □7 to less than 8 Million Won

□8 to less than 9 Million Won □Over 9 million won

Average household income includes labor income (salary and bonus), business income (calculated by subtracting expenses from sales), property income (interest, dividend, rent, etc.), and transfer income (pension, government subsidy, allowances, etc.) earned by all household members.

I. Economic Awareness

[6] Long-term rent, which is called Jeonse, is a house trading system commonly used in Korea in which tenant pays Jeonse prices to the owner of the house in the beginning of lease term and gets the same amount paid back at the end of the term.

1. Compared to 6 months ago, how has your living condition changed?

"Living conditions" mean comprehensive levels of living made in consideration of income level and consumption expenditure.

□ Has gotten a lot better

□ Has gotten a little bit better

□ Has been similar

□ Has gotten a little bit worse

□ Has gotten a lot worse

2. Compared to 6 months ago, how do you think the economic conditions (of the whole country in general) have changed?

"Economic conditions" mean the overall levels of economic activity made in South Korea.

□ Has gotten a lot better

□ Has gotten a little bit better

□ Has been similar

□ Has gotten a little bit worse

□ Has gotten a lot worse

II. Economic Expectations

3. How do you expect your living conditions to be in 6 months compared to the present?

□ Will be a lot better

□ Will be a little bit better

□ Will be similar

□ Will be a little bit worse

□ Will be a lot worse

4. How do you expect the economic conditions (of the whole country in general) to be in 6 months compared to the present?

□ Will be a lot better

□ Will be a little bit better

□ Will be similar

□ Will be a little bit worse

□ Will be a lot worse

5. How do you expect employment opportunities in the entire country to be in 6 months compared to the present?

□ Will increase significantly
□ Will increase slightly
□ Will be similar
□ Will decrease slightly
□ Will decrease significantly

6. How do you expect the overall interest rate to be in 6 months compared to the present?

□ Will increase significantly
□ Will increase slightly
□ Will be similar
□ Will decrease slightly
□ Will decrease significantly

III. Consumption Expenditure Expectation

7. How do you expect your household income to be in 6 months compared to the present?

□ Will increase significantly
□ Will increase slightly
□ Will be similar
□ Will decrease slightly
□ Will decrease significantly

8. How do you expect your consumption expenditure on each item to be in 6 months compared to the present?

(Please select one of the options below for each item)

<Options>
(i) Will increase significantly
(ii) Will increase slightly
(iii) Will be similar
(iv) Will decrease slightly
(v) Will decrease significantly

1) Durable Goods (Electronic devices, furniture, car, etc.)
2) Clothing (including shoes)
3) Eating outside
4) Travel
5) Education
6) Medical and Health
7) Entertainment
8) Transportation and Communication
9) Residence

9. Considering your response to Question 8, how do you expect your total consumption expenditure to be in 6 months compared to the present?

□ Will increase significantly
□ Will increase slightly
□ Will be similar
□ Will decrease slightly
□ Will decrease significantly

IV. Household savings and liabilities

Household savings include not only deposits, installment savings, and loans made to financial institutions, but also stocks, funds, and saving insurance.

10. Compared to 6 months ago, how has your household savings (in total balance) changed?

□ Has increased significantly
□ Has increased slightly
□ Has been similar
□ Has decreased slightly
□ Has decreased significantly

11. How do you expect your household savings (in total balance) to be in 6 months compared to the present?

□ Will increase significantly
□ Will increase slightly
□ Will be similar

□ Will decrease slightly

□ Will decrease significantly

Household debt includes all types of loans and credit card installments.

12. Compared to 6 months ago, how has your household debt (in total balance) changed?

□ Has increased significantly

□ Has increased slightly

□ Has been similar

□ Has decreased slightly

□ Has decreased significantly

13. How do you expect your household debt (in total balance) to be in 6 months compared to the present?

□ Will increase significantly

□ Will increase slightly

□ Will be similar

□ Will decrease slightly

□ Will decrease significantly

V. Price Level

Consumer prices refer to the average price levels of all goods and services purchased by consumers in the whole country.

14. Based on what you have felt, how much consumer prices have gone up / down over the past year?

□ Declined

□ Increased by 0% to less than 1%

□ Increased by 1% to less than 2%

□ Increased by 2% to less than 3%

□ Increased by 3% to less than 4%

□ Increased by 4% to less than 5%

□ Increased by 5% to less than 6%

□ Increased by more than 6%

□ Don’t know

15. Considering future economic conditions, how do you expect consumer price levels to be in 1 year compared to the present?

□ Will increase significantly
□ Will increase slightly
□ Will be similar
□ Will decrease slightly
□ Will decrease significantly

16. Considering future economic conditions, how much do you expect consumer prices to rise / fall during the next year?
□ Will decline
□ Will increase by 0% to less than 1%
□ Will increase by 1% to less than 2%
□ Will increase by 2% to less than 3%
□ Will increase by 3% to less than 4%
□ Will increase by 4% to less than 5%
□ Will increase by 5% to less than 6%
□ Will increase by more than 6%
□ Don't know

16-1. What do you expect to be the main items that will contribute to the increase in consumer prices over the next year?
(May select up to 2 items)
□ Agricultural / livestock / fishery products
□ Petroleum products (gasoline, diesel, etc.)
□ Industrial products (clothing, durable goods, etc.)
□ Residential cost (Jeonse, rent, etc.)
□ Cost of public services (electricity, communication, medical services, etc.)
□ Personal services (education, dining out, travel, entertainment, etc.)

17. How much do you expect consumer prices to rise / fall annually over the next five years on average?
□ Will decline
□ Will increase by 0% to less than 1%
□ Will increase by 1% to less than 2%
□ Will increase by 2% to less than 3%

□ Will increase by 3% to less than 4%

□ Will increase by 4% to less than 5%

□ Will increase by 5% to less than 6%

□ Will increase by more than 6%

□ Don't know

18. How do you expect the housing sales prices to be in 1 year compared to the present?

□ Will increase significantly

□ Will increase slightly

□ Will be similar

□ Will decrease slightly

□ Will decrease significantly

19. How do you expect the wage level of Korean workers to be in 1 year compared to the present?

□ Will increase significantly

□ Will increase slightly

□ Will be similar

□ Will decrease slightly

□ Will decrease significantly

Employee-oriented corporate social responsibility and environmental innovation: The moderating role of board gender diversity

ABSTRACT

This study analyzes the impact of employee-oriented corporate social responsibility (WS) on corporate green innovation (GI) based on a sample of 6,791 firms covering 27 countries from 2002–2021. WS is found to contribute significantly to GI enhancement. The positive impact of WS on GI is more substantial for firms with more gender-diverse boards, suggesting that corporate governance mechanisms and WS have a complementary connection. All dimensions of WS positively affect GI. Finally, while board gender diversity positively affects investment in environmental R&D, we find no significant direct impact of WS on green R&D after controlling for BGD and incorporating the interaction between WS and BDG in the regression.

Keywords: Environmental innovation, Employee-oriented CSR, Board gender diversity, Corporate governance, Climate change, Green R&D investment

JEL classification: G30 ; O32 ; Q55 ; Q56

1. Introduction

Climate change (CC), a costly negative externality on society (Nordhaus, 2019) and a risk factor for firms (Baldauf *et al.*, 2020), poses both a threat and an opportunity for corporations. While firms face direct costs related to CC, CC provides investment opportunities, for instance, in clean technologies (Krueger *et al.*, 2020). Under the strategic objective of transition toward low-carbon economies, technological innovation is an essential pathway for firms to harmonize environmental protection with competitiveness and financial performance (Yin *et al.*, 2025). In that regard, green innovation (GI) is crucial to climate action. As the world economy is trending toward a green economy, innovation is essential in achieving sustainable development goals and reducing environmental externalities (Jin *et al.*, 2024). GI is an opportunity to build a more sustainable and resilient world (Lakhal *et al.*, 2024), and then for firms to maintain competitiveness in a constantly changing world.

As Hao and He (2022) mentioned, green innovation is essential for firms to achieve both economic benefits and environmental protection in the long term. GI helps limit environmental degradation and enables firms to increase their reputation and competitiveness, thus, their financial performance under stakeholders' pressures (Chen *et al.*, 2018). However, compared with conventional innovation, GI is riskier and implies substantial investments and resources (Liu *et al.*, 2024; Yousaf *et al.*, 2022). GI also reflects firm creativity and its sensitivity to environmental issues (Lakhal *et al.*, 2024). In general, innovation requires special technical knowledge and talented human resources (Li and Wang, 2022). Notably, employee creativity is crucial to innovation (Greer *et al.*, 2023). As primary stakeholders in achieving company objectives, employees, if well treated, may be motivated to contribute to the innovation success (Chen *et al.*, 2016). In that regard, corporate social responsibility (CSR) components directly related to employee relations are an effective way to motivate employees (Bauman and Skitka, 2012), and enhance their productivity and creativity (Benlemlih and Bitar, 2018). CSR also enables the company to attract competent technicians who will promote innovation (Liu *et al.*, 2020; Chen *et al.*, 2016). Talented and well-motivated people are more crucial to GI than other resources.

There is so much debate in the literature regarding the incremental value of CSR on firm outcomes. Academics have examined the influence of CSR on different aspects of firm performance and have acknowledged its importance for corporate reputation, competitiveness, financial performance, and success in innovation (Hao and He, 2022; Yuan and Cao, 2022; Wang *et al.*, 2023; Chen et al., 2016). CSR is associated with firm innovation since it helps alleviate information asymmetry and financing constraints faced by innovative firms (Zhao and Xiao, 2019; Chan *et al.*, 2017). In that regard, El Ghoul *et al.* (2011) document that information asymmetry is more severe for low CSR firms than high CSR firms. Specifically, low CSR firms have a weaker reputation and are more likely to engage in greenwashing or to cover up their misconduct and counter-performance. Consequently, a high level of CSR is beneficial for firms' valuation and access to external financing, thus enabling socially responsible firms to finance their innovative projects more easily. Hao and He (2022) argue that CSR disclosure increases firms' transparency, helps investors

understand corporate information, and reduces information asymmetry, thus enabling them to invest in green innovation. Alves and Meneses (2024) show that environmental, social, and governance (ESG) factors provide additional information beyond traditional risk measures in explaining the cost of debt. The authors consider increased ESG performance tends to lower the increase in debt cost caused by agency costs, signaling that lenders do not regard ESG activities as a waste of corporate resources.

Drawing on both stakeholder and resource-based theories, researchers document the importance of CSR toward employees for corporations. Hur *et al.* (2018) argue that firms actively engaged in CSR activities promote work environments that allow employees to develop more innovative products. Furthermore, employees perceive the firm's CSR activities positively and are motivated to adopt positive attitudes that enhance their productivity and creativity. Empirical studies also reveal a positive impact of CSR on employee outcomes. Chaudhary and Akhouri (2018) show that CSR effectively enhances employee work engagement. Hur *et al.* (2018) find employees' perceptions of CSR positively impact employee creativity at work. CSR toward employees (WS) positively affects job satisfaction and employees' commitment, enhances employee motivation for innovation (Li and Wang, 2022; Liu *et al.*, 2020), and improves inventor productivity and the firm's financial performance (Bai, 2022). In addition, involving the internal stakeholders using CSR activities motivates employees to become more creative and contributive towards environmental sustainability initiatives (Shahzad *et al.*, 2020). CSR practices help improve employees' organizational identity, forming an adequate atmosphere for employees to implement environmentally friendly behavior (Yuan and Cao, 2022).

Although previous empirical studies reveal various factors affecting GI (Yin *et al.*, 2025; Yousaf *et al.*, 2022; Liu *et al.*, 2024), the role of WS has been neglected despite the importance of human resources in the firm's success. At present, the actual effect of WS on GI remains unclear. Previous researches examine the impact of CSR on employee engagement (Nazir and Islam, 2020), employee creativity, and innovative behavior (Hur *et al.*, 2018; Chaudhary and Akhouri, 2018; Gullifor *et al.*, 2023). Although a few studies explored the relationship between ESG ratings (Hao and He, 2022; Yuan and Cao, 2022; Wang *et al.*, 2023) or CSR reporting (Mbanyele *et al.*, 2022) and green innovation, they do not consider the individual dimensions of CSR, such as employee-related CSR. However, not all dimensions of CSR are relevant for innovation (Chen *et al.*, 2016). As Benlemlih and Bitar (2018) noticed, using an aggregate CSR score masks the effect of each dimension since CSR components related to employees are more relevant to firms' success than those related to secondary stakeholders, for example. Yet, despite its importance, very few studies have investigated the relationship between CSR and green innovation, and no study examines the impact of employee-oriented CSR on green innovation. Thus, there is limited systematic evidence evaluating the ability of CSR firms to produce innovations that alleviate environmental problems. The present study aims to fill this gap in the literature by examining the relationship between CSR toward employees and green innovation.

Building on both stakeholder and agency theories, we argue that employee-oriented CSR reduces information asymmetry and agency conflicts, stimulates work efficiency and

creativity (Bai, 2022), and contributes to employee motivation and engagement, which is essential to reducing moral hazards that impede negatively technological innovation. Using a sample of 6,791 firms from 2002-2021, covering 27 countries worldwide, the study documents a significantly positive impact of WS on GI. In addition, all dimensions of WS positively affect GI.

In the finance and economics literature, the board of directors is considered the primary internal governance mechanism, as it plays a critical role in decision-making processes and monitoring at the organizational level (Bernile *et al.*, 2018), including those on sustainability. The board of directors plays a key role in driving the firm's innovative investments (Lakhal *et al.*, 2024). Specifically, board gender diversity (BGD) is an essential factor affecting firms' environmental strategy and green innovation (Liao *et al.*, 2019; Bazel-Shoham *et al.*, 2024). He and Jiang (2019) consider that board gender diversity enables companies to meet the complex needs of different stakeholders regarding environmental strategies and facilitates the strategic transformation of companies towards socially responsible firms. In that regard, we examine how the BGD moderates the relationship between WS and GI. We find that the positive impact of WS on GI is stronger for firms with more gender-diverse boards, suggesting a complementary connection between corporate governance mechanisms and employee-oriented CSR. An association of stronger governance induced by BGD with better employee-oriented CSR helps alleviate the free-riding problem that reduces firms' innovation.

This article is the first economic analysis of CSR toward employee policies and sustainable development. It applies insights from the financial, CSR, accounting, and economic literature to derive and discuss CSR activities' economic and financial consequences on the firm and society. It, therefore, contributes to the advancement of the literature in these four areas.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework and develops the hypotheses. Section 3 presents the data and discusses the methodology. Section 4 examines how WS affects green innovation. Section 5 checks for the robustness of the results. Section 6 presents further analysis, and section 7 concludes.

2. Theoretical framework and hypothesis development

Innovation faces serious problems of information asymmetry, leading to moral hazards and financing constraints. This section reviews how CSR can enhance green innovation and how board gender diversity moderates this relationship.

2.1. CSR, information asymmetry, and green innovation

A key debate in the finance literature is whether CSR benefits the shareholders or arises because managers act in their private interest. Some proponents of agency theory argue that in the absence of adequate supervision and incentives, managers tend to show a strong preference for enjoying a quiet life since their efforts are difficult to observe (Wang *et al.*, 2023). From this perspective, CSR results from the opportunism of managers who seek to profit from the company's free cash flows instead of investing optimally (Gillan *et al.*, 2021). CSR expenses, including those towards the internal stakeholders such as employees, reduce the resources available for investment in other activities and innovation (Ferrell *et al.*, 2016),

and would destroy value for shareholders. In that regard, CSR represents costly diversions of firm resources and a source of agency conflicts between managers and shareholders (Goss and Roberts, 2011), particularly when managers act as philanthropists (Krueger, 2015). On the other hand, the firm's insiders may engage in CSR for their private benefit to improve their reputation, gain legitimacy toward a specific group of stakeholders, or cover up their misconduct behaviors (Barnea and Rubin, 2010). In such a situation, the management would not invest in innovation and would not increase CSR performance by environmental expenses (Hao and He, 2022). Along these lines, Fabrizi *et al.* (2014) find that when the CEO's private interests are strictly related to those of shareholders, the CEO is less likely to invest in CSR since CSR investments do not generate short-term profit.

An alternative view of firms' CSR activities is that CSR enhances firm value since it constitutes a long-term strategy integrated with stronger corporate governance (Naciti, 2019; Ferrell *et al.*, 2016). Proponents of this approach are close to the stakeholder theory and consider CSR mitigates agency conflicts and strengthens the relationship between the firms and their stakeholders (Liang and Renneboog, 2018; Bai, 2022). Socially responsible firms generally have effective governance mechanisms and operate ethically (Ferrell *et al.*, 2016). Ethical management involves undertaking good CSR practices to establish a stronger reputation, improve credibility and transparency, increase investor confidence, and establish and maintain good stakeholder relationships and legitimacy (Hao and He, 2022). Given that CSR increases the firm's legitimacy and reputation, it may enhance firm value and competitiveness in the long term (Fabrizi *et al.*, 2014). Then, CSR expenditures are consistent with value maximization goals as long as they respond to stakeholders' expectations (Barnea and Rubin, 2010). Innovation is a long-term value-enhancing strategy; thus, CSR may encourage corporate innovation, including green innovation.

CSR toward employees may promote green innovation for various reasons. Information asymmetry is among the most important factors limiting firms' ability to innovate. Wang *et al.* (2023) argue that it is difficult for investors to observe companies' green innovation processes, leading to high agency costs associated with innovation activities. They consider ESG rating disclosure by firms alleviates the information asymmetry between managers and external investors, thus promoting corporate green innovation. Hao and He (2022) observe that CSR enhances green innovation since CSR disclosure increases firms' transparency and helps investors understand corporate information. The increased firm transparency promotes strong partnerships with stakeholders, facilitates internal and external knowledge sharing, and makes managers pay more attention to environmental protection, thus enhancing the firm's green innovation capabilities. Wang *et al.* (2023) noted that ESG ratings can effectively reduce the cost of investor monitoring, which, in turn, promotes corporate green innovation. They also find that the simple fact that a company has an ESG rating assigned by a rating agency increases green innovation output by 3.9%.

Information asymmetry results in financing constraints faced by innovative firms. CSR helps alleviate these challenges. El Ghoul *et al.* (2011) argue that information asymmetry is more severe for low CSR firms. Specifically, low CSR firms have a weaker reputation and may be more likely to engage in greenwashing or misrepresent their performance than high CSR

firms. In addition, ESG investors are likely to pay more attention to information related to high CSR firms while neglecting information related to low CSR firms. Finally, ESG investors prefer not to include low CSR firms in their portfolios. Thus, high CSR firms may have a lower cost of capital than low CSR firms. The negative association between CSR and financial constraints also results in the positive impact of CSR on financial performance (Chan *et al.*, 2017) and, thus, its negative impact on financial distress risk (Boubaker *et al.*, 2020). For instance, Boubaker *et al.* (2020) show that higher CSR levels bring better financial stability. They consider that CSR gives firms less financial default risk, which is rewarded with better access to external financing, and the employee dimensions of CSR particularly drive this relation. Thus, better CSR makes firms more creditworthy, which is necessary to finance innovation. Empirical studies also find that CSR alleviates financial constraints (Zhao and Xiao, 2019; Chan *et al.*, 2017), positively affects the firm's financial performance, and reduces financial distress (Chan *et al.*, 2017). As CSR is a long-term value maximization strategy (Barnea and Rubin, 2010), helpful for firms' valuation and access to external financing (El Ghoul *et al.*, 2011), CSR toward employees may undoubtedly promote corporate innovation, including innovation that benefits the environment.

Furthermore, CSR allows firms to obtain low-cost financing to undertake innovative projects. For instance, Apergis *et al.* (2022) prove that borrowing firms' debt cost is associated with ESG scores. Firms with low ESG scores are considered riskier because low ESG factors are perceived as an increase in the probability of default. Alves and Meneses (2024) relate ESG scores, credit risk, and the cost of debt. They show that firms with better ESG performance benefit from lower debt costs and financial risk. This suggests that ESG factors provide additional information beyond traditional risk measures in explaining the cost of debt. Increased ESG performance reduces the agency costs and thus the debt cost, signaling that lenders do not regard ESG activities as a waste of corporate resources. Concerning bank debt, Goss and Roberts (2011) find that lenders are more sensitive to CSR concerns. Consequently, firms with CSR concerns pay between 7 and 18 basis points more than socially responsible firms as banks register CSR concerns as risks and respond with less attractive loan contract terms. Finally, El Ghoul *et al.* (2011) document that firms with better CSR scores exhibit cheaper equity financing. However, the authors noticed that not all dimensions of CSR are related to the cost of equity. In particular, improving employee relations contributes more substantially to reducing firms' cost of equity, suggesting that firms with employee-oriented CSR practices have higher valuation and lower risk. Thus, improved CSR toward employees enhances firm value by reducing the firm's cost of equity.

Overall, CSR toward employees reduces information asymmetry and agency conflicts, improves transparency, limits financial constraints, and helps firms innovate. Thus, CSR toward employees may positively affect green innovation.

2.2. CSR toward employees and green innovation

The stakeholder theory states that firms must focus on the expectations of their stakeholders to create long-term value (Harrison and Wicks, 2013). Accordingly, managing stakeholder relationships is essential for firms' success. Effective stakeholder involvement and

participation can enhance corporate reputation and competitive advantage (Mahajan *et al.*, 2023). In that regard, all stakeholders may have positive views concerning CSR (Barnea and Rubin, 2010), as CSR allows them to have converging visions that might help the firms achieve their objectives (Shahzad *et al.*, 2020). The firms must undertake CSR for their stakeholders to enhance their competitive advantage and reputation (Bai, 2022). On the other hand, employees are the most critical primary stakeholders, essential to achieving corporate objectives (Bauman and Skitka, 2012). Since climate change is a negative externality globally, an initiative by the firm aimed at limiting this externality will be strongly supported and encouraged by all stakeholders, including its employees. CSR practices can also help improve corporate culture, forming an atmosphere that encourages employees to implement green innovation behaviors (Yuan and Cao, 2022).

Based on the stakeholder theory, CSR toward employees may positively impact green innovation (Yuan and Cao, 2022). As a policy enhancing employee satisfaction (Erhemjamts *et al.*, 2013), CSR toward employees is a motivational tool that may help improve employee performance. CSR toward employees positively affects employee engagement and attitude toward the company (Yuan and Cao, 2022; Bai, 2022). For instance, Nazir and Islam (2020) show that CSR activities lead to employee engagement via compassion. They also believe that CSR initiatives signal the ethical nature of the firms' actions and create trust. This positive perception of CSR makes employees change their attitude, leading to pro-social behaviors. Chaudhary and Akhouri (2018) observe that when a firm engages in CSR due to its will to help society, it is likely to signal to employees that they will also be treated well, and the firm will not act opportunistically, creating a climate of psychological safety. Involvement in CSR influences employees' justice perceptions by reflecting the firm's respect for human dignity and worth. CSR builds trust and long-term relationships between employees and employers and stimulates employees' creativity (Bai, 2022; Chen *et al.*, 2016), which are necessary to enhance corporate green innovation.

Furthermore, firms actively engaged in CSR tend to promote work environments that allow employees to develop more innovative products, and mutually, employees who perceive their firm positively due to its CSR are motivated by personal interest and the challenge of solving problems and tackling complex tasks, which enhances their productivity and creativity (Hur *et al.*, 2018). Involving the internal stakeholders using CSR can motivate employees to become more creative and contribute to environmental sustainability initiatives (Shahzad *et al.*, 2020). Gullifor *et al.* (2023) argue that when employees perceive their firms as socially responsible, they are more likely to engage in organizational citizenship behaviors, resulting in increased individual performance. Similarly, employees view their company's CSR favorably, leading to behaviors that benefit both employees and the firms. Employees' CSR perceptions create a positive work environment that enhances their intrinsic motivation, eliciting creative behaviors (Hur *et al.*, 2018). Thus, CSR toward employees may promote corporate innovation.

Empirical studies also reveal the positive impacts of CSR on employee behaviors. Chaudhary and Akhouri (2018) show that CSR effectively enhances employee creativity and work engagement. Hur *et al.* (2018) support the argument that developing an ethical context in a

firm using CSR initiatives leads to positive job attitudes and beneficial behaviors among employees. Yuan and Cao (2022) remark that CSR fosters employee environmental behaviors and provides competitive advantages and positive economic outcomes for corporations. Shahzad *et al.* (2020) and Hao and He (2022) focus on the influence of CSR on firms' green innovation. They find CSR practices significantly promote green innovation, which is mainly manifested in the increase in the number of green patents. However, these studies did not examine the specific impact of employee-oriented CSR on green innovation. Based on these results and the preceding theoretical developments, we formulate the following hypothesis:

H1: Employee-oriented CSR is positively associated with corporate green innovation

2.3. Moderating role of board gender diversity

The board of directors plays a key role in a firm's governance as it monitors and advises (Fama and Jensen, 1983). One of the main features of corporate boards is diversity (Bernile et *al*., 2018). Diversity brings a greater variety of skills to the boards (Lu and Herremans, 2019). A diverse board helps better balance the expectations of various stakeholders to produce higher-quality decisions and more innovative solutions when dealing with complex issues (He and Jiang, 2019). Specifically, gender diversity provides several advantages. Female directors are better monitors, resulting in lower agency costs through improved board monitoring effectiveness (García Lara *et al.*, 2017; Cardillo *et al.*, 2021). Because of this monitoring role, more gender-diverse boards are more likely to reduce moral hazard and counterproductive behaviors in the workplace, thereby promoting corporate innovation. Gender diversity also enhances carbon reduction initiatives and climate change mitigation strategies (Liu, 2018; Haque, 2017). Board gender diversity helps firms effectively track the complex needs of distinct stakeholders concerning environmental strategies, resolve conflicts, and reach a consensus in decision-making regarding environmental strategy (He and Jiang, 2019). Konadu *et al.* (2022) consider that more gender diversity puts pressure on the board to pursue sustainable development goals due to women's emphatic and caring nature. Atif *et al.* (2021) observe that female directors are more sensitive to the quality of the environment than male directors and are more likely to encourage firms to adopt environmentally friendly practices. These different characteristics suggest more engagement of women directors in green technologies and developments (Jin *et al.*, 2024). Thus, one can hope for an improvement in green innovation in a context characterized by gender-diverse boards.

Empirical studies also confirm the positive impact of board gender diversity on the quality of the environment and green innovation. Firms with more female directors are less likely to be subject to environmental violations (Liu, 2018), as women are more likely to accept the introduction of environmental regulations than men (Konadu *et al.*, 2022). Kreuzer and Priberny (2022) and Konadu *et al*. (2022), among others, analyze how board characteristics affect a firm's carbon emissions and identify the boards with a higher share of female members to emit a lower amount of greenhouse gases. Rjiba and Thavaharan (2022) emphasize the benefits of having more female directors in fostering corporate environmental sustainability. Furthermore, women on boards facilitate the strategic transformation of the firms toward socially responsible firms by improving corporate governance along the

ecological dimension (He and Jiang, 2019). In that regard, board gender diversity is crucial for innovation-related initiatives and strategic resource allocation decisions as it enhances the board's effectiveness in satisfying the needs of broader groups of stakeholders' interests (Chu, 2024). As Lakhal *et al*. (2024) mentioned, green innovation reflects the firm's creativity and sensitivity to environmental problems. Therefore, women directors are likely to commit to green innovation because they can better manage all stakeholders' interests, including environmental issues.

Furthermore, Chu (2024) finds that firms with more female directors place greater importance on environmental activities and engage in more green innovation strategies. Besides, their result shows that the effect of female executive directors outweighs that of female independent directors. Based on a sample of French-listed firms, Lakhal *et al.* (2024) show that women's presence on boards improves the innovative capacity of firms by encouraging the board to invest in long-term innovation projects while respecting the environment. Jin *et al.* (2024) document that firms with more gender-diverse boards address sustainability issues by taking advantage of new prospects, thus integrating their company objectives with global sustainability goals. He and Jiang (2019) capture green product innovation through green patents and green process innovation through environmental management certification. They show that board gender diversity increases the occurrence of green product innovation rather than green process innovation.

In sum, the well-documented impact of gender diversity on firm environmental policies and green innovation reinforces our belief that increasing board gender diversity may enhance the positive impact of employee-oriented CSR on green innovation. Thus, in light of the previous discussion, we formulate the following hypothesis:

H2. Board gender diversity has a positive impact on green innovation.

H3. The positive impact of CSR toward employees on green innovation is stronger for firms with more gender-diverse boards.

3. Data and methodology

3.1. Data and variables

We collect the firms' environmental, social, and governance (ESG) data from the Refinitiv ESG database, one of the most widely used in empirical ESG research. Financial and accounting data are from Compustat.

3.1.1. Green innovation

In the literature, R&D intensity is generally used as the ex-ante measure of innovation, and patents as the ex-post measure (Sapra *et al*., 2014). The previous studies employed several indicators to capture corporate green innovation. Green innovation is sometimes decomposed into green product innovation and green process innovation (Li *et al.*, 2017; He and Jiang, 2019). The measures of green product innovation include green R&D expenses (Lee and Min, 2015; Makpotche *et al.*, 2024), green patents (Amore and Bennedsen, 2016), eco-

labeling products (Lin *et al.*, 2014; He and Jiang, 2019). As indicators of green processes innovation, the attainment of ISO14001 standards is employed (He and Jiang, 2019; Li *et al.*, 2017; Lin *et al.*, 2014). ISO14000 is a series of international environmental management systems (EMS) standards. Its adoption is voluntary and implies that the quality of environmental management has been recognized and is subject to scrutiny (He and Jiang, 2019). ISO14001 is the best-known in the ISO14000 family. It specifies the requirements for an effective EMS.

In recent studies, the eco-innovation score has been employed to measure green innovation (Bazel-Shoham *et al.*, 2024; Mansour *et al.*, 2024). We Follow this approach by adopting the Refinitiv ESG eco-innovation score (GI score) to capture the firm's environmental innovation (GI). GI score[1] reflects a company's capacity to reduce its customers' environmental costs and burdens, thereby creating new market opportunities through new environmental technologies and processes or eco-designed products. It measures a company's management commitment and effectiveness toward supporting the research and development of eco-efficient products or services. The GI score ranges from 0 to 100, with a higher value representing better GI. This measure of green innovation presents several advantages. First, it captures both green product innovation and green process innovation. Second, Refinitiv covers almost 70% of the global market cap, and its ratings are available on close to 9,000 firms worldwide. Third, the GI score is an alternative that overcomes one of the weaknesses of patents since all innovations are not patented, and all inventions are not innovative (Mansour *et al.*, 2024). In addition, obtaining the patent data for all firms included in our studies is impossible since patent data are not available for most countries. Finally, the Refinitiv ESG database is widely used in empirical studies in various fields (Al-Shaer *et al.*, 2024; Mbanyele *et al.*, 2022; Bazel-Shoham *et al.*, 2024; Konadu *et al.*, 2022; Rjiba and Thavaharan, 2022).

3.1.2. CSR toward employees

Using a similar approach as Chen *et al.* (2016), we measure employee-oriented CSR by the workforce score (WS) collected from the Refinitiv ESG database. The WS includes four dimensions, namely: workforce diversity and inclusion (WDIS), training and career development (TCDS), employment quality and working conditions (WCS), and health and safety (HSS). The WS, as defined in the Refinitiv ESG database, measures a firm's effectiveness in providing job satisfaction, a healthy and safe workplace, maintaining diversity and equal opportunities, and developing opportunities for its workforce.

3.1.2. Board gender diversity

Following the literature (Bazel-Shoham *et al.*, 2024), we measure BGD using female directors' percentage on firms' boards, available in the Refinitiv ESG dataset. The BGD is computed as the percentage of women on the board of directors.

[1] For more details, see Refinitiv ESG scores methodology

3.1.3. Control variables

Following previous studies examining environmental innovation, we used a set of control variables (Jin *et al*., 2024; Bazel-Shoham *et al*., 2024; Lakhal *et al*., 2024; He and Jiang, 2019). We control for the board characteristics by adding board size computed as the natural logarithm of the total number of board members in the firm at the end of each year, the board independence as the percentage of independent board members, and the board meetings measured by the logarithm of the number of board meetings in the year. We also control for firm size computed as the logarithm of the book value of the total assets; the debt ratio measured by the ratio of the book value of total debt to the book value of total assets; the return on the assets (ROA) computed as the ratio of the earnings before interest and taxes (EBIT) to the book value of the total assets; Tobin's Q measured by the market-to-book ratio and calculated as the ratio of the market value of the total equity to the book value of the total assets; the cash to asset ratio (Cash-to-total); and the capital expenditure to asset ratio (Capex_to_Asset). The final sample is an unbalanced panel with 46,998 firm-year observations of 6,791 unique firms domiciled in 27 countries from 2002–2021. Table 1 reports the summary statistics.

Table 1.
Summary statistics (full sample)

Variables	Obs	Mean	Median	Std. dev.	Min	Max
GI score	57,240	0.2064	0	0.2955	0	0.9987
GPI (green product innovation)	57,346	0.3277	0	0.4693	0	1
Green_R&D_to_ASSET	2,740	0.0057	0.0012	0.0152	0	0.2197
WS (Workforce Score)	57,240	0.5056	0.5053	0.2850	0	0.9993
WDIS	57,341	0.5092	0.4512	0.3052	0.0127	0.9883
WCS	57,341	0.5001	0.4908	0.3034	0.0224	0.9950
HSS	57,341	0.5026	0.4681	0.3039	0.0107	0.9959
TCDS	57,341	0.5056	0.5511	0.3169	0	0.9826
GOV (Governance Score)	57,341	0.5344	0.5964	0.2973	0.0082	0.9850
BGD	56,577	0.4931	0.4759	0.2924	0.0702	1
Board_independence	55,031	0.5371	0.6005	0.3012	0.0055	0.9524
Board_size	57,168	2.2293	2.1972	0.3438	0	3.6635
Board_meeting	49,556	0.4626	0.4100	0.2393	0.0139	1
Tobin's Q (firm value or MTB)	56,170	3.9971	1.8933	5.7821	0.01	37.54
ROA (Return on assets)	56,280	0.0605	0.0658	0.1521	-1.7189	3.1167
Firm Size (Log Total assets)	57,318	9.2059	8.8239	2.6610	0.3357	19.7510
Debt ratio	48,964	0.4963	0.3683	0.6486	0	0.8946
Cash-to-total assets	56,614	0.1177	0.0772	0.1325	0	0.9992
Capex_to_Asset	55,970	0.0454	0.0319	0.0527	0	0.5831

This Table reports the mean, the median, the standard deviation, the minimum, and the maximum of the key variables. The sample includes all firm-year observations from 2002 to 2021 covering 27 countries worldwide. All the sample firms are up to 6,791, with maximum observations of up to 57,346. Employee-related CSR data and corporate governance ratings are comprised between 0 and 1.
Source: Authors own work

3.2. Baseline model specification

We examine the relationship between employee-oriented CSR and environmental innovation using the following specifications:

$$(1) \quad GI_{it} = \alpha + \beta_{ws} WS_{it-1} + \gamma_c X_{it} + \rho_1 FirmEffets_{it} + \rho_2 YearEffects_t + \varepsilon_{it}$$

$$(2) \quad GI_{it} = \alpha + \beta_{ws} WS_{it-1} + \beta_{bgd} BGD_{it-1} + \beta_{int} WS_{it-1} BGD_{it-1} + \gamma_c X_{it} + \rho_1 FirmEffets_{it} + \rho_2 YearEffects_t + \varepsilon_{it}$$

In the model, GI_{it} represents the firm *i*'s environmental innovation in year *t*. WS_{it-1} indicates the firm *i*'s workforce score in year *t-1*. X_{it} are the firm-level control variables. Since ESG factors may affect firm outcomes with lag, and to reduce endogeneity, we follow the previous studies and use the lag values of WS and governance variables (Mbanyele *et al.*, 2022; Bazel-Shoham *et al.*, 2024). To account for unobservable factors, we include firm and time-fixed effects. ε_{it} represents the random error term.

4. Empirical results

We estimated the baseline models using a panel model with firm and year-fixed effects.

4.1. The baseline analysis

The baseline regression results reported in Table 2 show a positive and statistically significant relationship between employee-oriented CSR and green innovation. The coefficients for WS are positive and significant at the 1% level, even after including corporate governance mechanisms and other control variables (Columns 1 and 2). The coefficient of WS is 0.1598 with financial and accounting control variables only (column 1), and 0.1329 with all control variables, including the interaction between WS and BGD (column 2). These findings indicate that better employee-oriented CSR leads to higher environmental innovation performance, consistent with the argument that employee-oriented CSR is an effective way to motivate employees and enhance their creativity. These findings confirm hypothesis H1, that employee-oriented CSR is positively associated with corporate green innovation.

4.2. The moderating role of the board gender diversity

Regression in column 2 of Table 2 also analyzes the moderating role of BGD. As can be seen, the coefficient of WS remains significantly positive at the 1% level, while BGD is not significant, indicating that WS has a straightforward effect on GI. The interaction between WS and BGD is also positive (0.0325) and significant at 1%, indicating that BGD moderates the relationship between WS and GI. Specifically, the positive impact of WS on GI is stronger for firms with more gender-diverse boards, confirming our basic argument that combining WS with BGD is an effective way to motivate employees and reduce the moral

hazards that limit innovation. The board independence is also significant at 1%. These findings support hypothesis H3 that the positive impact of CSR toward employees on green innovation is stronger for firms with more gender-diverse boards.

Table 2. The Impact of Employee-oriented CSR on Green Innovation

Dependant variable: Green innovation score (GI score)							
Parameter	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L.WS	0.1598***	0.1329***	-	-	-	-	-
	(27.28)	(12.30)					
L.WDIS	-	-	0.0682***	0.1033***	-	-	-
			(12.40)	(10.87)			
L.WCS	-	-	0.0161***	-	0.0389***	-	-
			(3.97)		(4.79)		
L.HSS	-	-	0.0552***	-	-	0.1042***	
			(10.56)			(11.00)	-
L.TCDS	-	-	0.1004***	-	-	-	0.1051***
			(18.75)				(11.57)
L.BGD	-	0.0132	0.5056***	0.0053	0.0208**	0.0317***	0.0115
		(1.25)	(7.38)	(0.54)	(2.34)	(3.29)	(1.24)
L.WS*BGD	-	0.0325**	-	-	-	-	-
		(1.99)					
L.WDIS*BGD	-	-	-	0.0415***	-	-	-
				(2.79)			
L.WCS* BGD	-	-	-	-	0.0290**	-	-
					(2.25)		
L.HSS*BGD	-	-	-	-	-	0.0074	-
						(0.51)	
L.TCDS*BGD	-	-	-	-	-	-	0.0772***
							(5.46)
L.Board_independence	-	0.0883***	-	0.0843***	0.0914***	0.0904***	0.0838***
		(10.90)		(10.39)	(11.22)	(11.14)	(10.39)
L.Board_size	-	-0.0037	-	-0.0007	-0.0047	-0.0041	-0.0046
		(-0.58)		(-0.11)	(-0.72)	(-0.64)	(-0.72)
L.Board_meeting	-	-0.0017	-	-0.0014	0.0004	-0.0022	-0.0037
		(-0.29)		(-0.23)	(0.07)	(-0.36)	(-0.61)
Debt Ratio*100	-0.0065	-0.0064	-0.0053	-0.0063	-0.0076	-0.0076	-0.0057
	(-0.94)	(-0.90)	(-0.77)	(-0.88)	(-1.06)	(-1.07)	(-0.81)
ROA	-0.0736***	-0.0748***	-0.0570***	-0.0698***	-0.0835***	-0.0747***	-0.0668***
	(-7.35)	(-7.21)	(-5.73)	(-6.72)	(-8.00)	(-7.18)	(-6.46)
Tobin's Q *100	0.0259***	0.0233***	0.0194***	0.0193***	0.0224***	0.0228***	0.0209***
	(3.74)	(3.32)	(2.83)	(2.75)	(3.17)	(3.24)	(2.98)
Firm Size	0.0656***	0.0609***	0.0548***	0.0618***	0.0715***	0.0673***	0.0583***
	(28.40)	(24.03)	(23.58)	(24.54)	(28.70)	(26.98)	(23.18)
Cash-to-assets	0.0892***	0.0734***	0.0772***	0.0663***	0.0765***	0.0763***	0.0680***
	(6.57)	(5.06)	(5.73)	(4.57)	(5.24)	(5.24)	(4.70)
Capex_to_Asset	-0.1089***	-0.1027***	-0.0420	-0.0716**	-0.1172	-0.0857***	-0.0721**
	(-4.01)	(-3.57)	(-1.56)	(-2.48)	(-4.05)	(-2.97)	(-2.51)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.1686	0.1894	0.2063	0.1870	0.1612	0.1880	0.1983
Firms	6,791	6,414	6,791	6,414	6,414	6,414	6,414
Nb. Obs	41,026	35,632	41,031	35,637	35,637	35,637	35,637

This Table presents the results of the relationship between WS and GI using a panel model with firm and year-fixed effects. The coefficients appear first, and the statistic tests are in parentheses. The relevant explanatory variables are the WS and its four dimensions. We also examine the moderating role of BGD. We use the lag values of the WS and board characteristic variables. All regressions include constant, firm, and year-fixed effects. The sample consists of all firm-year observations from 2002-2021. The symbols *, **, and *** indicate, respectively, that the estimate is significant at the 10%, 5%, and 1% levels. Adjusted R^2 are in decimals (not in percentage).

Source: Authors own work

4.3. Dimensions of employee-oriented CSR and green innovation

The main question is whether specific dimensions of WS are more relevant than others. The WS employed in the previous analysis includes four dimensions: WDIS, TCDS, WCS, and HSS. We explore the relationship between each of these dimensions and GI using a panel

model with firm and year-fixed effects. The results reveal that each dimension positively impacts GI (Table 2; Columns 3 to 7). In addition, except for HSS, the BGD positively moderates these relationships. Thus, all dimensions of WS matter in firms' GI strategy. Furthermore, in models 3, 5, and 6 (columns 3, 5, and 6), the BGD has a significantly positive impact on GI, providing support for H2 that the board gender diversity positively affects green innovation.

5. Robustness tests

To validate the robustness of the results, we employ several methods: the instrumental variable approach and the dynamic generalized method of moments (system-GMM). We also use an alternative measure of green innovation and employee-oriented CSR, as well as the probit regressions and the propensity score matching. All these specifications confirm our baseline estimating results.

5.1. Alternative measures of green innovation

To check for the possibility that the results are sensitive to the proxy of green innovation, we employ two alternative measures of green innovation. Since our study covers 27 countries worldwide, getting the patent data for all countries is impossible. First, we adopt eco-labeling products as an alternative measure of green innovation to capture "green product innovation" (GPI), following a similar approach as Lin *et al*. (2014) and He and Jiang (2019). GPI collected from the Refinitiv ESG database is a dummy variable equal to 1 if the firm declares at least one product line or service designed to affect the environment positively or which is environmentally labeled and marketed in a given year, and 0 otherwise. GPI measure covers both patented and unpatented innovations. In this sense, it is an alternative that overcomes one of the weaknesses of patents since not all innovations are patented, and all inventions are not innovative (Mansour *et al.*, 2024). However, as a dummy variable, it only allows us to understand whether a company is innovative in ecology without knowing the number of green products it has invented. With this measure, we estimate the model using probit regressions. The results in Table 3 (Columns 4, 5, and 6) confirm the positive effect of employee-related CSR on GPI and the moderating role of BGD.

In the second robustness test, we use a similar approach to Li *et al*. (2017) and He and Jiang (2019) by employing the firms' adoption of ISO14000 or EMS standards to capture green process innovation. ISO14000 or EMS Certified (percent), collected from the Refinitiv ESG database, is defined as the percentage of company sites or subsidiaries certified with any environmental management system. With this alternative measure, we estimate panel models with firm and year-fixed effects and find similar results to the baseline estimations, as can be seen in Table 3 (Columns 1, 2, and 3). However, the coefficients estimated for green process innovation are higher than those estimated for GI score in the baseline models and GPI in the probit regressions. Especially in column 1, the coefficient associated with WS is 12.2511 and significant at a 1% level. In column 2, we also find a positive (10.5198) and significant impact of WS at a 1% level. Board gender diversity (BGD) totally moderates the relationship between WS and GI (the coefficient of the interaction term is 2.2311 and significant at a 1%

level, and the coefficient associated with BGD is 0.4598 but not significant). In column 3, BGD and all dimensions of WS positively and significantly affect green process innovation. Thus, using this proxy of green innovation confirms the baseline results and our hypothesis.

In sum, our results are not sensitive to the measure of green innovation used. Thus, there is strong evidence that WS positively affects green product and process innovation. In addition, there is strong evidence that board gender diversity moderates this relationship positively.

Table 3.
Robustness tests: The impact of employee-oriented CSR on green innovation

Dependant variables: ISO14000 or EMS certified and "green product innovation dummy" (GPI)						
	Fixed effects (ISO14000 or EMS)			Probit regression (GPI)		
Parameter	1	2	3	4	5	6
L.WS	12.2511***	10.5198***	-	1.1440***	0.9029***	-
	(18.08)	(8.86)		(49.97)	(16.80)	
L.WDIS	-	-	3.3013***	-	-	0.2528***
			(4.98)			(9.36)
L.WCS	-	-	1.6291***	-	-	0.0904***
			(3.36)			(3.72)
L.HSS	-	-	3.7511***	-	-	0.9316***
			(5.96)			(35.40)
L.TCDS	-	-	3.7604***	-	-	0.7145***
			(5.87)			(25.36)
L.BGD	-	0.4598	2.3065***	-	0.1476*	0.5034***
		(0.39)	(3.48)		(1.69)	(6.74)
L.WS*BGD	-	2.2311***	-	-	0.14763***	-
		(3.13)			(2.72)	
L.Board_independence	-	3.1146***	2.7911***	-	0.0739***	-
		(3.50)	(3.13)		(2.88)	
L.Board_size	-	0.7464	0.7377	-	0.0210	-
		(1.04)	(1.02)		(0.83)	
L.Board_meeting	-	-0.2628	-0.2767	-	0.0322	-
		(-0.38)	(-0.40)		(1.10)	
Debt Ratio*100	-0.4634	-0.4960	-0.4741	-0.0845	-0.0049	-0.0496
	(-0.57)	(-0.63)	(-0.60)	(-1.21)	(-0.08)	(-0.70)
ROA	-1.6862	-1.2823	-0.6810	0.2683***	0.3027***	0.0717
	(-1.46)	(-1.12)	(-0.60)	(5.12)	(5.40)	(1.33)
Tobin's Q *100	0.0138*	0.0148*	0.0119	-0.0709	-0.0783*	-0.0472
	(1.73)	(1.93)	(1.55)	(-1.62)	(-1.76)	(-1.04)
Firm Size	2.4471***	2.1164***	1.8842***	0.1451***	0.1566***	0.1211***
	(9.16)	(7.59)	(6.67)	(56.12)	(42.37)	(45.10)
Cash-to-assets	4.9643***	4.9012***	4.5552***	0.0322	0.1218**	0.2864***
	(3.16)	(3.07)	(2.85)	(0.62)	(2.10)	(5.27)
Capex_to_Asset	-5.1847*	-4.7224	-1.6555	-1.321***	-1.40***	-2.171***
	(-1.65)	(-1.49)	(-0.52)	(-9.40)	(-9.31)	(-14.44)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.1125	0.1172	0.1303	0.1290	0.1298	0.1788
Nb. Obs	41,029	35,635	35,642	46,994	41,323	46,998
Firms	6,792	6,415	6,415	6,791	6,791	6,791
Period	2002-2021	2002-2021	2002-2021	2002-2021	2002-2021	2002-2021

This Table presents the robustness test results using alternative green innovation measures. In Columns 1, 2, and 3, ISO 14,000 or EMS certification is used to measure green process innovation, and we employed a panel model with firm and year-fixed effects. In Columns 4, 5, and 6, we employ the green product innovation dummy and estimate the probit regressions. The coefficients appear first, and the statistic tests are in parentheses. The relevant explanatory variables are the WS and its four dimensions. We also examine the moderating role of BGD. We use the lag values of the WS and board characteristic variables. All regressions include constant, firm, and year-fixed effects. The sample consists of all firm-year observations from 2002-2021. The symbols *, **, and *** indicate, respectively, that the estimate is significant at the 10%, 5%, and 1% levels. Adjusted R^2 are in decimals (not in percentage).

Source: Authors own work

5.2. Accounting for endogeneity: Identification strategy

Endogeneity is a key problem when examining the impact of CSR on firms' outcomes (O'Connor and Rafferty, 2012; Jo and Harjoto, 2012). Endogeneity bias results from three potential sources: simultaneity effects, measurement errors, and omitted variables. While using lagged variables helps mitigate the simultaneity bias, the serial correlation may occur if shocks to green innovation are persistent. Although we control for variables that may affect the results from multiple perspectives and fixed effects, it is possible that green innovation may be affected by unobservable factors that may bias the results. Then, we use the instrumental variable (IV approach) and the system-GMM techniques to address endogeneity.

5.2.1. Instrumental variable approach

We employ the instrumental variable (IV) method to address potential endogeneity concerns. For the exclusion restrictions, the instrument must satisfy both the exogeneity and the "only-through" condition (Atanasov and Black, 2016). That is, a valid IV should not impact the dependent variable (green innovation) directly or through unobserved variables, but should have an indirect impact "only through" its association with the instrumented endogenous explanatory variable (WS). Adopting a similar approach as Yu *et al.* (2024) and El Ghoul *et al.* (2011), we use the average value of the percentage of employee turnover specific to each industry-year as an instrument for CSR toward employees (WS). Employee turnovers are collected from the Refinitiv ESG database and correspond to the total number of workers who leave an industry in a given year, including those who voluntarily exit and those who are fired. A high value means that the industry is failing to retain employees, which could be due to poor working conditions or inadequate human resources policies. Thus, although not directly associated with green innovation, employee turnover may be strongly and negatively related to WS. Negative associations are expected since a higher employee turnover indicates a lower score of CSR toward employees, i.e., lower WS, and in turn, a lower WS may imply fewer green innovations. Employee turnovers are ranked from 0 to 100, but the percentage can sometimes be over 100. To harmonize this indicator to correspond directly to WS (not the opposite), we checked in our sample whether there are values greater than 100. We found that for only two companies, the values of employee turnover were higher than 100 (respectively 126 and 658). We considered these companies as outliers and excluded them from our sample. Thus, for the remaining firms, the values of employee turnover are between 0 and 100, which means that the closer the value is to 0, the higher the WS, and the closer it is to 100, the lower the WS. Since the higher values of employee turnover correspond to lower WS scores, we computed the inverse of employee turnover as 100 minus "employee turnover", which should be positively correlated with WS. For instance, if employee turnover equals 0, then 100 minus "employee turnover" is 100, corresponding to the highest level of employee-oriented CSR. Alternatively, if employee turnover equals 100, then 100 minus "employee turnover" equals 0, corresponding to the lowest level of employee-oriented CSR. Using this transformed variable as an instrument, we estimated the IV models.

Table 4 reports the 2SLS IV regression results. In the first stage (Column 4), the industry-level employee turnover (TurnEmpAsWorkfS) is significantly and positively correlated with

WS at the 1% level, as expected, with a Cragg–Donald F-statistic of 159.84, indicating a valid instrument. The coefficient estimated is 0.206 with the R square of 34.92 percent. The second stage results (Column 5) confirm WS's positive and significant impact on green innovation at the 1% level, validating hypothesis H1. The coefficient estimated in the second stage is 0.3159, confirming the positive effect of CSR toward employees on green innovation.

Table 4.
Robustness tests: The impact of employee-oriented CSR on green innovation

Dependant variables: Green innovation (GI score), and "green product innovation" (GPI)					
	System GMM			IV approach	
				WS First stage	GI score 2SLS
Parameter	1	2	3	4	5
L.GI score	-0.0621***	-0.0285***	-0.0460***	-	-
	(-6.66)	(-2.76)	(-4.79)		
TurnEmpAsWorkfS				0.206***	
				(10.19)	
WS	0.3870***	0.1132**	-		0.3159***
	(20.51)	(2.33)		-	(4.03)
WDIS	-	-	0.1238***	-	
			(5.30)		
WCS	-	-	0.0468**	-	
			(1.97)		
HSS	-	-	0.2324***	-	
			(9.53)		
TCDS	-	-	0.1579***	-	
			(6.38)		
BGD	-	0.1108*	0.1236**	0.1536***	0.1267**
		(1.94)	(2.41)	(2.96)	(2.11)
WS*BGD	-	0.3094***	-	-	-
		(4.04)			
Board_independence	-	0.0928***	-	-	-
		(3.84)			
Board_size	-	0.0088	-	-	-
		(0.39)			
Board_meeting	-	0.0606*	-	-	-
		(1.88)			
Debt Ratio*100	-0.22	-0.0708	-0.1483	-0.2470***	-0.4159***
	(-1.54)	(-0.66)	(-1.25)	(-3.60)	(-3.57)
ROA	-0.0106	0.0043	-0.0473	0.0244	-0.1436***
	(-0.26)	(0.11)	(-1.15)	(1.24)	(-4.53)
Tobin's Q *100	-0.0273	-0.0763*	0.0230	0.0393**	0.0278
	(-0.61)	(-1.85)	(0.54)	(2.50)	(1.08)
Firm Size	0.0389***	0.0416***	.0363***	0.0579***	0.0963***
	(19.69)	(12.53)	(19.34)	(17.01)	(9.15)
Cash-to-assets	-0.0494	0.0849	0.0538	-0.0027	0.1057***
	(-0.97)	(1.43)	(1.09)	(-0.01)	(3.01)
Capex_to_Asset	-0.5309	-0.4596	-0.7067	-0.0986**	-0.2912***
	(-4.70)	(-4.05)	(-6.21)	(-2.20)	(-4.04)
Pseudo R^2	-	-	-	0.3492	0.2753
F statistic	-	-	-	159.84***	-
Nb. Obs	20956	16232	20961	11,712	11,712
Firms	3906	3310	3905	2,556	2,556
Period	2002-2021	2002-2021	2002-2021	2002-2021	2002-2021
Arellano-Bond test for AR1	-1.12	-1.02	-1.57	-	-
Arellano-Bond test for AR2	-0.86	-0.68	-1.27	-	-
Hansen overidentification test	11.24	9.24	7.23	-	-

This Table presents the results of the robustness tests using the system-GMM, and IV regressions. The coefficients appear first, and the z statistics are in parentheses. In the system-GMM, we use the lags 1 to 2 of the GI score as instruments for the dependent variable, and the lags 1-4 for the explanatory variables. We report the Arellano-Bond test statistics and the Hansen statistic tests. The symbols *, **, and *** indicate, respectively, that the estimate is significant at the 10%, 5%, and 1% levels. Pseudo R^2 are in decimals.

Source: Authors own work

5.2.2. The system-GMM technique

Besides the instrumental variable estimations, we also employ the GMM method to ensure the robustness of our results to endogeneity concerns. The system-GMM technique is one of the best ways to obtain consistent estimates since it solves endogeneity and the individual factor heterogeneity problem as well as a weak instrument problem that can occur with the instrumental variables approach (Blundell *et al.*, 1992; Arellano and Bond, 1991; Roodman, 2009; O'Connor and Rafferty, 2012). Following the recommendations of Arellano and Bond (1991), we use the lags 1 to 2 of the green innovation score as instruments for the dependent variable, to account for the dynamic effect of corporate green innovation (i.e., the green innovation in the previous year affects current green innovation). We express the model in difference to obtain the difference GMM. To mitigate the issue of reverse causality (i.e., the green innovation in the previous year affects current values of the explanatory variables, including the WS), we follow O'Connor and Rafferty (2012) and El Ghoul *et al.* (2011), among others, and include the lag 1 to 4 of the WS and the control variables as instruments of the independent variables. This dynamic panel model is estimated using the system-GMM developed by Blundell and Bond (1998) which simultaneously estimates the equation in both differences and levels using both sets of instruments.

The results reported in Table 3 (Columns 1, 2, and 3) confirm the findings of the baseline estimations. In model 1, WS continues to load positively at the 1% level (columns 1) on green innovation with an estimated coefficient of 0.3870. In model 2, WS is significant at the 5% level, with the coefficient estimated to be 0.1132 (columns 2). BGD positively moderates this relationship (the coefficient of the interaction term is 0.3094 and significant at the 1% level). In model 3 (columns 3), BGD and all dimensions of WS are positively related to green innovation at the 5% level or better, reinforcing our previous findings of a positive association between CSR toward employees and corporate green innovation. These findings indicate that endogeneity concerns are not likely to be driving our core evidence. Thus, there is consistent evidence that WS positively affects GI, and BGD positively moderates this relationship.

5.3. Alternative measure of CSR toward employees and propensity score matching

We also address endogeneity concerns using the propensity score matching (PSM) approach to estimate the causal effect of WS on green innovation. This procedure alleviates the potential impact of sample selection bias (Wang *et al.*, 2023). Our matching procedure aimed to ensure that the treated and the control firms are as similar as possible in their characteristics, except for their CSR toward employees. We capture WS by "Employment Awards", a dummy variable equal to 1 if the company received an award for its general employment quality during the sample period, and 0 otherwise. From 2002 to 2017, we have identified a total of 689 firms that were awarded for their employment quality, accounting for 4,301 observations (7.50% of the observations). The number of awards the firms won regarding their employment quality varies between 1 and 40. These firms are assigned to the treated group (Employment_Awards =1). Alternatively, 6,102 firms (accounting for 53,043

observations, i.e., 92.50% of the observations) did not win any award. These firms are assigned to the control group (Employment_Awards =0).

Table 5.
Robustness tests: Matching and treatment effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Green innovation score (GI score)						
ATE Employment_Awards (1 vs 0)	0.0896***	0.0069	12.85	0.000	[0.0760	0.1033]
ATET Employment_Awards (1 vs 0)	0.0597***	0.0079	7.50	0.000	[0.0440	0.0753]
ISO14000 or EMS certified						
ATE Employment_Awards (1 vs 0)	5.5300***	0.6841	8.08	0.000	[4.189	6.8709]
ATET Employment_Awards (1 vs 0)	2.2278***	0.7926	2.81	0.000	[0.6742	3.7814]

ATE: Average treatment effect in the population
ATET: Average treatment effect on the treated
Source: Authors own work

Table 6. Pstest results

	Mean			t-test		V(T)/V(C)
Variable	Treated	Control	%bias	t	p>t	
Gender_diversity	0.65024	0.64276	2.8	1.16	0.246	0.86*
Board_independence	0.6714	0.66131	3.8	1.61	0.108	0.94
Board_size	2.3999	2.3996	0.1	0.05	0.964	1
Board_meeting	0.45182	0.44942	1.1	0.45	0.654	0.86*
DebtRatio	1.0292	0.9342	0.8	0.74	0.462	2.88*
ROA	0.09435	0.09626	-1.6	-0.67	0.5	0.34*
QTobin	4.818	4.9437	-0.7	-0.2	0.841	0.44*
Size_Firm	10.073	10.101	-1.3	-0.52	0.606	0.71*
CashtoASSET	0.09108	0.09134	-0.2	-0.12	0.906	0.86*
Capex_to_Asset	0.04689	0.04881	-3.6	-1.59	0.112	1.06

* if variance ratio outside [0.93; 1.07]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.001	10.28	0.671	1.8	1.3	7.8	0.93	62

* if B>25%, R outside [0.5; 2]

We estimate the propensity score that a firm is selected to be awarded for the quality of its employment using a logit model, where we regress the treatment indicator variable "Employment Awards" on several variables. The matching is based on the following variables: board gender diversity, board independence, board size, board meeting, firm size, Tobin's Q, ROA, Debt Ratio, Capex to asset ratio, and Cash-to-total assets ratio. We also require that the treated and the control firms operate in the same industry (based on the two-

digit industry SIC codes) and in the same country. In addition, each observation for the treated firms is matched with an observation for the control firm from the same year. The matching is with no replacement (one-to-one). We adopt the nearest neighbor method to select control firms. Each firm-year observation in the treatment group is matched with a firm-year observation in the control group with the closest propensity score. Finally, we matched 686 firms in the treatment group, accounting for 3430 observations from 2002 to 2017, with the same number of firms and observations in the control group. We conduct diagnostic tests to ensure that none of the differences in the mean of each observable characteristic between the treatment and the control firm-year observations is significant.

Table 6 shows the PS test (pstest) results, which indicate no significant difference in the observable characteristics between the treated and the matched control firms. To examine the causal effect of WS as measured by "Employment Awards" on green innovation, we estimate both the average treatment effect in population (ATE), and the average treatment effect on the treated (ATET). We assume that the firms awarded during the sample period have a higher quality of employment in the year prior to receiving the award and will continue to maintain this quality in the following years to maintain their reputation. This assumption allows us to estimate the ATE and the ATET. The ATE and ATET, as indicated in Table 5, are significantly positive for all two measures of green innovation, suggesting that WS positively affects firm green innovation performance as measured by the Refinitiv eco-innovation score and the green process innovation measured by the adoption of ISO14000 by the companies. As can be seen, the ATE estimated for green innovation score is 0.0896 and significant at a 1% level. The ATET is 0.0597, which is also significant at the 1% level. The ATE and ATET estimated for green process innovation (ISO 14 000 or EMS certified) are 5.53 and 2.2278, respectively, which are also significant at a 1% level. These findings confirm that CSR toward employees promotes corporate green innovation.

6. Further analysis

This section explores how transparency and the proportion of female managers moderate the relationship between WS and corporate green innovation. In addition, it examines the relationship between WS and R&D intensity.

6.1. Mechanisms analysis

Given the negative impact of information asymmetry and agency conflicts on innovation (Alves and Meneses, 2024; Islam and Rahman, 2023), corporate governance mechanisms play an essential role in CSR and green innovation. Transparency is a key characteristic of well-governance firms. Transparency reduces information asymmetries, facilitates access to external financing, and thus reduces financial constraints related to green innovation (Alves and Meneses, 2024; El Ghoul *et al.*, 2011). Then, we examine the moderating effect of transparency in the relationship between WS and green innovation score using a panel model with fixed effects. We measure transparency by a dummy variable that equals one if the firm publishes a CSR or sustainability report following the GRI (Global Reporting Initiative) guidelines, and zero otherwise. Transparency data are from the Refinitiv ESG database.

Table 7.
Mechanisms analysis: The impact of employee-oriented CSR on green innovation

Dependant variables: Dependant variable: Green innovation score (GI score)						
	Woman manager			Transparency		
Parameter	1	2	3	4	5	6
L.WS	0.1352***	0.1327***	0.1331***	0.0339***	0.0941***	0.0662***
	(19.44)	(19.47)	(19.53)	(3.13)	(13.71)	(8.66)
L.BGD	0.0279***	0.0285***	0.0296***	0.0277***	0.0149*	0.0168*
	(4.81)	(4.57)	(4.87)	(4.82)	(1.69)	(1.95)
L.WomanManager	0.014***	0.0088***	0.0097***	-	-	-
	(4.01)	(3.92)	(5.18)			
L.WS*WomanManager	0.0075**	-	-	-	-	-
	(1.98)					
L.Transparency	-	-	-	0.0570***	0.0715***	0.0872***
				(5.78)	(8.21)	(14.04)
L.WS*Transparency	-	-	-	0.1181***	-	-
				(7.00)		
L.BGD*WomanManager	-	0.0063**	-	-	-	-
		(2.21)				
L.BGD*Transparency	-	-	-	-	0.0835***	-
					(6.30)	
L.WS*BGD*WomanManager	-	-	0.0275***	-	-	-
			(2.86)			
L.WS*BGD*Transparency	-	-	-	-	-	0.1047***
						(7.90)
L.Board_independence	0.0866***	0.0867***	0.0867***	0.0833***	0.0826***	0.0821**
	(10.70)	(10.70)	(10.71)	(10.39)	(10.29)	(10.23)
L.Board_size	-0.0033	-0.0032	-0.0032	-0.0034	-0.0033	-0.0030
	(-0.51)	(-0.50)	(-0.50)	(-0.53)	(-0.51)	(-0.46)
L.Board_meeting	-0.0018	-0.0019	-0.0019	0.0003	-0.0003	-0.0002**
	(-0.30)	(-0.32)	(-0.31)	(0.05)	(-0.05)	(-0.03)
Debt Ratio*100	-0.0063	-0.0063	-0.0062	-0.0048	-0.0046	-0.0045
	-0.88)	(-0.88)	(-0.88)	(-0.69)	(-0.65)	(-0.64)
ROA	-0.0704***	-0.0709***	-0.0708***	-0.0655***	-0.0641***	-0.0646***
	(-6.78)	(-6.83)	(-6.82)	(-6.37)	(-6.23)	(-6.28)
Tobin's Q *100	0.0220***	0.0222***	0.0222***	0.0185***	0.0178**	0.0018***
	(3.14)	(3.16)	(3.16)	(2.66)	(2.56)	(2.60)
Firm Size	0.0589***	0.0589***	0.0589***	0.0524***	0.0529***	0.0526***
	(23.14)	(23.14)	(23.14)	(20.70)	(20.90)	(20.76)
Cash-to-assets	0.0701***	0.0699***	0.0700***	0.0705***	0.0722***	0.0715***
	(4.83)	(4.82)	(4.82)	(4.90)	(5.02)	(4.97)
Capex_to_Asset	-0.0988***	-0.0993***	-0.0988***	-0.0681**	-0.0694**	-0.0712**
	(-3.44)	(-3.45)	(-3.44)	(-2.39)	(-2.43)	(-2.49)
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.1907	0.1906	0.1906	0.2252	0.2242	0.2255
Nb. Obs	35,629	35,629	35,629	35,629	35,629	35,629
Firms	6,414	6,414	6,414	6,414	6,414	6,414
Period	2002-2021	2002-2021	2002-2021	2002-2021	2002-2021	2002-2021

This Table presents the results of the relationship between WS and GI using a panel model with firm and year-fixed effects. In particular, it examines the moderating role of transparency and the percentage of female managers. The coefficients appear first, and the statistic tests are in parentheses. All regressions include constant, firm, and year-fixed effects. The symbols *, **, and *** indicate, respectively, that the estimate is significant at the 10%, 5%, and 1% levels. Adjusted R^2 are in decimals (not in percentage).

Source: Authors own work

The results in Table 7 show that the interaction between transparency and WS is positive and significant in column 4, at a 1% level. In column 5, the interaction between transparency and BGD is also positive and significant at a 1% level. In addition, the interaction between transparency, WS, and BGD is positive and significant at a 1% level (columns 6). In all regressions, transparency is significant at a 1% level. Although BGD is significant at a 1%

level in column 4, it is significant only at a 10% level in columns 5 and 6, as these models include its interaction with transparency. These findings support Alves and Meneses (2024) and Hao and He (2022) that CSR disclosure increases firms' transparency and helps investors understand corporate information, thus enabling these firms to invest in green innovation.

Besides board diversity, women managers play a crucial role in firms' environmental policies (Konadu *et al*., 2022). Indeed, we investigate whether the percentage of women managers in the firm moderates the relationships between WS and green innovation and the relationship between BGD and green innovation. As can be seen, our results show a significantly positive impact of the interaction term at a 5% level in columns 1 and 2 and a 1% level in columns 3 (Table 7). In column 1, the interaction between WS and women managers is 0.0075, suggesting that more women managers in the firms enhance the impact of WS on corporate green innovation. In column 2, the interaction between BGD and women managers is 0.0063, which is also significant, suggesting that more executive women on corporate boards enhance the impact of BGD on corporate green innovation. In column 3, the interaction between WS, BGD, and women managers is significant at a 1% level, and the coefficient estimated is almost 4 times larger than those in columns 1 and 2 (0.0275), revealing that more executive women on corporate boards enhance the positive impact of WS and BGD on green innovation. Finally, in all regressions, women managers, WS, and BGD positively impact green innovation. The coefficients associated with these variables are significant at a 1% level. These findings align with Chu (2024), who finds that the effect of female executive directors on green innovation strategies outweighs that of female independent directors.

6.2. Employee-oriented CSR and green R&D investment

Since employee-oriented CSR positively impacts green innovation performance, one can argue that it may also affect corporate investment in environmental R&D. In previous studies, O'Connor and Rafferty (2012) document a causal relationship between firm governance and R&D expenses, Amore and Bennedsen (2016) and Makpotche *et al*. (2024) discuss the impact of corporate governance on green innovation, and Li *et al*. (2025) explore the link between ESG performance and corporate environmental investment. Using a similar approach as Li *et al*. (2025), we examine if employee-oriented CSR affects green R&D investment using a panel model with firm and year-fixed effects. We measure green R&D investment as environmental R&D expenses (collected from the Refinitiv ESG database) to total assets. The results reported in Table 7, column 1 show a positive significant impact of WS on green R&D investment at a 5% level. In model 2, the effect of WS on green R&D investment is positive and significant only for firms with more gender-diverse boards (column 2). Although affecting green product innovation and green process innovation, employee-oriented CSR has a limited impact on corporate investment in environmental R&D activities. The impact of WS on green R&D investment disappears (the coefficient is positive but non-significant) when we incorporate BGD and its interaction with WS in the model. However, BGD positively and significantly directly affects green R&D investment (at a 5% level), even in the presence of WS in the model, confirming the previous studies that corporate governance mechanisms are the main drivers of firm investment.

Table 8.
Employee-oriented CSR and green R&D investment

Dependent variable: Green R&D expenses to total assets		
	Green_R&D_To_Asset	Green_R&D_To_Asset
Parameter	Model 1	Model 2
WSx100	0.1978**	0.1735
	(2.01)	(1.57)
BGD x 100	-	0. 2116**
		(2.16)
WS*BGD x 100	-	0.4336**
		(2.05)
Debt Ratio x100	0.0028	0.0021
	(0.11)	(0.08)
ROA	-0.0107**	-0.0112***
	(-2.54)	(-2.66)
QTobin x100	0.0080	0.0081
	(0.40)	(0.40)
Firm_Size*100	-0.3012***	-0.3139***
	(-4.75)	(-4.93)
Cash_to_ASSETx100	-0.15	-0.2104
	(-0.49)	(-0.67)
Capex_to_Asset	0.0181***	0.0172**
	(2.69)	(2.46)
R square	0.1561	0.1636
Nb. Obs	1,928	1,290
Firms	336	294
Period	2002-2021	2002-2021

This Table presents the fixed-effects results. The dependent variable is green R&D expenses to total assets (Green_R&D_To_Asset). The coefficients appear first, and the t statistics are in parentheses. The sample includes all firm-year observations from 2002–2021. The symbols *, **, and *** indicate, respectively, that the estimate is significant at the 10%, 5%, and 1% levels.

Source: Authors own work

7. Conclusion

This study investigated the processes and impact of employee-oriented CSR on corporate green innovation, using a sample of 6,791 firms covering 27 countries between 2002 and 2021. It provides the first evidence that green product innovation and green process innovation increased for firms with better CSR toward employees, and board gender diversity positively moderates this relationship. While board gender diversity positively affects investment in green R&D, we find no significant impact of CSR toward employees after controlling for board gender diversity and incorporating the interaction between CSR toward employees and board gender diversity in the regression model. Furthermore, all dimensions of CSR toward employees positively affect green innovation. In firms with more gender-diverse boards, each dimension has a stronger beneficial effect on green innovation, suggesting that corporate governance mechanisms and employee-oriented CSR have a complementary connection. Better CSR toward employees combined with adequate governance mechanisms, such as board gender diversity, may help alleviate agency costs and free rider problems that limit innovation within firms. Thus, firms should develop incentive mechanisms and enhance their internal governance and employee-oriented CSR. Finally, future research should explore other dimensions of CSR activities.

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Next-Generation Supply Chains Through a Lens of General Systems Theory and Complexity Theory: A Bibliometric Analysis

Abstract

Even though sustainable and digital supply chains are getting more attention, scholars do not widely use the term "next-generation supply chain" (NGSC), which was created at the end of the first millennium, and includes both sustainable and digitised supply chains. General Systems Theory (GST) is still one of the leading modern theories across the disciplines, and it is used to analyse NGSC as a system. However, like all other theories, it faces limitations that can be solved by combining it with Complexity theory (CT). Therefore, a comprehensive bibliometric analysis of publications related to NGSC, GST, and CT within the Web of Science (WOS) database is provided. Bibliometrix and CitNetExplorer software are utilised to create visual information. This article has limitations, including only one database and focusing solely on bibliometric analysis. Future works may research and deliver results on systematic literature reviews on synthesising NGSC and other least common business and management theories.

Keywords: Next Generation Supply Chain (NGSC), Sustainable Supply Chain, Digital Supply Chain, General Systems Theory (GST), Complexity Theory (CT).

Introduction

Modern General Systems Theory (GST) is similar to what Aristotle talked about - a practical wisdom that makes intelligent decisions based on understanding the relationships between parts and the whole system, not only isolated parts. It shares similarities with "Gestalt" psychology that emphasises wholeness – an entire system is greater than the sum of its elements. GST furthers this idea by treating the organisation as an open, hierarchical, complex system. An open system means that the system receives input from the environment or interactions (e.g., raw materials and information) and transforms it into output for other actors (e.g., final products and information) (Aprile et al., 2023; Wasieleski et al., 2022; Craighead et al., 2020; Bag et al., 2020; Verhoeff et al., 2018; Drack, 2009; Caddy & Helou, 2007; Dudley, 1996).

Using more sustainable materials (59% of respondents), efficiency in energy usage (59% of respondents), and efficient or green technologies-equipment (54% of respondents) are leading actions taken by the organisations related to sustainability efforts (*Sustainability Worldwide | Statista*, n.d.). However, back in 2022, sustainability within supply chains was only the ninth leading trend to impact supply chains by 2030 and fell behind after such topics as big data and analytics, digitalisation, process standardisation, COVID-19, mobile technologies, cloud

services, global trade uncertainties, and artificial intelligence (AI) (APQC, 2022). The market size of the "next-generation supply chain" (NGSC) is expected to increase more than twice and reach 75 billion US dollars in 2030. Besides the three pillars, the NGSC includes digitisation to enhance economic and environmental sustainability within supply chains (Report: Global Next-Gen Supply Chain, 2019).

As Complexity theory (CT) suggests, both digital and sustainable supply chains face disruptions and dynamic changes, for instance, related to such external factors as complex global sourcing, governing multi-tier suppliers, geopolitical situation changes, international trade wars, wars in Ukraine and Israel, or pressures of non-governmental organisations to use more sustainable materials or rapidly increase usage of such technologies as the AI (Tseng et al., 2019; Siems et al., 2023; Gong et al., 2023). This article focuses on sustainable supply chains, claiming that complex, dynamic systems cannot reach their goals without digitisation. These are also known as "next-generation supply chains", which make sustainability and digital transformation interrelated within the supply chain. The term "next-generation supply chains" is not widespread in other publications, and the article focuses on the phenomenon to close this research gap. The paper consists of three main parts. The first section describes the methodology used. The second section presents the discussion. The third section offers the conclusion on this research topic. While bibliometric analysis provides insight into the scientific inputs of other authors, it is restricted to the WOS database. Future works may include different scientific databases, such as Scopus.

1. Methods

Bibliometric analysis is the primary method for analysing scientific GST and CT publications. The WOS database is one of the most common and respected academic sources due to its broad applicability within academia. Based on the WOS, the "next generation supply chain" query (without limiting the academic fields) resulted in 13 publications from 1998 to 2024. Additionally, business and management field publications were searched using the "general system* theory" query, and 136 publications from 1991 to 2024 were found. The search for "complexity theory" provided 862 publications within the management and business fields. Bibliographic analysis tools, including Bibliometrix (R-package) and CitNetExplorer software,

were used to visually represent the results, including annual scientific production, three-field plot, word clouds, and author relations.

2. Discussion

This part analyses the phenomenon of the next-generation supply chain (NGSC). CT and GST are proposed and analysed as suitable theories for complex systems like NGSC. It starts with diagrams and analysis of annual scientific production. Then, it covers relationships within research domains and three-field plot visuals. It ends with primary keyword analysis presented visually in word clouds.

2.1. Annual scientific production of NGSC, GST, and CT

Although Ramachandran (1998) mentioned the term "next-generation supply chain" a couple of decades ago (Issues in Next-Generation Supply Chain Management, n.d.), the "next-generation supply chain" keyword analysis within the WOS provided only 13 related articles, despite the title being used to search for all academic fields.

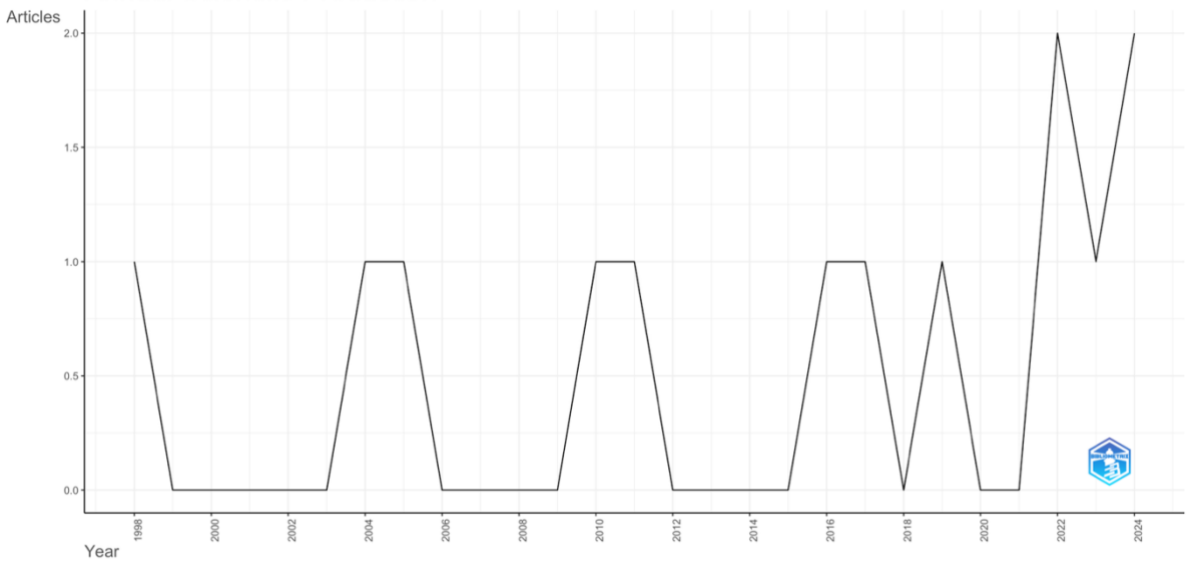

Fig. 1. An annual scientific production of NGSC (Source: author based on the results of WOS, 2025)

As per Figure 1, the NGSC topic has not peaked despite the scientific production results from 1998 to 2024, and it received the most scholarly interest in 2022 and 2024. GST and CT are used to explain NGSC. NGSC is a system with elements, including sourcing, production, warehousing, and distribution, impacted by digitisation and the three pillars of sustainability – economic, environmental, and social (Peng, 2023). Manufacturing is the second industry after

services, with most companies having emission reduction targets worldwide (*Sustainability Worldwide | Statista*, n.d.). Sustainability within the supply chain also means that the aspects of the triple bottom line have strategic attention from the management (Siems et al., 2023). The supply chain moves from a linear perspective to a circular system (Allen et al., 2021).

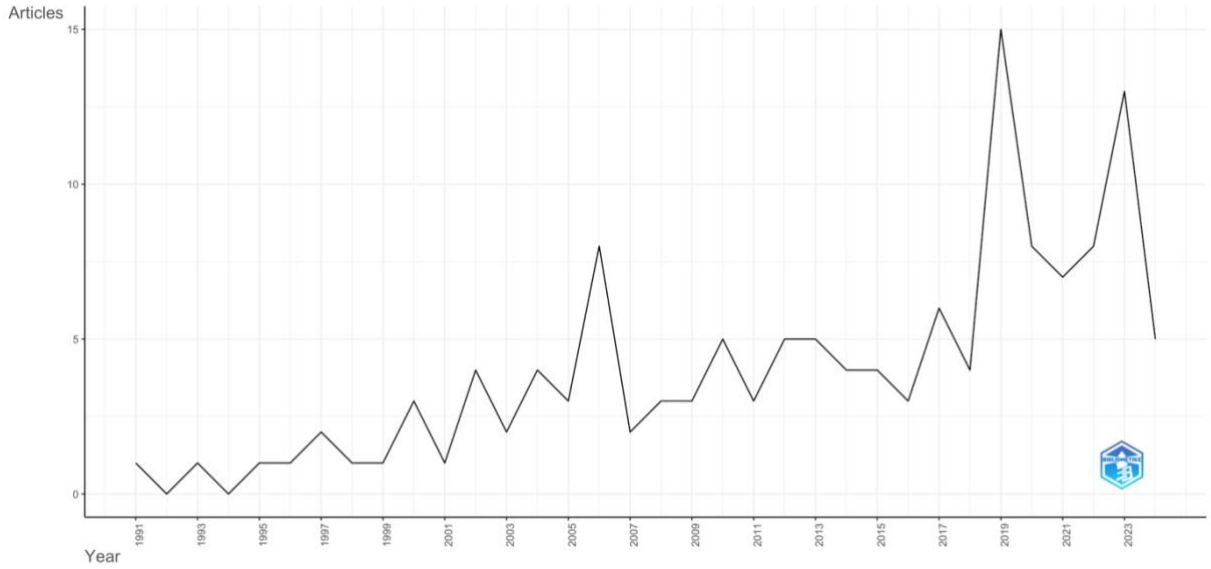

Fig. 2. An annual scientific production of GST (Source: author based on the results of WOS, 2025)

Figure 2 shows the "general system* theory" query within the WOS results, focusing only on business and management field publications. It indicates the annual scientific production period from 1991 to 2024, with a peak in 2019 – an interest in GST has already reached its peak. The Systems theory is considered to have begun in the eighteenth century, but GST, cybernetics, and dynamic systems theory remain leading modern systems theories (Bag et al., 2020; Verhoeff et al., 2018). Systems thinking helps understand and interpret complex and dynamic systems (Verhoeff et al., 2018). It contributes to studying the whole system, not separate components (Bag et al., 2020). Systems thinking can be used within interdisciplinary and different research fields, such as social, life, and applied sciences (Aprile et al., 2023; Bag et al., 2020; Verhoeff et al., 2018). Kaine & Cowan (2011, p. 232) use GST to analyse system regulators and policies in line with agricultural industries and climate change. Ogbonnaya et al. (2023) use GST's dynamic equilibrium and human resource management practices, which could also relate to a social pillar of sustainability.

5

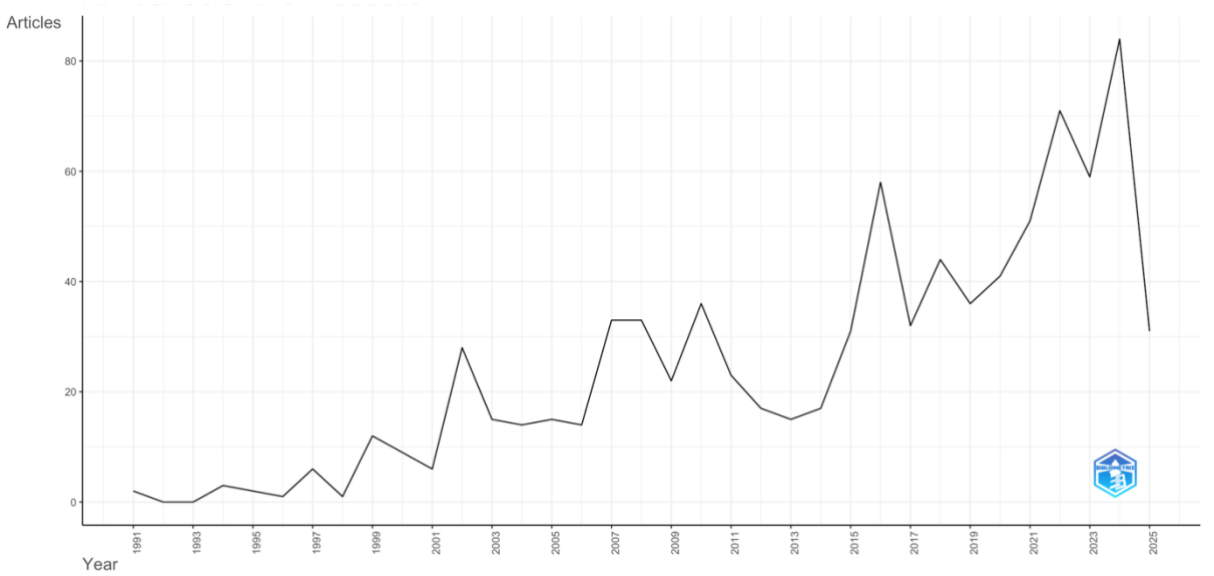

Fig. 3. An annual scientific production of CT (Source: author based on the results of WOS, 2025)

Figure 3 provides the visuals of the "complexity theory" query within the WOS 862 results, focusing only on business and management fields. It indicates the annual scientific production period from 1991 to 2025, peaking in 2023 – an interest in CT has reached its potential. Fransman et al. (2021, p. 331, 334) claimed that "complexity theory focuses on the disruption and reconfiguration of patterns". CT was formulated from GST, cybernetics, and non-linear, unstable, non-equilibrium systems-based chaos and catastrophe theories (Bustamante-Ubilla & Arenas-Torres, 2022, p. 2; Bousquet & Curtis, 2011, p. 45). Even though CT origins stem from natural sciences with the specific purpose of mathematical systems modelling, it is interdisciplinary and emerged within social sciences and has been applied to supply chain and project management, and organisational change (Bustamante-Ubilla & Arenas-Torres, 2022; Fransman et al., 2021; Turner & Baker, 2019; Demjén, 2018).

2.2. Relations within the research domains of NGSC, GST, and CT

The Three-field plot helps to understand the relations within the research domain, as per Figure 4. "CR" is cited references, "AU" - authors, and "DE" - descriptors.

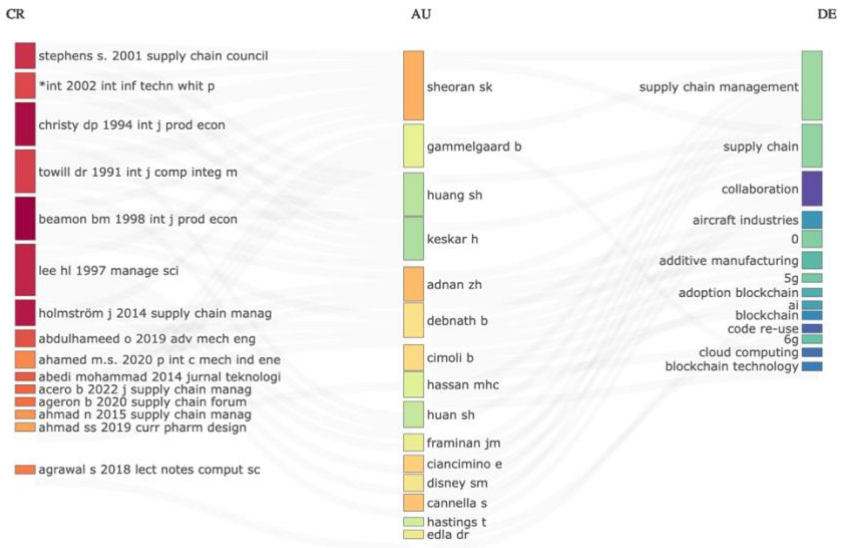

Fig. 4. A three-field plot of NGSC (Source: author based on the results of WOS, 2025)

As for the NGSC publications, Towill (1991), Christy & Grout (1994), Lee et al. (1997), and Beamon (1998) are foundational works. Towill (1991) focuses on applying the models of system dynamics to supply chain management, while Christy & Grout (1994) analyse safeguards in trading relationships between suppliers and buyers within the supply chain. Lee et al. (1997) explore the phenomenon within the supply chain called “bullwhip effect”, when inventory and production decisions are based on false information on increasing demand. Beamon (1998) claims that supply chain processes are usually analysed individually, but in 1998 they started to be analysed systemically, as a whole, and include “reverse logistics”.

Huang et al. (2005), Gammelgaard and Nowicka (2024) mainly contribute to the NGSC publications. Others analyse the supply chain operations reference (SCOR) model, which is suited for next-generation supply chain management and decision-making (Huan et al., 2004). SCOR includes standard processes, relations, metrics, practices, and software functionality. The authors also emphasise digital and data-based solutions for improving the supply chain's performance (Huang et al., 2005). Gammelgaard and Nowicka (2024) provide insights on NGSC and cloud computing. They claim that digitisation is related to supply chain competitive advantage and flexibility. The dominant concepts within the WOS research results are supply chain management, collaboration, and digitisation-related technologies: additive manufacturing, AI, blockchain, and cloud computing.

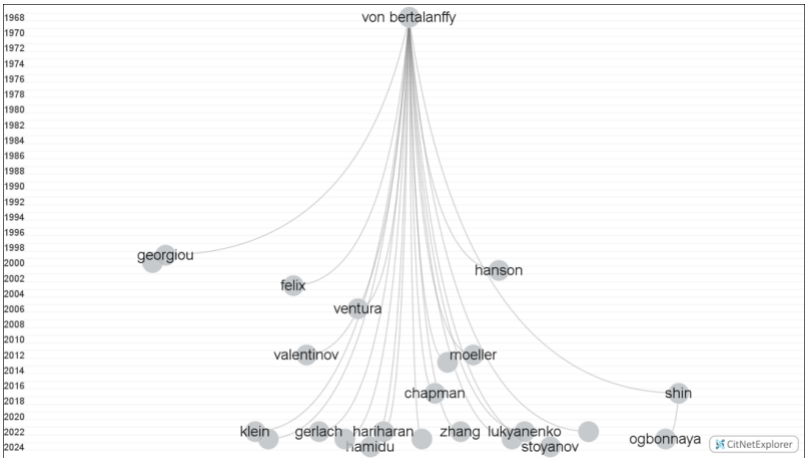

Fig. 5. Bertalanffy's (1968) connections to other authors (Source: author based on the results of WOS, 2025)

As for GST publications, Bertalanffy (1968) is one of the foundational authors, as shown in Figure 5. The philosopher and theoretical biologist Ludwig Von Bertalanffy (1901-1972) started to develop modern systems theory in the 1920s. This interdisciplinary, holistic meta-theory or general systemology views different disciplines and organisations as systems and is now considered a standard for social sciences. GST is used to increase the knowledge of the world in various disciplines ranging from life sciences to social sciences (Mackay et al., 2023; da Silva & Parente, 2019; Turner & Baker, 2019; Miranda, 2014; Hofkirchner & Schafranek, 2011; Drack, 2009; Georgiou, 1999; Dudley, 1996). As shown in Figure 5, Bertalanffy's (1968) publication on the foundation of general system theory influenced or inspired criticism and was highly cited by several other contemporary authors, as shown in Figure 6.

Fig. 6. A three-field plot of GST (Source: author based on the results of WOS, 2025)

Drack & Apfalter (2007) claim that GST began in the 1920s as a holistic system view proposed by Paul A. Weiss, which Bertalanffy encountered as a student. This early general system theory suggests a broader view than it is described today and differs across the disciplines. Drack & Schwarz (2010, p. 606) disagree with Dubrovsky's (2004) statement that GST does not provide system principles. Drack (2009) indicates that Bertalanffy's two principles are working hypotheses and proposes that the goal of GST has not been achieved (Drack & Schwarz, 2010). Van Assche et al. (2019, p. 308) analyse GST concerning resilience, including complexity thinking, and insist that GST is still relevant. Dudley (1996) claims that Bogdanov-Malinovski (1912) founded systems theory instead of Bertalanffy. Valentinov (2012) also analyses "universal organisational science", known as "Tektology" by Bogdanov-Malinovski. However, none of these claims are scientifically proven. Georgiou (2000, p. 421) suggests rethinking GST because the idea of understanding knowledge through the "human world" perspective is echoed in systems literature, especially in research on CT. Schneider & Somers (2006) analyse leadership-based general system and complexity theories and provide open system properties. Van Assche et al. (2019) analyse GST concerning resilience, including complexity thinking. Valentinov (2014) researched complexity and its relationship to sustainability. Schneider & Somers (2006) analysed leadership through the GST-CT lenses.

Rousseau (2015, p. 522-523, 529) proposes that the systems community is fragmented and that the hard systems were developed in the 1950s, soft systems in the 1970s, and critical systems in the 1980s. Valentinov (2012, p. 257) analyses GST and institutionalism. Valentinov (2014) links sustainability and GST to explore categories (system, environment, complexity). Kaine and Cowan (2011) concentrated on the sustainability aspect of GST. The dominant concepts are GST, Bertalanffy, resilience, and systems thinking, and complexity is also mentioned within Figure 6. To solve GST limitations related to being unable to properly analyse non-linear and complex systems that go in all directions without input and output, some researchers suggest using another umbrella theory – Complexity theory (Fransman et al., 2021; Turner & Baker, 2019; Cabrera et al., 2018; Bousquet & Curtis, 2011). As per Figure 7 publications, Stacey (1995) and Anderson (1999) are the primary authors cited for the CT.

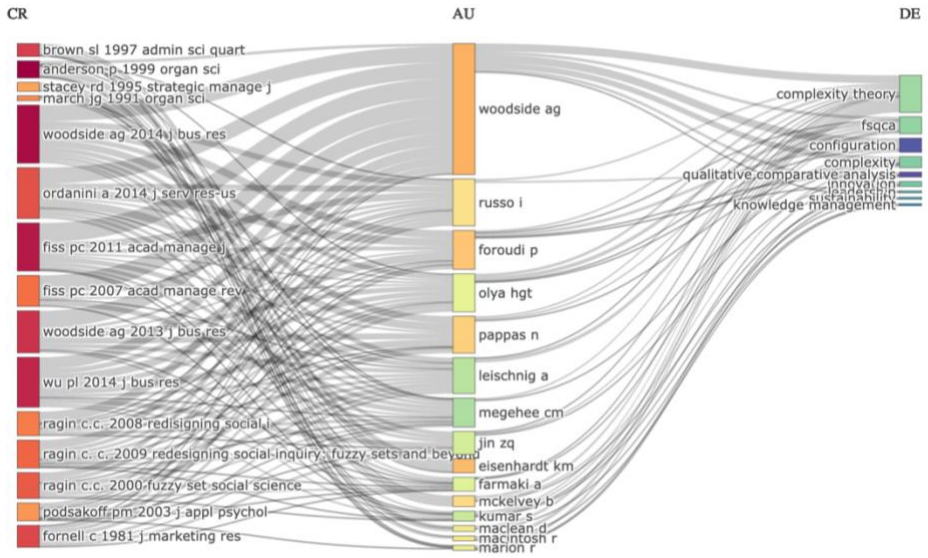

Fig. 7. A three-field plot of CT (Source: author based on the results of WOS, 2025)

Stacey (1995) proposes the perspective of adaptive systems based on complex and non-linear systems and positive and negative feedback, including chaos theory, artificiality, and self-organisation. Anderson (1999) analyses CT and strategic management. The main topics include complexity theory, complexity, innovation, and sustainability, which are also related to the NGSC. The main current contributors are focusing on CT, also including strategic management and firm anomalies (Woodside et al., 2018), technical and non-technical innovation and customer loyalty (Foroudi et al., 2016), drivers of supply chain complexity (SCC) and its impact on performance (Chand et al., 2022).

2.3. Main keywords of NGSC, GST, and CT

The last section focuses on the main keywords within the word cloud that propose the most common thematic areas for NGSC, GST, and CT.

Fig. 8. A word cloud of NGSC (Source: author based on the results of WOS, 2025)

Figure 8 shows the word cloud based on the WOS query results. The main keywords are related to systems, which indicates that NGSC is related to the Systems theory. GST usually enables the open system to decompose the organisation into several smaller and simpler sub-systems (levels) and components (elements). Then it explains the specifics of the sub-systems or components, finds the relations between them (known as management), and describes the components and their interconnections. GST provides insights into how changes in one component affect other components and the whole system or specific sub-systems, as relations between components express their organisation (Aprile et al., 2023; Wasieleski et al., 2022; Craighead et al., 2020; Bag et al., 2020; Turner & Baker, 2019; Verhoeff et al., 2018; Martini & Vespasiano, 2015; Caddy & Helou, 2007). The keywords also include dynamic capabilities related to the CT. Numbi and Kupa (2017) suggested that the NGSC should include waste and logistics cost reduction, increased data visibility, recurring maintenance, data and evidence-based decision-making, and adaptability to change. Malakar et al. (2025) study, based on CT and dynamics capabilities, proposes that digital technologies help solve social aspects of supply chain sustainability, including using blockchain and internet-of-things (IoT) sensors for supplier condition monitoring.

Fig. 9. A word cloud of GST (Source: author based on the results of WOS, 2025)

Figure 9 shows the word cloud based on the WOS query results for GST. The GST word cloud analysis indicates keywords related to general systems theory, general systematology, complexity, and technology. As some other authors suggest, CT complements GST. Similarly to GST, CT incorporates other sub-theories, such as complex adaptive systems theory, dynamic systems theory, and chaos theory (Demjén, 2018, p. 93).

Fig. 10. A word cloud of CT (Source: author based on the results of WOS, 2025)

Figure 10 provides the main keywords related to CT publications. The keywords include complexity theory, uncertainty, innovation, technology, systems, and adoption. According to Turner and Baker (2019), systems theory could function alongside CT if complex adaptive systems are included. Cabrera et al. (2018, p. 932) applied CT and systems thinking and created a new organisational model, VMCL (based on "vision, mission, culture/capacity, learning").

Conclusions

The WOS publication results show that the most current topic is related to next-generation supply chains (NGSC). While General Systems Theory (GST) is still relevant, the interest has declined, and Complexity Theory (CT) peaked in 2023. GST and CT share similarities and differences in focus and application. GST proposes hierarchical, open, complex systems and multiple forms of causality (Turner & Baker, 2019, p. 13; Verhoeff et al., 2018, p. 3). Authors of CT believe that systems are open but dynamic, complex, nonlinear, chaotic, unpredictable, process-based, self-organising, feedback-sensitive, and adaptive (Al-Hoorie et al., 2023; Fransman et al., 2021; Duvendack & Sonne, 2021; Turner & Baker, 2019; Demjén, 2018; Cabrera et al., 2018).

The foundation works differ for NGSC (Towill, 1991; Christy & Grout, 1994; Lee et al. 1997; Beamon 1998), GST (Bertalanffy, 1968), and CT (Stacey, 1995; Anderson, 1999). However, the dominant concepts within the authors' publications provide similarities, as NGSC mentions supply chain management, collaboration, additive manufacturing, AI, blockchain, and cloud computing. The word cloud analysis emphasises systems and dynamic capabilities. GST publications include GST, systems thinking, Ludwig von Bertalanffy, resilience, and complexity, while word cloud analysis provides general systematology, complexity, and technology keywords. CT publications propose such main descriptions as complexity theory,

innovation, and sustainability, with a word cloud analysis focusing on uncertainty, innovation, technology, systems, and adoption.

Despite being a suitable theory, GST faces limitations. Applying GST to social systems, such as organisations, could be challenging, as organisations can be partially closed and open or have unpredictable systems. Some claim that is too mechanical – unable to uncover complex and non-linear systems and complex or wicked problems (Aprile et al., 2023; Wasieleski et al., 2022; Craighead et al., 2020; Bag et al., 2020; da Silva & Parente, 2019; Turner & Baker, 2019; Verhoeff et al., 2018; Martini & Vespasiano, 2015; Hofkirchner & Schafranek, 2011; Caddy & Helou, 2007; Georgiou, 2000). GST requires identifying boundaries and analysis levels (systems or subsystems) for structure modelling (Turner & Baker, 2019, p. 3). Before conducting their studies, the GST researchers must decide and identify the level to analyse. The researchers should avoid bias, subjectivity, and their scientific interests when excluding the system components or concentrating on specific elements. They should be aware that the objectives and relations of the overall system and subsystems could differ (Aprile et al., 2023; da Silva & Parente, 2019; Turner & Baker, 2019; Caddy & Helou, 2007).

Complexity theory (CT) is used to solve the limitations of GST. Grabowski et al. (2023, p. 2) advised that CT is used to comprehend "human societies as complex systems". Bustamante-Ubilla and Arenas-Torres (2022, p. 9) claim that CT helps analyse the "scientific-technical and social evolution of reality". Metelenko et al. (2024) believe that Agile methodology could be used for complex adaptive systems. People, social groups, and technological organisations are a source of complexity and societal evolution. CT helps understand complexity, organisational patterns, networks of relationships, historical context, technology, globalisation, and markets. Also, cultural, interlinked, unexpected, and episodic change, challenges, and opportunities without a deterministic cause. CT is based on relational and processual thinking and positive and negative feedback loops (Bustamante-Ubilla & Arenas-Torres, 2022; Fransman et al., 2021; Duvendack & Sonne, 2021; Turner & Baker, 2019; Demjén, 2018; Bousquet & Curtis, 2011). Further studies could provide different results by using different theory combinations to analyse sustainable and digital supply chains, also known as "next-generation supply chains".

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THE IMPACT OF EXTENDED SELF ON BRAND LOYALTY: THE MEDIATING EFFECT OF BRAND LOVE*

Abstract

Consumers use products as part of their selves. They tend to buy products that reflect their selves. Here in, consumers use the brand to express their selves. In this context, this study examines the effect of extended self on brand loyalty and brand love. In the study, an online questionnaire was administered to 456 people. Smart PLS-SEM used to assess the impact of the extended self on brand loyalty and brand love. The study revealed that the extended self significantly influences both brand affection and brand allegiance. The results demonstrated that brand love mediates the connection between the extended self and brand loyalty, highlighting its critical role within the proposed framework.

Key Words: Extended Self, Brand Loyalty, Brand Love

1. Introduction and Purpose of the Study

Consumers use products and brands to construct and restructure their identities. Consumers want brands to have meaning for them. The meanings of products and brands are transferred to the identities of consumers. The meanings of products and brands are transferred to consumers' identities. In the purchasing decision process, consumers look for information about products and brands to determine whether the product or brand they want to buy is related to who they are and what they want to be (McCracken, 1993: 127). The meaning of a brand is the reason why consumers are attached to it. Strong brands also serve as a focal point for consumers to reflect who they are and who they want to be (McCracken, 1993: 129). As a result, not only products but also brands can become extended self-elements for customers. Customers can purchase products and brands that they believe reflect their identities. This study intends to determine the effect of the extended self on brand loyalty and brand love and the mediating effect of brand love on the relationship between extended self and brand loyalty. This study will contribute to filling a gap in the fields of consumer behavior and brand with the extending self.

There are gaps in the literature on the effect of the extended self on consumer behavior. Some of the studies are theoretical (Belk, 1988: 139-168; Belk, 1989: 129-132; Belk, 2018: 53-67; Benli and Güler, 2019: 1078-1082), some are qualitative (Ahuvia, 2005: 171- 184; Belk, 2013: 477-500; Belk, Russel W., 2014: 1101-1118; Mcneill and Graham, 2014: 403-410; Çelik, 2020: 509-547; Manolica, Cluci and, Roman, 2021: 572- 581) and some of them are quantitative (Edson Escalas, 2004: 168-180; Clayton, Leshner and Almond, 2015: 119-135; Oflazoğlu and Çelik, 2020: 119-144). Although there have been studies on brand loyalty with brand love and self (Rodrigues, Brandão & Rodrigues, 2018: 189-210; Chand & Fei, 2020: 1-13; Çavuşoğlu & Demirağ, 2020: 1065-1087; Kalebozan & Dölarslan, 2021) and brand and self-consistency (Liu et al., 2012: 922-937; Das, 2014: 130-138; Lu & Xu, 2015: 365-376), this study is expected to fill a gap in the number of studies. As a result, the study's findings are critical.

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2. Literature Review

2.1. Brand Loyalty and Brand Love

Although different definitions of brand loyalty have been proposed in the literature, brand loyalty can be defined as the degree of continuous purchase of a brand. Behavioural (attitudinal) loyalty and affective loyalty are the two types of brand loyalty (Bandyopadhyay and Martell, 2007: 37). Behavioural loyalty is loyalty that develops as a result of a consumer's habit. In other words, the consumer is accustomed to repurchasing the brand. In the case of behavioural (attitudinal) loyalty, the consumer may be sensitive to competing brand offers and may change the brand they buy continuously in response to these offers. A consumer who goes to the hairdresser in his neighbourhood but not the hairdresser in his former neighbourhood when he moves to another area is an example of behavioural loyalty. Affective loyalty refers to a customer's emotional connection to a brand. For emotional reasons, the consumer is emotionally attached to the brand. In other words, the consumer and the brand share an emotional tie.

There are many studies on brand loyalty in the literature. According to the findings of various research, brand trust influences brand loyalty (Lau ve Lee, 1999: 341-370; Chaudhuri ve Holbrook, 2001: 81-93; Şahin, Zehir ve Kitapçı, 2011: 1288-1301; Torlak, Doğan ve Özkara, 2014: 147-161; Başer, Cintamür ve Arslan, 2015: 101-128). Another study showed that behavioral loyalty influences market share and, emotional loyalty affects high pricing (Chaudhuri ve Holbrook, 2001: 81-93). Another study discovered that brand awareness and brand image affect brand loyalty (Chaudhuri ve Holbrook, 2001: 81-93). According to some research, brand experience and satisfaction affect brand loyalty (Şahin, Zehir ve Kitapçı, 2011: 1288-1301; Başer, Cintamür ve Arslan, 2015: 101-128) and satisfaction on brand loyalty (Şahin, Zehir ve Kitapçı, 2011: 1288-1301; Başer, Cintamür ve Arslan, 2015: 101-128).

"Brand love is defined as the degree of passionate emotional attachment a satisfied consumer has for a particular trade name." (Carrol and Ahuvia, 2006: 81). A consumer with brand loyalty likes the brand more over time and, an emotional bond is formed between him and the brand. Therefore, brand love can be considered as the next level of brand loyalty. Considering the types of brand loyalty, it can be said that it is more likely to be seen in consumers who are emotionally committed to the brand. As emotional commitment develops, the bond established with the brand may turn into love depending on the relationship the brand establishes with the customer.

Numerous studies have been conducted on brand love. According to some studies, brand love influences paying more (Aydın, 2016: 125-149; Heinrich, Albrecht and Bauer, 2012, 137-150), re-purchasing (Aydın, 2016: 125-149; Heinrich, Albrecht and Bauer, 2012, 137-150), re-visiting in the service business (Shen, Huang, Choi and Joppe, 2016), and word-of-mouth marketing yapma (Ünal ve Aydın, 2013: 76-85; Anngraeni and Rachmanita, 2015: 442-447; Ismail and Spinelli, 2012: 386-398; Shen, Huang, Choi and Joppe, 2016).

The first hypothesis of the investigation is articulated as follows.

H_1: Brand love influences brand loyalty.

2.3. Extended Self

Extended self can be defined as the individual's feeling of possession of objects and belongings as a part of herself after a while.

The concept of the extended self was first mentioned by Russell W. Belk (1988: 139-168) in his article named “Possessions and the Extended Self”. Belk (1988: 139) cited William James (1890,

quoted from 291 – 292), who established the self-concept, and included the following phrase in his article:

> "*a man's Self is the sum total of all that he CAN call his, not only his body and his psychic powers, but his clothes and his house, his wife and children, his ancestors and friends his reputation and works, his lands, and yacht and bank-account. All these things give him the same emotions. If they wax and prosper, he feels triumphant; if they dwindle and die away, he feels cast down,-not necessarily in the same degree for each thing, but in much the same way for all.*"

Belk (1988: 139-168) introduced the concept of the extended self, which he traced back to William James (1890: 291-292) and discussed in his subsequent writings, and therefore became a spoken concept in the literature. Individuals are emotionally attracted to things that are part of their identities, according to Belk (1989: 130), and this loyalty is different from functional and compulsory loyalty. He used the umbrella as an example: he argued that commitment to an umbrella is due to functional anxiety that will occur from the umbrella's loss and, that emotional attachment to the umbrella may be created if the umbrella is important and a gift (Belk, 1989: 130). With the absence of the umbrella, the functional anxiety induced by the loss of the umbrella may be getting wet. It's possible that the umbrella's significance comes down to the fact that it's a family heirloom.

According to Elliott and Wattanasuwan (1998: 133), the consumer's efforts to construct his own identity typically include the consumption of products, services, and media. Consumer goods not only help shape an individual's identity, but they also influence the conduct of others (Ditmar, 1992 as cited in Elliott, 1997: 287). As a result, the products purchased have become critical to the individual. Brands also help customers help themselves by providing value. Thus, consumers mirror their selves to others by choosing brands with brand images that they believe are consistent with their own.

There is a gap in the field of marketing about the influence of the extended self on customer behaviour, brand, and brand dimensions. Some of the studies on the self and the extended self and their results are summarized below:

The study on the influence of self-congruity and brand-self-congruity on luxury brand perception and the luxury value indicated that self-congruence and brand-self-congruity affected brand love (Rodrigues, Brandão and Rodrigues, 2018: 189-210).

In research that attempted to identify the intention to purchase imitations of luxury goods, it was discovered that self-connection had an influence on the emotional attachment to the brand, as well as the purchase intention (Chand and Fei, 2020: 1-13).

A study to determine the effect of self-congruence brands on brand love and brand love on brand loyalty and positive word-of-mouth communication concluded that a brand with self-congruence influenced brand love and brand love affected brand loyalty and positive word-of-mouth communication (Çavuşoğlu and Demirağ, 2020: 1065-1087).

Brand-user congruence and brand-use congruence, which are self-congruence dimensions, were shown to have an influence on consumer attitude and brand loyalty in research attempting to discover if the dimensions of self-congruity influenced consumer attitude and brand loyalty in luxury brands (Liu vd., 2012: 922-937).

According to the findings of a study done to investigate the influence of retailer brand personality and self-congruence on store loyalty, brand personality and self-congruence have an effect

on store loyalty. Gender was found to have a mediating effect on brand personality and self-congruence in the same study (Das, 2014: 130-138).

Brand self-congruence has an effect on brand association, perceived quality, and attitudinal and behavioural loyalty in sportswear products, according to a study conducted to determine the effect of brand self-congruence on brand association, perceived quality, and attitudinal and behavioural loyalty in sportswear products (Lu and Xu, 2015: 2014: 365-376).

In the limited investigations on the extended self, the following findings were obtained:

In research that attempted to assess if Taiwanese and British consumers perceived luxury products as indicators of their extended selves, it was discovered that Taiwanese consumers saw luxury brands as more indicative of their extended selves than British customers (Wu, Chen and Nguyen, 2015: 153-173).

A study attempted to determine the influence of the need to be different and the materialist tendency on the extended self in the virtual world, as well as the moderator effect of the need to think variable discovered a statistically significant relationship between the desire to be different and the influence of materialism on the extended self, as well as the materialism and the extended self for low levels of the need to think. At higher levels of thinking need, it has been found that there is a statistically significant relationship between the need to be different and the extended self (Oflazoğlu and Çelik, 2020: 120-139).

Ahuvia (2005) reexamines the notion of the extended self within an emotional context, scrutinizing how consumers shape their identities through their attachment to objects. This emotional connection encompasses brands, as consumer-brand interactions gain importance through the concepts of brand love and brand loyalty. Consumers' attachment and devotion to brands are fundamentally linked to the companies' capacity to mirror their identities, offer significant narratives to their life experiences, and cultivate emotionally profound relationships.

The remaining hypotheses of the investigation were articulated as follows.

H_2: Extended self affects brand love.

H_3: Extended self affects brand loyalty.

H_4: Brand love mediates the relationship between extended self and brand loyalty.

3. Methodology

3. 1. Model of the Study

The possession of the product as a part of the individual's self is referred to as the extended self. Today, the products/services/brands that people have acquired and utilized represent their identities or personalities. Therefore, the aim of this study is to investigate the effect of the extended self on brand loyalty and brand love. Figure 1 shows the research model in this context.

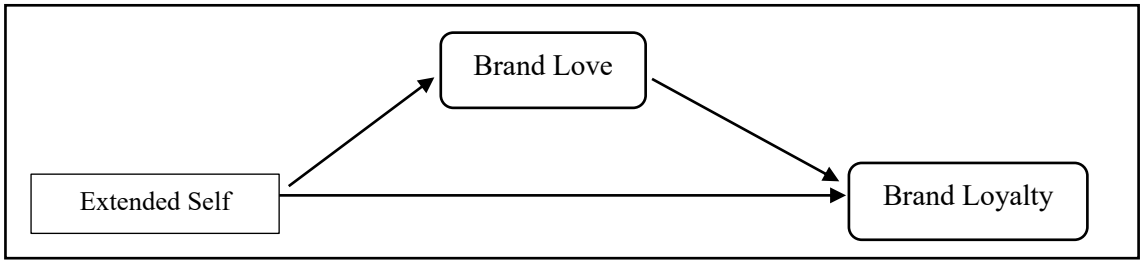

Figure 1. Model of the Study

3. 2. Sampling Process

This study's universe includes users over the age of 18 who own mobile phones and live in Turkey. Research indicates that distancing oneself from a cell phone induces anxiety in the individual (King, 2014: 28-35; Clayton, Leshner ve Almond, 2015: 119-135; Gezgin, Şahin ve Yıldırım, 2017: 1-15). A research analysis by Hootsuite and We Are Social indicates that, in early 2025, Turkey had 80.7 million active cellular mobile connections, or 92.1% of the entire population. (https://datareportal.com/reports/digital-2025-turkey; Erişim Tarihi: 02.05.2025). As a result of a large number of mobile phone users, the use of mobile phones as a product is acceptable. The survey was distributed online to 456 mobile phone users using Google Forms.

3. 3. Data Collection Method

A literature review was undertaken to ascertain the research variables. Dodson's (1996: 317–322) and Oflazolu and Çelik's (1996: 317–322) research was used to develop the extended-self scale (2020: 135). The brand loyalty scale was developed using the study of Chaudhuri and Holbrook (2001: 81 – 93) and Deniz and Erciş (2010: 141 – 165). The scale of Carroll and Ahuvia was used for the brand love scale (2006: 79 - 89). The questionnaire consists of five parts. The first section consists of four questions. In the first part, participants were asked about the mobile phone brand they had used, how long they had used it, how long changed phones, and how long they had used the same phone. The second part consists of twenty items regarding the extended self. There are ten items on the brand love scale in the third part. In the fourth part, there are seven items on the brand loyalty scale. In the last part, five questions were asked to determine the demographic characteristics of the participants. The questionnaire form consists of 46 questions. The questions in the first and last sections are multiple-choice, and the statements in the second, third and fourth sections are formed in the form of a 5-point Likert scale. The first part consists of four questions. The second part contains 20 items regarding the extended self. Also on the brand love scale, there are ten items in the third part. The fourth part has seven items on the brand loyalty scale. In the last part, five questions were answered to determine the participants' demographic characteristics. The questionnaire form has a total of 46 questions. The first and last parts have multiple-choice questions, whereas the second, third, and fourth sections contain items on a 5-point Likert scale.

3. 4. Findings of the Study and Analysis of the Data

The statistical software packages SPSS22 and Lisrel11 were used to analyze the data received from the study, and the analysis findings were interpreted based on the data.

3. 5. Demographic Characteristics of Respondents

Table 1 shows the results of the questions used to determine the demographic characteristics of the participants.

68.2% of the participants are female and, 31.8% are male. The majority of the participants (69.5%) are between 18-25 years old. 20.6% of the participants are 36-35 years old, 6.4% are 36-45 years old, and 3.5% are 46 years old and over. 3.3% of the participants are a primary school, 45.6% high school, 46.9% university, and 4.2% postgraduate.

Table 1. Demographic Characteristics of Respondents

Gender	**Frequency**	**Per. (%)**
Female	311	68,2
Male	145	31,8
Total	456	100
Age		
18-25	317	69,5
26-35	94	20,6
36-45	29	6,4
46 and over	16	3,5
Total	456	100
Education		
Primary	15	3,3
High School	208	45,6
University	214	46,9
Postgraduate	19	4,2
Total	456	100

3. 6. Measurement Model

In assessing the measurement model, external loadings, reliability, composite reliability (CR), and average variance extracted (AVE) values were analyzed (Wong, 2013: 15). Initially, validity and reliability evaluations of the study scales were performed, excluding items with invalid outer loadings from the analysis, following which the subsequent analyses were undertaken accordingly. Table 2 illustrates that the AVE values for the variables span from 0.633 to 0.766, the composite reliability (CR) values range from 0.939 to 0.956, and the Cronbach's Alpha values vary from 0.927 to 0.948. AVE values must be a minimum of 0.50 (Fornell & Larcker, 1981: 46), CR values should be no less than 0.70, and Cronbach's Alpha values should be 0.70 or higher (Garson & Statistical Associates Publishing, 2016: 64-65). The results demonstrate that the variables surpass the necessary threshold values.

The Fornell-Larcker criterion was assessed to ascertain the attainment of discriminant validity (values in brackets in Table 3). The values of the Fornell-Larcker criterion must exceed the correlations among variable pairs. The HTMT value, seen as more robust than the Fornell-Larcker criterion, was also evaluated. HTMT values under 0.90 suggest that the model maintains external validity (Henseler, 2015: 121) (Table 3). Table 3 indicates that the HTMT values are below 0.90. Consequently, it was determined that the research model meets the criteria for discriminant validity. The research model is both valid and dependable, as evidenced by Table 3.

Table 2. Measurement Model

Variables	Items	Outer Loadings	Cronbach α	CompositeReliability (CR)	AVE
BRAND LOVE (LOVE)	LOVE1	0,838	0,948	0,949 (CR – rho_a) 0,956 (CR – rho_c)	0,733
	LOVE2	0,892			
	LOVE3	0,843			
	LOVE4	0,859			
	LOVE5	0,905			
	LOVE6	0,839			
	LOVE7	0,875			
	LOVE8	0,805			
BRAND LOYALTY (LOYAL)	LOYAL1	0,878	0,940	0,942 (CR – rho_a) 0,952 (CR – rho_c)	0,769
	LOYAL2	0,891			
	LOYAL3	0,879			
	LOYAL4	0,907			
	LOYAL5	0,899			
	LOYAL6	0,804			
EXTENDED SELF (EXSELF)	EXSELF1	0,793	0,927	0,929 (CR – rho_a) 0,936 (CR – rho_c)	0,633
	EXSELF2	0,819			
	EXSELF3	0,751			
	EXSELF4	0,819			
	EXSELF5	0,760			
	EXSELF6	0,737			
	EXSELF7	0,862			
	EXSELF8	0,808			
	EXSELF9	0,804			

Table 3. Discriminant Validity

FORNELL-LARCKER CRITERION			
	LOVE	**LOYAL**	**EXSELF**
LOVE	(0,856)		
LOYAL	0,823*	(0,877)	
EXSELF	0,774*	0,778*	(0,796)
* p < 0,01			
HTMT CRITERION			
LOVE			
LOYAL	0,871		
EXSELF	0,824	0,829	

3. 11. Structural Model

In alignment with the structural model evaluation criteria established by Hair et al. (2017), multicollinearity was evaluated, and the analysis was revised by excluding all variance inflation factor (VIF) values exceeding five for three variables—LOVE, LOYAL, and EXSELF—ensuring that all

items remained below the advised threshold of 5, thereby indicating the absence of collinearity issues. The model fit was subsequently assessed using the standardized root mean square residual (SRMR) approach, as proposed by Henseler et al. (2016).

The research model's fit indices revealed an SRMR value of 0.058, which is below the acceptable threshold of 0.08, thereby satisfying the necessary criteria. The NFI value of 0.838 lies within the acceptable range of 0.80–0.90. Consequently, it can be asserted that the research model is valid.

Table 4. Structural Model

Direct Effect	Beta	Sample Mean	Standard Deviation	t Statistics	p Values	Decision
LOVE→LOYAL	0,550	0,549	0,054	10,219	,000	Supported
EXSELF→LOVE	0,774	0,775	0,025	31,525	,000	Supported
EXSELF→LOYAL	0,778	0,779	0,027	28,759	,000	Supported
Indirect Effect						
EXSELF→LOVE→LOYAL	0,426	0,425	0,039	10,809	,000	Supported
VAF: Indirect Effect/ Direct Effect → 0,7745						

This research evaluates the hypotheses employing a bootstrapping method with 5,000 resamples and sample replacement, adhering to the protocols established by Hair et al. (2017). The findings are represented in Table 4.

Table 4 illustrates that brand love has a substantial positive effect on brand loyalty (β = 0.550, t-value = 10.219, p-value = 0.000). Additionally, as demonstrated in Table 4, extended self exhibits a substantial positive influence on both brand love (β = 0.774, t-value = 31.525, p-value = 0.000) and brand loyalty (β = 0.778, t-value = 28.759, p-value = 0.000). The results offer compelling evidence endorsing the adoption of Hypotheses H_1, H_2, and H_3.

The bootstrapping method was utilized to assess the mediating effects specified in Hypothesis H_4. The research depicted in Table 4 demonstrated that brand love significantly mediates the link between the extended self and brand loyalty (β = 0.426, t-value = 10.809, p-value = 0.000).

The widely recognized guideline states that a Variance Accounted For (VAF) number below 20% denotes minimum mediation, a value ranging from 20% to 80% shows moderate mediation, and a value beyond 80% represents full mediation (Nitzl, Roldan&Cepeda, 2016). Hence, H_4 is supported. The computed Variance Accounted For (VAF) value in the analysis is 0.7745, signifying that 77.45% of the impact of expanded self on brand loyalty is mediated by brand love. Since the VAF value is between 20% and 80%, the observed mediation can be categorized as “partial mediation” as per the classification established by Nitzl, Roldan&Cepeda, 2016.

4. Conclusion

Consumers who regard their possessions as extensions of themselves assign meaning to the brands they purchase. Consumers want their products and brands to represent who they are to others. They want the product and brand they buy to reflect who they are and / or want to be. As a result, customers purchase things that represent their personalities. This is where the brand intervenes. Consumers also buy brands that they believe reflect their personalities. The effect of the extended self on brand loyalty and brand love was studied in this study.

The research demonstrated that the extended self substantially impacts both brand love and brand loyalty. The findings indicated that brand love mediates the relationship between the extended self and brand loyalty, underscoring its essential function within the proposed framework. The

findings are mostly about the self (Rodrigues, Brandão ve Rodrigues, 2018: 189-210; Chand ve Fei, 2020: 1-13; Çavuşoğlu ve Demirağ, 2020: 1065-1087; Liu vd., 2012: 922-937; Das, 2014: 130-138; Lu ve Xu, 2015: 2014: 365-376) with a few studies on the extended self (Wu, Chen ve Nguyen, 2015: 153-173; Oflazoğlu ve Çelik, 2020: 120-139).

This research significantly contributes by addressing key gaps in the current literature on consumer-brand connections and identity-driven conceptions.

The study elucidates the concept of the extended self by illustrating its significant influence on brand affection and brand fidelity. Although previous research (e.g., Belk, 1988; Kleine & Kleine, 1995) has recognized the extended self as a psychological concept associated with consumer behavior, its dynamic influence on emotional and behavioral consequences in brand-related contexts has been little examined. This research establishes the direct influence of the extended self on brand love and brand loyalty, so bridging a substantial gap in theoretical debate and providing a more comprehensive perspective on identity-driven consumer behaviors.

The findings emphasize the mediating role of brand love, illustrating its essential significance in the connection between the extended self and brand loyalty. While prior work (e.g., Carroll & Ahuvia, 2006; Batra, Ahuvia & Bagozzi, 2012) recognizes brand love as an emotional component of consumer-brand interactions, its function as a mediator linking personal identity to loyalty behaviors remains inadequately explored. This study enhances the current knowledge base by establishing brand love as a vital mechanism that translates the impact of the extended self on loyalty, thereby offering a refined comprehension of emotional engagement in consumer-brand interactions.

The classification of mediation as "partial" or "complementary," substantiated by the computed Variance Accounted For (VAF) value, enhances the precision of theoretical models about mediation in consumer-brand interactions. This research expands upon the categories established by Nitzl, Roldan&Cepeda (2016) by providing a comprehensive classification of mediation types, elucidating the interaction between identity-driven conceptions and emotional mediators that provide loyalty results. This comprehensive viewpoint advocates for future investigations to examine more mediators and contextual factors, tackling the intricacies of consumer-brand connections that have been inadequately delineated in current studies.

This study addresses these gaps, establishing a solid platform for theoretical developments and facilitating future empirical studies to elucidate the complex relationship between identity-driven constructions, emotional engagement, and brand loyalty results.

Theoretical Implications

This study's findings greatly enhance the theoretical comprehension of consumer-brand relationships by highlighting the crucial influence of extended self and brand love on brand loyalty. The results emphasize that the extended self is not just a psychological concept but a dynamic element that influences emotional and behavioral consumer outcomes, enhancing the comprehension of its significance in brand-related circumstances.

Secondly, the study underscores the mediating role of brand love, illustrating its significance as a crucial mechanism by which the extended self affects brand loyalty. This finding enhances current literature by positioning brand love as a vital intermediate that connects personal identification and loyalty behaviors. It proposes that emotional elements in consumer-brand interactions ought to be more prominently incorporated into theoretical models.

Finally, the categorization of mediation as "partial" or "complementary," substantiated by the VAF value, provides a refined comprehension of the interaction among extended self, brand affection,

and brand allegiance. This classification enhances theoretical frameworks that seek to elucidate the interplay between identity-driven conceptions and emotional engagement in influencing loyalty outcomes. The study establishes a basis for future research to investigate more mediators and contextual elements that may elucidate the dynamics of consumer-brand relationships.

Managerial Contributions

The results of this study provide numerous significant insights for brands and business executives. Comprehending the extended self as a significant catalyst for brand affection and devotion enables managers to create marketing tactics that profoundly align with consumers' identities. By cultivating emotional affiliations with their brands, managers can markedly improve loyalty results.

The moderating function of brand love in the relationship between extended self and brand loyalty underscores the need of fostering robust emotional connections. Managers must prioritize the development of experiences, narratives, and visual identities that elicit brand affection, as this emotional connection is essential for enhancing loyalty.

Ultimately, with 77.45% of the extended self's influence on brand loyalty mediated by brand love, it is clear that partial mediation presents potential for supplementary tactics. Managers should strive to cohesively merge expanded self and brand affection, ensuring that their branding initiatives encompass both functional and emotional dimensions. This strategy can enhance loyalty, deepen consumer-brand ties, and establish enduring competitive advantages.

Consequently, this work is crucial to fill a gap in the area because there is little research on the extended self. At the same time, the study provides essential information for marketers that want to attract customers' attention. People consider products as extensions of themselves, according to the extended self-theory. The study offers guidance to businesses in the field on how to approach customers who buy or want to buy mobile phones, as well as how to successfully ensure brand loyalty and love. Marketing efforts should focus on the extended self to build emotional ties with businesses. Consumers should believe that the brands they purchase are compatible with them. To put it another way, the impression that a bridge can be built between the brand and the self, and the outside world may be constructed. Thus, consumers who are loyal to and love their brands will be built.

Limitations and Future Research Suggestions

This study offers significant insights into the impact of extended self and brand love on brand loyalty, although it is crucial to recognize its limits. The study was done solely among mobile phone users, therefore limiting the focus to a certain customer niche. The results, derived from a sample of 456 people, may lack full generalizability to other product categories or wider customer demographics. The study emphasizes quantitative indicators and does not explore qualitative factors, including the intricate emotional experiences of consumers or contextual variations among cultures and regions.

Future research could address these constraints by investigating the extended self, brand affection, and brand loyalty dynamics across other product categories and customer segments. Examining the manifestation of these constructs in luxury goods, household products, or services may provide deeper insights. Furthermore, integrating qualitative approaches, such as comprehensive interviews or ethnographic research, may reveal profound dimensions of emotional involvement and identity-based behaviors in consumer-brand interactions.

A promising direction for future research involves cross-cultural studies to investigate the influence of cultural differences on the links among extended self, brand affection, and loyalty. This

method can enhance theoretical frameworks by considering heterogeneity in identity notions and emotional engagement across diverse cultural contexts. Furthermore, longitudinal studies may be undertaken to examine the progression of these relationships over time, especially in reaction to fluctuations in market conditions, brand strategies, and customer preferences.

Researchers should explore further mediators and moderators that influence the relationship among expanded self, brand love, and brand loyalty. Elements such as social impact, digital engagement, and brand authenticity may offer additional information, hence enhancing the comprehension of consumer-brand connections. By following these guidelines, subsequent research can expand upon the existing findings and enhance the knowledge of the theoretical and practical ramifications of identity-driven consumer behaviours.

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From Addiction to Recovery: A Netnography Study of Online Gambling Behaviour and Support Systems in Facebook Groups

Abstract

This study explores the dynamics of online gambling addiction and recovery within Facebook groups through a netnographic approach. The research aims to answer three key questions: How do individuals transition from non-gamblers to gamblers and navigate recovery? What processes lead recovered gamblers to relapse? Do online groups function as genuine support forums or covert gambling promotion channels? By focusing on these aspects, the study seeks to uncover the behavioral and emotional dynamics of individuals dealing with online gambling addiction, while also examining the role of online communities in supporting or exacerbating these issues. The research is based on qualitative data collected from five active public Facebook groups related to gambling. These groups were selected based on their accessibility, member engagement, and relevance to the addiction and recovery discourse. The study utilizes both deductive and inductive coding methods in NVivo 12 for thematic analysis, allowing for a comprehensive exploration of themes such as addiction behaviors, recovery strategies, and relapse triggers.Findings reveal that the transition from non-gambler to gambler often starts with curiosity and exposure to online promotions, leading to addiction. Early wins contribute to a false sense of control, deepening the engagement with gambling. While recovery is initiated through self-awareness and crisis points, relapse is common, triggered by environmental cues and cognitive distortions like the gambler's fallacy. The research also highlights the dual nature of Facebook groups: some act as supportive communities that foster recovery, while others inadvertently promote gambling, often through covert marketing tactics or shared strategies.This study underscores the complex nature of online gambling addiction, emphasizing the need for effective interventions and moderated online communities. The findings suggest that while these groups can provide emotional support and peer validation, they also harbor risks of relapse, especially when unmoderated or exploited by commercial interests. The study calls for a more structured approach to managing these online spaces and improving recovery support systems.

Keywords: online gambling, addiction recovery, relapse, netnography, Facebook groups

1. Introduction

In Indonesia, online gambling has become a growing concern, particularly with the rise of internet access and the increasing popularity of online gambling platforms. Despite being illegal in the country, online gambling has found a significant following, with many individuals turning to offshore websites and mobile apps to engage in gambling activities. The allure of anonymity, ease of access, and a wide range of games have contributed to the surge in online gambling participation.

Online gambling has become a widespread phenomenon, primarily due to the increasing accessibility of the internet. As a result, understanding the behavior and psychological impacts associated with gambling is more important than ever. Social media platforms, such as Facebook, have become crucial spaces for individuals to share their gambling experiences, seek advice, and build supportive networks. These online communities not only provide insights into how people engage with gambling but also shed light on the psychological consequences of addiction. While some groups focus on rehabilitation, others inadvertently reinforce gambling behaviors, serving as both spaces for recovery and perpetuation of addiction.

One of the most common patterns observed within these communities is the belief that gambling can lead to substantial financial gains. This mindset is often reflected in statements such as, "I invest this amount, and I can win this much." It drives individuals to continue gambling, hoping that their next attempt will yield success, despite repeated failures. Many players find themselves caught in a cycle of

losing and trying again, as expressed by numerous members who say, “I lost, but I’ll try again.” This pattern reveals the psychological concept of “chasing losses,” where gamblers continue betting in an attempt to recover their previous losses.

The psychological toll of online gambling is profound, often leading to severe mental health issues. As one individual shared, “As a result of online gambling, many people start to daydream endlessly, and some even resort to suicide.” This statement underscores the emotional impact that gambling can have, leading to depression, anxiety, and suicidal thoughts. Gambling not only drains individuals’ finances but also disrupts their mental well-being, leaving them feeling hopeless and isolated. The stigma associated with gambling addiction often causes individuals to withdraw from social circles, further deepening their sense of isolation and perpetuating the cycle of addiction.

Recent studies and reports highlight the concerning scale of the problem. According to data from the Indonesian National Anti-Narcotics Agency (BNN), online gambling has led to substantial financial losses among Indonesian citizens. Data from the Financial Transaction Reports and Analysis Center (PPATK) recorded that online gambling transactions in the first quarter of 2025 reached IDR 47 trillion, and without intervention, the economic losses caused by online gambling could exceed IDR 1,000 trillion by the end of 2025. This indicates that online gambling has a significant impact on the economy, as individuals spend large amounts of money on gambling often resulting in personal bankruptcy and financial devastation (Jakarta Globe, 2025).

Despite being strictly illegal, online gambling has proliferated across Indonesia as a pervasive underground activity, drawing in diverse demographics from teenagers and workers to housewives. This phenomenon transcends mere legal prohibition; it represents a complex behavioral epidemic fueled by digital accessibility. Online gambling encompasses internet-based betting, including card games, slots, sports wagering, and virtual casinos, all readily accessible via smartphones. Its allure lies in convenience: the ability to bet on football matches or spin digital lotteries from home at any time.

However, these platforms are deliberately engineered to exploit psychological vulnerabilities, triggering addictive behaviors that trap users in cycles of financial loss, eroded well-being, and familial discord. Millions of Indonesians engage daily, often unaware of their deepening addiction until they face devastating consequences not just monetary, but also temporal, emotional, and social.

The social and psychological impact of online gambling in Indonesia is profound and multifaceted. Individuals developing gambling addictions frequently experience devastating consequences, including strained familial relationships, job loss, and severe mental health deterioration manifesting as depression, anxiety, or even suicidal ideation. Supporting this, Indonesian survey data reveals a significant proportion of online gamblers report acute psychological distress, driving many to seek solace in online communities where they share struggles and seek support. Critically, the persistence of this crisis despite stringent government bans underscores an urgent need to examine gamblers' behavioural dynamics and their navigation of informal support systems. This research gap is where the present study intervenes: deploying netnography within Facebook groups, it uncovers the lived experiences of Indonesian gamblers, tracking their pathways from addiction to recovery. It specifically investigates how these covert communities’ function as double-edged spaces simultaneously incubating risky behaviours yet offering potential lifelines and explores the emotional and psychological dynamics that shape coping mechanisms. By analysing how online spaces paradoxically perpetuate harm *and* foster resilience, this study provides essential insights for designing effective interventions in Indonesia's shadowed yet devastating gambling landscape

Research Formulation

Online gambling poses severe societal harms in Indonesia including depression, financial ruin, family breakdown, and broader social consequences driving many affected individuals to seek support through Facebook-based rehabilitation groups. Paradoxically, these groups often become exploited

spaces where gambling is covertly promoted, trapping recovering addicts in the same destructive cycle or worsening their addiction. Empirical evidence further indicates that even recovered individuals who establish new support groups may relapse upon re-exposure to gambling content. This crisis persists despite the Indonesian government's limited intervention, which remains largely advisory rather than actionable.

Research Questions

The study employs a netnographic approach centred on three critical dimensions:

1. How do individuals transition from non-gamblers to gamblers and subsequently navigate recovery?
2. What processes lead recovered gamblers to relapse and re-engage with gambling?
3. Do online groups function as genuine support forums (free of commercial motives) or as covert gambling promotion channels?

2. Literature Review

Online gambling has become a significant public health issue in Indonesia, exacerbated by the increasing accessibility of digital platforms, despite strict legal prohibitions. As gambling moves from traditional venues to digital platforms, it has become more normalized, especially through social media, making regulation and control more challenging. This shift not only changes how gambling is conducted but also how it is experienced and perceived, with individuals now routinely exposed to gambling content disguised as entertainment or lifestyle. The influence of social media in promoting gambling, particularly among youth, has further complicated efforts to mitigate this growing problem (Andersson et al., 2025).

Online gambling includes a variety of internet-based betting activities such as slots, poker, and sports wagering, all of which are accessible via smartphones and social media platforms. According to Gainsbury et al. (2014), online gambling can be categorized into three types: social casino games, real-money gambling, and practice sites. Social casino games, like Facebook slots, are free-to-play simulations involving microtransactions but not monetary rewards. Real-money gambling activities require payment and offer monetary returns based on chance, while practice sites are demo versions designed to ease users into real-money gambling. In Indonesia, these categories are often blurred, particularly through social media platforms, which facilitate the normalization of gambling behavior, especially among the youth. This has further complicated regulatory enforcement, as individuals may unknowingly transition from free-to-play games to real-money gambling without fully understanding the associated risks (Griffiths, 2013).

The underlying mechanisms of gambling addiction are shaped by neurobiological and psychosocial processes. Operant conditioning, especially through variable-ratio reinforcement, and cognitive distortions like the illusion of control and gambler's fallacy, play a significant role in the persistence of gambling behavior. Intermittent rewards in social casino games trigger dopamine release, which mirrors the neurobiology of substance addiction, making adolescents particularly vulnerable due to their underdeveloped prefrontal cortices (Griffiths, 2013; Blaszczynski & Nower, 2002). Blaszczynski and Nower's (2002) Pathways Model identifies three pathways to gambling addiction: behaviorally conditioned gamblers, emotionally vulnerable gamblers, and antisocial impulsivity. In Indonesia, emotionally vulnerable gamblers, often dealing with economic distress and emotional pressures, are the most prevalent group. These individuals tend to use gambling as a maladaptive coping mechanism, particularly in the face of post-pandemic unemployment or ongoing emotional struggles (Rafli et al., 2025; Trisnandi & Ulfatun, 2024).

The societal impact of online gambling in Indonesia is profound and extends beyond individuals to affect families and communities. Financially, many online gamblers accumulate significant debt, with 78% turning to loan sharks or depleting their savings to cover losses (Rafli et al., 2025). Mental health issues, such as depression, anxiety, and suicidal ideation, are widespread among affected individuals.

Adolescents, in particular, report sleep disorders and declining academic performance (Trisnandi & Ulfatun, 2024). Family relationships also suffer, with financial deception and gambling-related stress leading 63% of spouses to consider divorce. On a broader scale, the depletion of household resources reduces overall productivity, as seen in Pabelan Village, where youth abandon education and employment opportunities in favor of gambling, seeking a "quick fix" for financial difficulties (Trisnandi & Ulfatun, 2024).

Despite the legal status of online gambling, its prevalence in Indonesia continues to rise, fueled by structural and cultural vulnerabilities. Regulatory enforcement remains weak due to under-resourced agencies and corruption, which allows gambling platforms to operate with little oversight. The use of digital tools like VPNs and cryptocurrencies adds an extra layer of anonymity, making it difficult to track and regulate online gambling activities. Social media platforms, such as Facebook, play a significant role in promoting gambling, often through groups that disguise themselves as "rehabilitation communities," exploiting vulnerable individuals seeking help (Griffiths, 2013). Moreover, the gamification of gambling colorful slot machines and enticing "free spin" bonuses—appeals strongly to younger generations, particularly Gen Z, capitalizing on their digital nativity (Trisnandi & Ulfatun, 2024).

To effectively address the growing issue of online gambling in Indonesia, a multi-faceted approach is required, incorporating both policy and clinical interventions. Policy measures should include the implementation of stringent regulations, such as mandatory age verification and blocking gambling-related content on platforms, to prevent exposure among minors (Gainsbury et al., 2014). Financial monitoring systems should be established to track gambling transactions and provide immediate access to crisis resources for those at risk (Rafli et al., 2025). On the clinical side, pathway-specific therapies should be utilized. Cognitive restructuring can assist behaviorally conditioned gamblers, while trauma-informed counselling and the use of SSRIs (Selective Serotonin Reuptake Inhibitors) can help emotionally vulnerable individuals (Blaszczynski & Nower, 2002). Additionally, culturally tailored education to debunk common "win myths" and promote financial literacy is crucial in enabling individuals to make more informed decisions about gambling (Trisnandi & Ulfatun, 2024).

The role of online communities in shaping gambling behavior remains underexplored. Platforms such as Facebook provide spaces for gamblers to exchange experiences, strategies, and support, but little research has delved into how these communities influence gambling habits. Netnography, introduced by Kozinets (2010), is a valuable methodology for analyzing communal interactions in online spaces. This approach enables researchers to explore the collective experiences of individuals in gambling communities without direct participation, offering a deeper understanding of social dynamics. Studies, like those of Thanh and Kirova (2018), have demonstrated the effectiveness of netnography in analyzing user interactions in online communities, further highlighting its potential in understanding online gambling behaviors.

The Pathways Model of Problem Gambling, developed by Blaszczynski and Nower in 2002, is a useful framework for understanding gambling addiction. The model categorizes addiction into three pathways: behaviorally conditioned, emotionally vulnerable, and antisocial-impulsivist gamblers. This model has evolved to reflect new findings, recognizing that environmental, psychological, and biological factors differently contribute to each pathway (Blaszczynski & Nower, 2020). In the context of online gambling, the model helps explain the complexities of addiction, with intermittent reinforcement mechanisms, such as random bonuses or visual animations, strengthening gambling habits through operant learning patterns (Palomäki et al., 2025). Studies have shown that emotional gamblers are more prone to relapse due to a lack of alternative coping strategies (Guillou-Landreat et al., 2020). Research has also indicated that tailored interventions, such as cognitive-behavioral therapy for emotional gamblers and impulse control training for antisocial gamblers, improve recovery outcomes (Ford & Håkansson, 2020).

Furthermore, technology-driven interventions such as e-CBT, ecological momentary assessments (EMAs), and ecological momentary interventions (EMIs) show promise in addressing online gambling-related issues. Diaz-Sanahuja et al. (2024) found that online psychological interventions, particularly those based on cognitive-behavioral therapy and supported by ecological momentary tools, are effective and feasible. However, challenges related to participant reach and adherence must be addressed to enhance the scalability and effectiveness of these digital treatment programs. These interventions represent scalable, user-friendly strategies for tackling online gambling addiction.

3. Method

This study adopted a qualitative netnographic approach, as outlined by Kozinets (2010), to examine archival data from public Facebook groups centered around online gambling. This approach is particularly effective for analyzing the dynamics of communal interactions within virtual spaces, as it allows for a comprehensive investigation while preserving the researcher's observational distance from the participants.

The selection of the groups was guided by specific criteria to ensure relevance and depth. Initially, a total of 345 Facebook groups were identified through the use of the keyword "online gambling." From this pool, five public groups were chosen based on several key factors.

First, the groups had to be publicly accessible, meaning that private or closed groups were excluded in adherence to ethical standards. Additionally, each group had to have a minimum of 1400 active members, ensuring that the discussions and interactions within these spaces were robust and reflective of active engagement. Moreover, the groups selected displayed a high frequency of engagement in discussions directly related to gambling, indicating that the members were consistently involved in gambling-related conversations.

Table 1. Selected Facebook Groups

No	Facebook Group Name	Type	Members	Post Frequency
1	*Edukasi Berhenti Judol* [Education to Stop Online Gambling]	Publik	1400	10 Posts Per Day
2.	*Stop Judi Online Sebelum Terlambat* [Stop Online Gambling Before it's Too Late]	Publik	6400	6 Posts Per Day
3	*Rehabilitasi Korban Kecanduan Judi Slot Online*[Rehab for Online Slot Gambling Addiction Victims]	Publik	17,800	6 Posts Per Day
4	*Bebas Share Curhatan Korban Judi Slot Online* [Open Sharing of Online Slot Gambling Victims' Stories]	Publik	30,900	10 Posts Per Day
5	*Korban Slot Situs Sedot Wc/Scam 2025* [Victims of Scam Online Gambling Slot Sites 2025]	Publik	50.300	10 Posts Per Day

Source: processed from Facebook (2025)

Data were scraped from public Facebook groups using Instant Data Scrapper tools, adhering strictly to ethical protocols. Only public Facebook groups were utilized, where the content was freely accessible without the need for individual consent. This ensured the research complied with ethical standards while also focusing on observable interactions within these online spaces.

To gather the necessary data, a scraping technique was employed using Instant Data Scraper tools. This allowed for the efficient extraction of posts, comments, and reactions from the selected groups, ensuring comprehensive data collection for analysis. The scope of the data collected amounted to approximately 300,000 words of textual content, primarily in Indonesian, with minimal use of English

terms. This content focused on key aspects of online gambling, including personal gambling experiences, addiction and recovery narratives, peer strategies, and emotional exchanges.

Before proceeding with analysis, all identifiable user information was carefully anonymized to ensure participant privacy and confidentiality. This step was crucial to maintaining the integrity of the ethical standards and ensuring the data could be analyzed without any risk to individuals' identities.

Once the anonymized dataset was collected, it was processed using NVivo 12 software for thematic analysis. A hybrid approach was applied, combining both deductive and inductive coding methods to explore the content systematically.

The analytical framework began with deductive coding, where pre-defined categories, informed by the Pathways Model and existing gambling literature, were applied to the dataset. These categories included addiction manifestations, recovery mechanisms, social support dynamics, and risk behaviors, which were used to structure the initial analysis of the data.

Subsequently, inductive coding was employed to identify emergent themes that arose directly from the raw data. This iterative process allowed for a deeper understanding of the content, uncovering new patterns and insights that were not previously anticipated.

Table 2. Thematic Categorization

Category	Analysis Focus
Social Interactions	Peer communication patterns & support networks
Gambling Behavior	Strategies, frequency, and monetary patterns
Community Dynamics	Group norms, knowledge sharing, belonging
Emotional Expression	Linguistic markers of distress/hope in posts

Source: processed from Facebook Group “Online Gambling” (2025)

To ensure the validity and depth of the analysis, a triangulation approach was employed. Themes were examined across multiple data types, including posts, comments, and reactions. This allowed for a comprehensive understanding of the interactions and provided a broader perspective on the patterns and themes emerging from the community discussions.

In addition to triangulation, emotional valence was mapped by analyzing the emoticons used in reactions to posts and comments. This analysis helped in identifying the emotional tone of the interactions, providing insight into the participants' feelings and responses related to gambling experiences and recovery narratives.

Furthermore, a frequency analysis of theme recurrence was conducted to assess how often specific themes appeared throughout the dataset. This quantitative approach enabled the identification of key patterns and trends, offering a more structured understanding of the recurring topics within the groups.

3.2 Data Analysis

The textual data collected from the five selected public Facebook groups will undergo a comprehensive thematic analysis using NVivo 12, a powerful software tool for managing and analyzing qualitative data. The primary aim of this analysis is to identify key themes and patterns that emerge from the interactions within these online gambling communities. NVivo 12 will allow for both deductive and inductive coding approaches. The deductive coding will focus on pre-identified themes, such as addiction, responsible gambling, and social support, which are commonly discussed in the literature on online gambling. On the other hand, inductive coding will be employed to identify new and emergent themes that may arise during the analysis. This combination of coding techniques ensures that both expected and unexpected patterns in the data are captured and explored.

As this study employs a netnographic approach, the research will adopt an observational methodology. This means that the researcher will observe and analyze the content generated within the Facebook groups without actively participating or influencing the interactions. The observational nature of netnography ensures that the analysis remains true to the natural dynamics of the online communities being studied. The researcher will focus on documenting the frequency and context of certain themes that frequently emerge in the discussions. Key themes to be explored include gambling strategies, addiction concerns, emotional support, and peer interactions. These themes are central to understanding the behaviors and experiences of individuals within the online gambling communities, as well as the role these communities play in both enabling gambling behavior and offering support for those struggling with addiction.

To facilitate a deeper understanding of the online gambling communities, the textual data will be categorized into several thematic areas. These include social interactions, which will explore how group members communicate with each other, form relationships, and offer emotional support. Gambling behavior will focus on the descriptions of individuals' gambling habits, practices, and the challenges they face in managing their gambling activities. Community dynamics will address how members of the group share experiences, provide advice, and contribute to a sense of belonging and collective support. Lastly, emotional expressions will look at the emotional tone of the posts and comments, such as feelings of frustration, excitement, disappointment, or relief. This categorization will enable the researcher to map out the complex social and emotional landscape of online gambling communities and gain valuable insights into how individuals engage with gambling behavior in a shared online space.

Discussions

The Cycle of Online Gambling Addiction and Recovery: A Vicious Circle

Diagram 3. Vicious Circle

Source: processed from Nvivo (2025)

This study reveals that the journey of individuals experiencing online gambling addiction often follows a cyclical and destructive pattern. It begins with curiosity, develops into addiction driven by the illusion of quick wins, and ultimately results in psychological, social, and financial deterioration. At a critical low point, however, some individuals demonstrate self-awareness and begin to seek recovery, marking a potential turning point toward healing and behavioral change.

The process frequently starts with initial exposure to promotional content or invitations through social media, often accompanied by narratives that promise significant financial gains in a short time. As reflected in participants' accounts, phrases such as *"I invest this amount, and I can win this much"* illustrate the initial optimism that motivates individuals to engage. Early wins, which in many cases are intentionally engineered, reinforce the illusion that gambling is a viable financial strategy. This phase becomes the beginning of what is referred to as the false hope cycle.

As financial losses accumulate, individuals feel compelled to continue gambling in an attempt to recover what they have lost. This behavior is commonly known as chasing losses and is exemplified by statements like *"I lost, but I'll try again."* At this stage, individuals often begin to compromise their financial stability, strain relationships, and experience disruption in their professional lives. Despite these consequences, the design of online gambling platforms sustains the illusion of control, while in reality, the outcomes are often manipulated behind the scenes by administrators, as revealed by former insiders.

Over time, the psychological burden of gambling begins to surface. Individuals report feelings of intense regret, shame, and isolation. One particularly powerful quote illustrates this reality: *"As a result of online gambling, many people start to daydream endlessly, and some even resort to suicide."* This emotional and mental distress represents the deepest point in the addiction cycle, when individuals are often overwhelmed by hopelessness and social withdrawal.

The Catalytic Role of Regret in Gambling Recovery

The recovery process from gambling addiction is intrinsically linked to the experience of negative emotions, particularly regret, guilt, and shame. This aligns with Hodgins' (2001) model of behavioral change, which posits that during the *contemplation and preparation stages*, individuals engage in profound reflection on the consequences of their actions. Within this framework, regret functions as an emotional catalyst that motivates transformative behavioral shifts.

Narratives from recovery communities reveal intense regret through expressions of cognitive reckoning with past decisions: *"I'm just tired now. Even a big win doesn't feel good. Losing is certain"*. *"Because of my grudge against Spaceman [a slot game], I'm left with 30 million in debt. Oh God, I don't know what to do"*

These statements reflect painful retrospection about gambling's long-term impacts. Concurrently, profound helplessness surfaces in declarations like: *"Right now I'm struggling just to eat, and I'm the breadwinner"*, *"It really hurts when everything's gone"* Such utterances signify existential despair stemming from total loss.

Self-Blame and Cognitive Dissonance

Self-directed anger and distorted cognition often exacerbate emotional distress in individuals struggling with addiction, particularly in the context of online gambling. Many individuals express self-blame, as one participant shared, "Because I was too stupid." This type of self-accusation reflects an internalization of guilt and a harsh judgment of one's own actions. Additionally, individuals may experience reality denial, as one user stated, "Felt like being hypnotized." This statement suggests an attempt to distance oneself from the responsibility of their actions, as they struggle to reconcile the destructive nature of their behavior with the urge to protect their sense of self. These expressions highlight the psychological tension between accountability for their actions and the need for self-preservation, creating a complex emotional and cognitive battle.

Such conflicting feelings contribute to cognitive dissonance, where individuals attempt to justify or rationalize their destructive behavior while simultaneously grappling with deep feelings of guilt and shame. This internal struggle can intensify emotional distress, as it becomes difficult to reconcile the desire for self-compassion with the need to confront the negative consequences of their actions.

Public Articulation of Regret in Supportive Environments

When self-blame and cognitive dissonance are channelled within supportive environments, public articulation of regret can serve several critical functions. These environments, such as online recovery communities or peer support groups, provide a space for individuals to express their emotions and gain the necessary support to move forward.

The first function is emotional catharsis, where individuals are able to release pent-up shame and guilt. Speaking openly about their regrets allows them to process these intense emotions, offering a sense of relief and emotional release that is essential for recovery. This cathartic process helps to alleviate some of the psychological burden that has accumulated due to self-blame and guilt.

Another critical function of articulating regret in a supportive environment is social validation. By sharing their experiences and feelings of regret, individuals receive recognition from peers who have faced similar challenges. This recognition of shared trauma helps to establish a sense of connection and belonging, reinforcing the idea that they are not alone in their struggles. Social validation provides emotional comfort and encourages individuals to continue their recovery journey, knowing they are supported by others who understand their experiences.

Behavioral catalyst: Converting remorse into change motivation

Within the despair caused by online gambling addiction, a desire for change begins to emerge. Many individuals eventually seek help by joining Facebook groups dedicated to rehabilitation or peer support for victims of gambling. These communities become the starting point for the recovery process, as they provide a space for individuals to share their experiences and receive emotional support from others who understand their struggles. Statements such as “The first step is realizing that this is a problem” highlight the importance of self-awareness and recognition as critical first steps in initiating the recovery journey. In these groups, individuals can find encouragement and solidarity, which are crucial for sustaining the recovery process.

Efforts to quit often begin when individuals hit rock bottom, as one user admitted, “I admit, quitting gambling is extremely difficult before you reach your lowest point.” For some, recovery is successful. Statements such as “Thank God, I’ve been gambling-free for two weeks” and “Life is so much better after two years without gambling” reflect successful attempts at quitting. Another participant shared, “Thank God, I’ve quit, and now I’m just focused on paying off my remaining gambling debts.” Strategies for quitting vary, but they often include removing access to banking apps, as one user explained: “I transferred money directly to an account with no card or mobile banking.” Strengthening spirituality is another common strategy, with one participant stating, “The most important thing is to truly stop and draw closer to the Creator.” Research by Guillou-Landreat et al. (2020) shows that self-efficacy and trigger avoidance strategies, including spiritual support, can significantly enhance the chances of mid- and long-term recovery from online gambling addiction.

However, the path to recovery is rarely a straightforward one. Relapse is common, often exacerbated by continuous exposure to gambling promotions on social media and the psychological pull of past behaviors. This cyclical pattern reflects the nature of gambling addiction, where the journey through addiction and recovery forms a vicious circle. In this complex dynamic, feelings of damage and hope coexist, making the road to recovery both challenging and unpredictable.

The transition from online gambling addiction to recovery is marked by distinct stages. Initially, involvement in gambling is driven by curiosity. Over time, this curiosity deepens into addiction, leading to severe financial, social, and psychological consequences. Many individuals start with small bets, as one user shared: “It started with 50,000 IDR (approximately 3.30 USD) in 2020.” The addictive nature of online slot games, supported by psychological cues such as "The music is very hypnotic for the brain" and "animations during scatters," traps users in a cycle of compulsive betting. These audiovisual elements stimulate strong desires and reinforce addictive behaviors. Recent studies, such as the one by Murch et

al. (2020), highlight that game design features—like audiovisual cues and random rewards trigger dopamine responses similar to those seen in substance addiction, strengthening compulsive gambling behavior.

Contradictory Dynamics in Recovery Communities

A paradoxical pattern emerged within rehabilitation-focused groups: the pervasive infiltration of gambling advertisements despite their stated recovery purpose. Mass-promoted content featuring phrases like “The Most Trusted Site” and “Minimum Deposit Only 5,000 Rupiah (0.3 USD)" indicates bot-driven or affiliate marketing campaigns. This creates external pressures that undermine recovery efforts and potentially reignite gambling intentions among vulnerable members (Gainsbury et al., 2014). More insidiously, interpersonal exchanges contained gambling encouragement—from explicit prompts like "keep going for gambling" to implicit normalization through shared "winning strategies." These contradictions transform recovery spaces into high-risk environments where rehabilitative goals compete with predatory gambling promotion.

Intruders in Online Gambling Rehabilitation Groups

Online gambling rehabilitation groups often face the challenge of intruders who attempt to promote gambling, both openly and covertly, exploiting the vulnerabilities of the members. These intruders can be particularly harmful, as they prey on individuals who are already struggling with addiction or recovery.

Direct promotions are one way these intruders advertise gambling sites. Examples include statements like, “It’s the best place to play, you must try *papuwa4d* [online gambling application]” and “Highly recommend the papuwa4d site, I’ve personally proven that with a 500k IDR (approximately 33 USD) investment, I turned it into 4 million IDR (approximately 265 USD).” Such direct advertisements lure individuals back into gambling by promising quick and high returns, often exploiting their financial vulnerabilities. Another common promotion is “It’s very profitable to play on papuwa4d, it’s the best site,” which plays on the hope of financial gain through gambling.

Covert promotions are more insidious, disguised as offers of assistance or help for those in need. Examples include statements like, “For those still in debt, feel free to message me for a quick way to make money…” and “If you want to recover your gambling losses... but you must stop gambling for good.” These messages often present themselves as helpful solutions, but they ultimately redirect individuals toward gambling, exploiting their desire to regain lost money or alleviate financial distress. It indicates that such online gambling marketing often targets vulnerable individuals, especially those struggling with debt, by exploiting their financial and emotional weaknesses.

Despite these intrusive tactics, group members remain vigilant and protective of their fellow members. Responses such as, “Don’t trust him, he’s a scammer” and “All gambling sites are scams... but they cheat us in different ways” demonstrate the group’s efforts to maintain a focus on recovery. Critical remarks like, “Never play slots or casinos, everything is rigged” further help to counteract the influence of these harmful promotions and keep the group on track with its rehabilitation goals. The collective vigilance and moderation within these groups are vital for maintaining their integrity. It highlights how online communities can develop defences against gambling promotions through shared awareness and group cohesion.

Moderation as a Critical Safeguard

The presence of vulnerabilities in online recovery communities underscores the importance of active moderation to maintain safety and trust. As evidenced by Deng et al. (2023) in their study on online mental health forums, spaces without moderation are at risk of being exploited by illegal gambling

operators. Moderation plays a vital role in removing harmful promotional content and suspicious accounts, guiding discussions to remain aligned with the community's goals, and protecting members from being targeted by black-market actors. In the absence of such oversight, recovery forums may unintentionally reinforce the problematic behaviors they seek to address. Therefore, moderation should be seen not only as a technical task but also as a key pillar in building secure and supportive online environments for individuals in recovery.

Dual Function of Communities: Harm Exposure and Social Support

These groups function as dual-purpose platforms, providing spaces for both harm disclosure and peer support. Within these communities, members candidly recount the severe consequences of their gambling behavior, including financial devastation, such as the loss of over IDR 1.4 billion, depleted savings, and mounting debt. For instance, one anonymous participant reported losing IDR 480 million over five years. The emotional toll is equally alarming, with accounts of isolation such as fleeing to distant locations suicidal ideation, and harassment from debt collectors. These narratives are consistent with Kristensen et al. (2024), who emphasize the heightened suicide risk among individuals with gambling disorder, and Langham et al. (2016), who classify intimidation and threats as forms of psychological harm. Furthermore, as noted by Neophytou et al. (2023), avoidant coping strategies like escapism, when not accompanied by professional support, can increase the likelihood of relapse, highlighting the urgent need for integrated interventions.

Peer Support Mechanisms and The Dual Role of Facebook Groups

Facebook groups dedicated to online gambling represent a complex digital ecosystem that functions both as a facilitator of addictive behavior and as a medium for recovery. On the one hand, communities such as “Rehabilitation for Online Gambling Addicts” serve as platforms for emotional support and the exchange of recovery strategies, offering individuals a sense of solidarity in their efforts to heal. On the other hand, several groups remain centered on sharing gambling tips, wins, and promotional content, inadvertently reinforcing risky behaviors. This duality underscores the ambivalent nature of digital platforms, where mechanisms of support and temptation coexist in close proximity. Despite the inherent risks, many recovery-oriented communities demonstrate the potential of peer-led interventions to mitigate harm.

Drawing on House’s (1981) typology of social support, these communities provide emotional reassurance through empathetic affirmations (e.g., “there is no true happiness in gambling”), instrumental support by reaching out to socially withdrawn members, informational assistance through the dissemination of recovery strategies, and appraisal support by helping individuals gain perspective on the severity of gambling addiction (e.g., “gambling is more terrifying than drugs”). This shared vulnerability fosters collective resilience and accountability, transforming online spaces into informal yet meaningful systems of psychosocial support.

Multidimensional Harm Framework

The consequences of gambling addiction are profound and multifaceted, often resulting in cascading harm across several domains of life. Participants in this study reported substantial financial losses, with one individual recounting the liquidation of major assets, including a family car, motorcycle, and personal savings. Another participant disclosed cumulative losses of over IDR 250 million (approximately USD 16,500) since 2020, illustrating the magnitude of economic devastation that can accompany compulsive gambling. Beyond financial implications, participants frequently described severe social consequences, including damaged family relationships, as exemplified by admissions of pawning a sibling’s vehicle to repay gambling debts. On a psychological level, the emotional burden of gambling was

articulated through expressions of acute distress and suicidal ideation, with participants stating sentiments such as “I constantly thought about running away or even ending my life.”

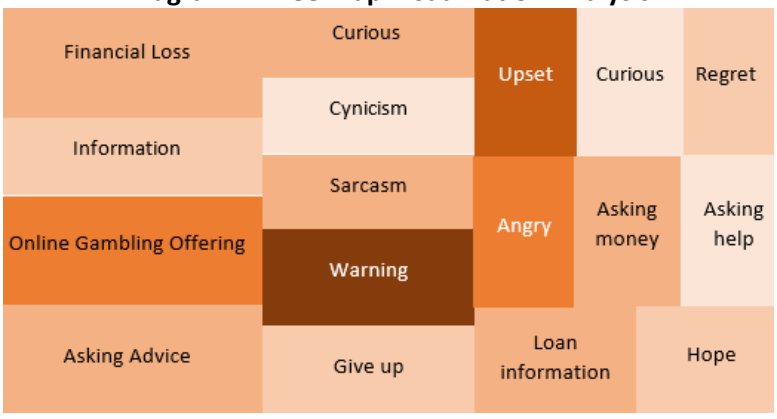
These accounts resonate with findings from Karlsson and Håkansson (2020), who documented elevated risks of suicidality and comorbid mental disorders among individuals with online gambling addiction. The data also align with Langham et al.'s (2016) seven-domain framework of gambling-related harm, which includes financial loss, relationship disruption, emotional and psychological distress, health deterioration, cultural erosion, occupational or academic impairment, and criminal involvement. Participant narratives demonstrate the interconnected nature of these harms, showing how initial financial collapse can precipitate relational breakdowns, emotional instability, and ultimately, threats to personal safety reinforcing the conceptualization of gambling harm as a dynamic and escalating crisis.

Intervention Implications

Effective recovery from gambling addiction necessitates a comprehensive approach that acknowledges the multifaceted nature of harm experienced by individuals. Merely addressing the financial consequences is insufficient, as the roots of addiction often lie in deeper psychosocial distress and layered trauma. Sustainable recovery requires an integrative framework encompassing financial counseling alongside mental health interventions, the restoration of personal identity beyond the “gambler” label, the repair of strained familial and social relationships, and the establishment of protective mechanisms to shield individuals from exploitative actors. This holistic approach aims to simultaneously address the emotional, relational, and structural dimensions of harm.

Without such structured and empathetic support, expressions of regret within recovery communities risk becoming cyclical and emotionally paralyzing. However, when regret is acknowledged and processed constructively, it serves as a transformative force. Drawing on Hodgins’ (2001) model, regret plays a critical role in disrupting denial and facilitating self-reflection. At the individual level, it compels individuals to confront the reality of their actions, fostering self-awareness and opening pathways toward behavioral change. At the communal level, expressions of regret contribute to the development of collective resilience, as shared vulnerability strengthens bonds within support networks. Within such contexts, regret is not merely a retrospective emotion but becomes a socially validated mechanism that both initiates psychological healing and scaffolds sustainable recovery.

Diagram 1. Tree Map Visualization Analysis



Source: processed from Nvivo (2025)

The tree map visualization, generated from the NVivo coding process, offers a clear representation of the intensity and distribution of themes within narratives related to online gambling practices. Each

box in the map corresponds to a specific theme or node, with its size reflecting how frequently the theme appears in the dataset. The larger boxes indicate themes that dominate the conversations, while smaller boxes represent less frequently mentioned issues.

The theme “Financial Loss” is the most prominent, occupying the largest space in the map. This suggests that economic concerns are the central issue for individuals discussing their experiences with online gambling. It highlights that financial hardship is the primary source of distress for affected individuals, reinforcing the overwhelming impact of monetary losses in the context of gambling.

Next, themes like “Information,” “Asking advice,” and “Online gambling promotion” are also notably present. These themes suggest that many individuals are initially exposed to online gambling out of curiosity or a desire for information, indicating that the engagement with gambling often begins with an exploratory phase or exposure to promotional material. This insight aligns with the early stages of online gambling engagement, where individuals seek knowledge or are drawn in by advertising content.

Additionally, emotional and social reactions to online gambling are evident through themes such as “Sarcasm,” “Cynicism,” and “Swearing.” These themes reflect disappointment, social criticism, and frustration with gambling practices, highlighting resistance to the normalization of gambling in online spaces. Such expressions illustrate how members of the community often use humor and critical language as a form of social commentary or coping mechanism.

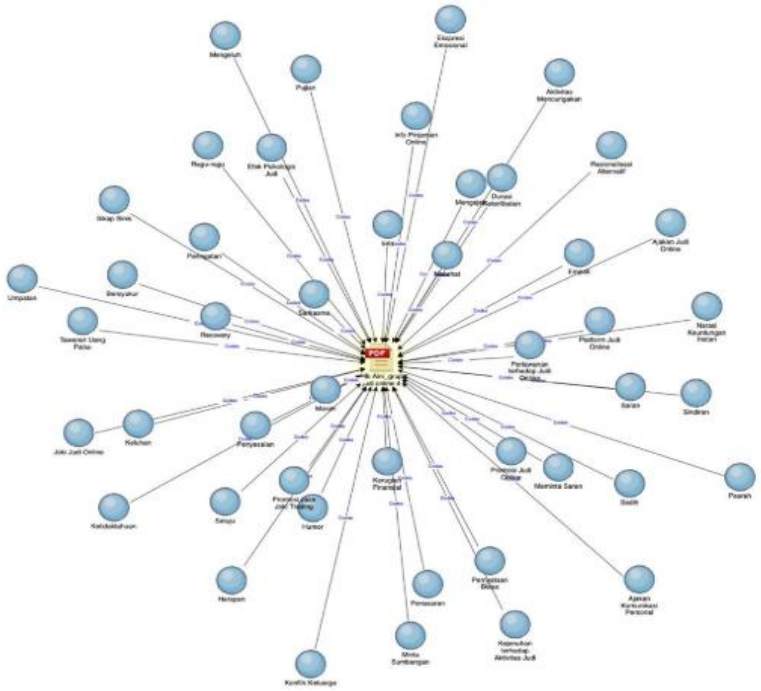
The psychological toll of gambling is another critical dimension captured in the visualization. Themes like “Regret,” “Give up,” and “Sadness” represent the emotional aftermath of gambling behavior. These themes underscore that the effects of gambling extend beyond financial losses, deeply impacting emotional and mental well-being. The presence of these themes in the map suggests that participants are grappling with feelings of guilt, hopelessness, and emotional exhaustion.

At the same time, themes such as “Requesting Money and Donations” and “Encouragement” indicate that individuals seek social support within the community. These nodes reveal a sense of solidarity and empathy, with individuals reaching out for help or offering motivational words to those struggling with gambling addiction. These interactions are indicative of the social support systems within these online communities, where individuals provide emotional and practical help.

While themes such as “Personal Invitations to Communicate” and “Online Loan Information” occupy smaller areas, their presence is still significant. These nodes point to the tactics used to lure individuals into gambling, emphasizing the subtle ways in which online gambling can be promoted, even within recovery spaces. Although these forms of engagement may no longer be shocking to participants, they remain a critical part of the online gambling ecosystem.

Themes like “Warning” and “Sarcasm” reflect the moral stances some participants adopt. These nodes signify active efforts by certain members to warn others about the dangers of online gambling. This moral resistance serves as a key component in the broader public discourse surrounding gambling, illustrating the tension between those who attempt to guide others toward recovery and those who may continue to promote or normalize gambling behavior.

Diagram 2. Visualization of Thematic Relationships in the Document



Source: processed from Nvivo (2025)

The visualization of thematic relationships within the file illustrates the complexity of narratives embedded in a single document. From the mapping of nodes, it becomes evident that the issue of online gambling is not only discussed as a behavioral activity, but also contains layers of emotional expression, moral reflection, social pressure, and deep economic impact. This shows that gambling is not merely a rational action, but one that triggers significant affective responses.

When articulated within supportive frameworks, public expressions of regret enable profound emotional catharsis. This release allows individuals to confront pent-up shame and guilt in psychologically safe spaces, transforming suffocating internal burdens into opportunities for healing. By vocalizing remorse, individuals initiate a therapeutic confrontation with their emotions—a critical first step toward sustainable recovery. The very act of externalizing these complex feelings undergirds emotional restoration, turning silent suffering into acknowledged vulnerability.

Regret's public articulation further functions as powerful social validation. Sharing experiences within communities of shared struggle generates peer recognition of collective trauma. This mutual acknowledgment dissolves isolation, forging connections that affirm "you are not alone." The resulting solidarity transcends mere empathy, creating ecosystems of acceptance where individuals feel fundamentally understood. Such validation becomes the bedrock of emotional support, reinforcing that personal failures reflect universal human experiences rather than singular defects.

Beyond emotional and social dimensions, voiced regret serves as a catalytic force for behavioral change. When articulated constructively, remorse evolves from passive reflection into active commitment. Acknowledging past missteps ignites accountability, compelling individuals to convert introspection into tangible action. This metamorphosis—where regret fuels proactive recovery efforts—transforms self-reproach into a motivational engine. What begins as contemplation of past errors culminates in purposeful strides toward future growth.

Thus, within nurturing environments, public regret operates as a tripartite instrument: facilitating emotional purgation, forging communal bonds through shared vulnerability, and propelling meaningful behavioral evolution. This synergy elevates regret beyond catharsis into a dynamic catalyst—simultaneously healing fractured psyches, validating human fallibility, and mobilizing redemption through actionable change. Interestingly, the document also reveals indirect yet critical forms of social expression, such as through Sarcasm and Cynicism**.** These patterns may be interpreted as symbolic resistance against the normalization of gambling, while also serving as a socially acceptable outlet for channelling tension in public discourse spaces.

The pervasive theme of "Financial Loss" directly triggers downstream household and community impacts. As losses accumulate, individuals resort to "Asking Money and Donations" to alleviate financial distress, while simultaneously seeking "Online Loan Information" as stopgap solutions. These pressures invariably escalate into "Family Conflict", demonstrating how economic devastation permeates domestic and social structures.

Chronologically following these crises, narratives shift toward remediation. Nodes like "Minta "Seeking Advice" reflect active efforts to address gambling-related damage. This evolves into mutual "Encouragement" within communities, establishing foundational support systems.

Building upon advice-seeking, the concept of "Recovery" emerges as a structured objective. Individuals progress from acknowledging harm to pursuing tangible rehabilitation strategies, culminating in the forward-looking theme of "Hope"—signifying belief in sustainable change. Thus, the documented trajectory reveals not only gambling's socioeconomic destruction but also a sequential resilience arc as follows:

Diagram 1. Sequential Resilience of Online Gambler

Source: processed from Nvivo (2025)

This illustrates both the gravity of addiction's consequences and the demonstrable human capacity for self-renewal through social solidarity.

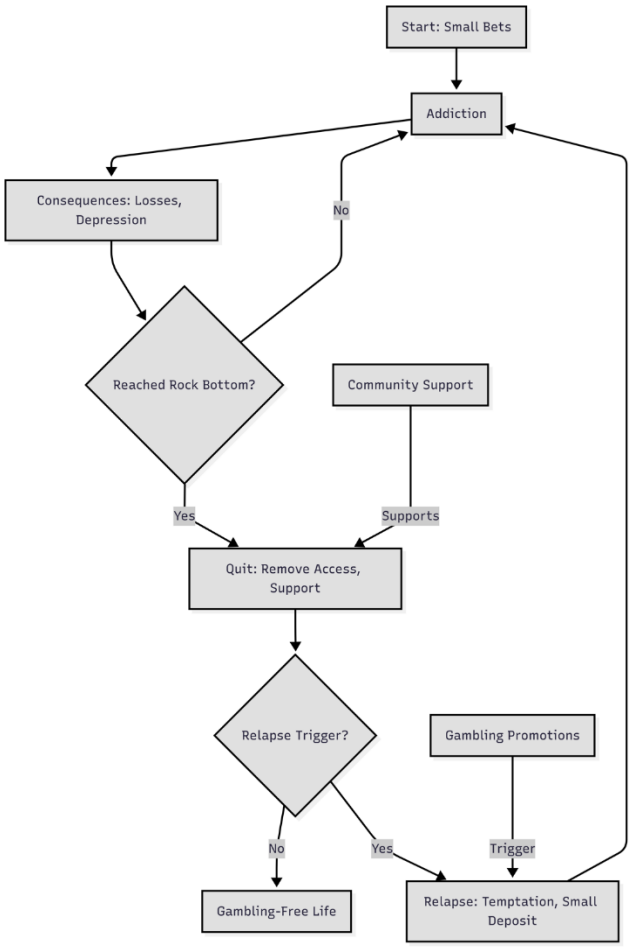
Factors Contributing to Relapse After Recovery

While some individuals successfully quit gambling, many relapse due to environmental temptations, old habits, and self-deceptive gambler mindsets. Relapse often occurs after a period of abstinence, triggered by small attempts to gamble again. For instance, one participant shared, "I stopped

for 4 months, but I got curious and deposited 200k IDR (approximately 13.20 USD), and it disappeared." Another individual stated, "I hadn't played for a year, but I fell back after a small deposit… up to 5 million IDR (approximately 330 USD)." Similarly, one user confessed, "I stopped depositing for two months… but I fell back, losing all the money I had saved in those two months." The role of social environments in relapse is also significant, as one participant noted, "I had stopped for 2 months, but the temptation from my environment was too strong." Research by Palomäki et al. (2025) highlights that involvement in uncontrolled online communities can increase the risk of relapse, particularly when individuals are exposed to environmental triggers or gambling ads.

The gambler's mindset also worsens the chances of recovery, leading to relapse. One user explained, "I tried, but sometimes the gambler's brain deceives me with reasons like 'the money is for this or that,' and I end up giving in." This cognitive distortion, known as the gambler's fallacy, often convinces individuals that their next bet will be the one that leads to a win. Some users switch to different forms of gambling as a way to manage their addiction, as one shared, "I lost hundreds of millions on slots and got stressed, but now I'm not playing slots, I'm playing PKV." Repeated failures to quit are common, with many individuals stating, "I failed to quit almost 20 times" or "I tried to quit but kept going back." Research by Ioannidis et al. (2020) confirms that cognitive distortions, such as the illusion of control and the belief that small bets are harmless, often trigger relapse among online gamblers, supporting the mindset observed in these communities.

Diagram 2. Cycle of Online Gambling Addiction, Recovery, and Relapse



Source: processed from Nvivo (2025)

Group Support Mechanism

Despite the challenges of relapse, members of Facebook support groups demonstrate strong solidarity in their recovery efforts. They provide emotional encouragement, practical advice, and warnings about the dangers of gambling. Emotional support is particularly vital, with individuals offering motivational words like, “Stay strong, focus on your worship...” and “You can do it, my brother... a healthy life without gambling.” Success stories also serve as powerful motivation, such as one participant who shared, “My life is so much better after two years of being free from gambling. I’m a civil servant with a full salary, getting 13th month pay, and can buy anything.” Research by Ford and Håkansson (2020) shows that emotional support from online peer groups significantly boosts motivation and resilience to stay free from gambling, aligning with the dynamics observed in these groups.

Practical advice within these communities is also instrumental in helping individuals maintain recovery. Strategies for quitting include deleting access to digital wallets, as one participant shared: “InshAllah, I want to stop depositing and delete my M Banking/Wallet.” Another individual stated, “I transferred money directly to an account with no card or mobile banking,” demonstrating the importance of limiting access to funds as a practical recovery tool. Additionally, warnings about gambling’s dangers help prevent further involvement. Participants often caution others with statements like, “Please, if you’ve never played online gambling, don’t even think about trying it...” or “Stop before it’s too late... it’s better than becoming a beggar.” Research by Palomäki et al. (2025) highlights that online communities providing practical strategies and raising awareness about the risks of gambling can significantly support recovery efforts.

Online gambling has significant consequences on social structures, particularly affecting family life and work. Many individuals experience the breakdown of family relationships and financial stability due to their gambling habits. As one individual described, "It destroys all aspects of life, from family, marriage, social life, and work." This statement underscores the profound impact gambling has not only on the individual but also on those around them, leading to a broader collapse of personal and social systems. The emotional and financial toll extends beyond the gambler, affecting loved ones and contributing to the destabilization of entire social structures.

The Deceptive Business Models of Online Gambling Platforms

Furthermore, the business models behind online gambling platforms, such as those seen in systems like Binomo, are designed to favor the operator, often leaving players with the illusion of control over the outcomes. Despite the belief that players can influence their success, the system is structured for them to lose. This systemic loss is one of the key factors contributing to the perpetuation of gambling addiction. The deceptive nature of these platforms is a crucial part of the gambling ecosystem, ensuring that individuals continue to invest, even when the odds are stacked against them.

In addition to the social and psychological consequences, fraudulent practices exacerbate the issue of online gambling. A recent disclosure from a former online slot gambling administrator from Indonesia reveals the rigged nature of these platforms. According to the revelation, all online slot games are designed to ensure that players lose. The "admin" or platform operator controls when a player wins, and there are no strategies, hacks, or tips that can guarantee success for the gambler. The outcome is entirely at the discretion of the admin, making it virtually impossible for players to win in a fair manner. This fraudulent setup is a significant factor in the ongoing addiction cycle.

The fraudulent nature of these platforms extends to the business model, where even individuals with minimal capital such as 100 USD can become administrators of online gambling websites. After paying a fee, these individuals are provided with gambling accounts that come with tokens of digital value. These tokens have no real-world worth and cannot be cashed out. The admin benefits by receiving real money from players while distributing worthless tokens. The entire system is designed to exploit the players, ensuring that they never win, despite the appearance of a fair and rewarding game.

The Illusion of Winning and the Admin's Control

Once the tokens are credited to a player's account, the admin can monitor the player's activities in real-time. For example, if a player is on the Dolphin Reef slot game, the admin can see this and manipulate the outcome of the game. No matter how much money the player invests, the game is rigged for the player to lose. The admin can even set specific win amounts, particularly during Free Spins, creating the illusion of a rewarding game. For instance, the admin might set the win amount to a precise number, such as 1,447,350 IDR (approximately 95 USD), and when the player spins the wheel, the game will appear to "reward" them with that exact sum.

For players who deposit larger amounts, the admin may "pretend" to offer a larger payout during a Free Spin, but the player is ultimately left with significant losses. For example, a player who deposits 1,000,000 IDR (approximately 66 USD) may appear to win 2,000,000 IDR (approximately 133 USD) during a Free Spin. However, the player has already lost 8,000,000 IDR (approximately 532 USD) in total. This deceptive practice keeps players engaged, continually hoping for a big win that never comes.

Raising Awareness and Exposing the Deception

This exposure not only reveals the deceptive mechanics behind online gambling platforms but also serves as a wake-up call for those who believe in the fairness of these systems. The former admin group @HermanPlaniSyafrudin disclosed these practices, emphasizes the need for educating gamblers and raising awareness about the scam nature of online gambling applications. He urges more individuals within the gambling industry, particularly those who have been involved in these fraudulent operations, to come forward and expose the truth. By doing so, they can help prevent others from falling into the trap of addiction and financial ruin. He also highlights the long-term dangers of online gambling addiction, stating, "The initial winnings are often the precursor to the eventual downfall." He further emphasizes that "Gambling addiction is more destructive than drug addiction," underscoring the profound and lasting impact gambling can have on an individual's life.

In addition to these revelations, personal experiences from individuals who have witnessed the destructive effects of addiction further highlight the significance of making informed choices. One individual, @SaratriWilonoyudho, shared his story of growing up surrounded by friends who indulged in heavy drinking and gambling. While he did not partake in these vices himself, he tried to guide his friends away from harm. Despite his efforts, his mother was unaware of his intentions, believing he was involved in the same behaviors. Saratri's testimony emphasizes the importance of making choices that safeguard one's future and the damage that gambling and alcohol abuse can cause.

Saratri's story, combined with Herman's insights into the fraudulent nature of online gambling, paints a clear picture of the dangers posed by gambling addiction. Both the individuals involved in these practices and the platforms themselves contribute to the perpetuation of harm. Online gambling not only depletes financial resources but also erodes personal well-being, relationships, and social stability. The deceptive nature of these platforms, coupled with the emotional and psychological toll of addiction, calls for increased awareness and support for those affected.

The Pathological Persistence of Online Gambling Behavior: Cognitive Distortion and Societal Imperatives

Empirical evidence derived from transactional records highlights a disturbing behavioral pattern: individuals persist in depositing funds—even after enduring significant financial and emotional losses—with transfer annotations such as "still hoping to win," "bankrupt," or even "final deposit before suicide." These data points reflect a pathological gambling cycle marked by persistent cognitive distortions, such as irrational optimism and the compulsion to chase losses. Despite facing severe consequences including psychological breakdown and suicidal ideation, many individuals remain ensnared in a self-perpetuating and self-destructive feedback loop. Addressing the multifaceted nature of gambling-related harm requires

a tiered intervention strategy. This framework consists of primary prevention aimed at reducing gambling initiation through education and public awareness, secondary intervention focused on identifying and supporting at-risk individuals before problems escalate, and tertiary safeguards that provide intensive support and harm mitigation for those already experiencing severe gambling disorders. These layers of intervention must be integrated and context-sensitive to effectively disrupt the cyclical nature of gambling addiction and facilitate long-term recovery.

1. Primary Prevention:

The first tier focuses on non-gamblers, with the primary objective of preventing the initiation of gambling. Public awareness campaigns are essential for conveying the risks of gambling, emphasizing its zero-sum nature, encapsulated in the phrase "no gambler ultimately wins". These campaigns aim to dissuade individuals from engaging in gambling activities by highlighting the inevitable financial losses and emotional consequences that come with it.

2. Secondary Intervention:

The second-tier targets active gamblers who are already involved in gambling behaviors. The goal here is to facilitate cessation through accessible rehabilitation programs and interventions such as cognitive-behavioral therapy (CBT). These therapeutic approaches are designed to counter the addictive mechanisms that drive individuals to continue gambling, even when faced with negative consequences. Secondary interventions focus on providing individuals with the tools and support necessary to break free from addiction and regain control over their behavior.

3. Tertiary Safeguards:

The final tier is aimed at individuals who have already recovered from gambling addiction. The objective here is to prevent relapse by providing ongoing support and monitoring potential triggers for returning to gambling behavior. These safeguards ensure that individuals who have successfully completed rehabilitation programs continue to receive the resources and community support necessary to maintain their recovery, particularly in environments where gambling-related temptations or predatory triggers may still be present.

Conclusion

This study aimed to explore the complex dynamics of online gambling addiction and recovery, focusing on the transition from non-gamblers to gamblers, the processes leading to relapse, and the role of online communities in offering support or promoting gambling. By adopting a netnographic approach, the study examined the behaviors and interactions of individuals within Facebook groups dedicated to gambling.

Firstly, the study revealed the pathway through which individuals transition from non-gamblers to gamblers. The process often begins with curiosity or exposure to online gambling promotions. As individuals engage with gambling platforms, they are quickly drawn into the addictive cycle, often fueled by early wins that create a false sense of control and reinforce the desire to continue gambling. This exploratory phase, coupled with the seductive design of online gambling platforms, entraps individuals, making it difficult for them to break free once they become involved. Over time, the addiction deepens, leading to severe financial, social, and psychological consequences. For many, the transition to recovery begins when individuals hit a low point, often marked by financial ruin and personal crisis. Self-awareness becomes the first critical step toward recovery, as individuals recognize their problem and seek help.

Secondly, the study explored the reasons behind relapse in recovered gamblers. It became evident that relapse is a common and challenging aspect of the recovery process. Environmental triggers, such as exposure to gambling promotions and the temptation of gambling sites, often play a significant

role in prompting relapse. Additionally, the gambler's mindset, characterized by cognitive distortions like the illusion of control and the gambler's fallacy, contributes to repeated attempts to gamble again despite negative consequences. The study found that even those who have successfully stopped gambling for extended periods may relapse after being exposed to these triggers, highlighting the cyclical nature of addiction and the difficulty of maintaining long-term recovery.

Finally, the role of online groups in supporting recovery or enabling continued gambling was critically examined. The study found that while some online groups serve as genuine support forums for individuals seeking recovery, others inadvertently promote gambling. These groups often function as spaces for sharing personal experiences and providing emotional support, which is essential for individuals in recovery. However, some groups covertly promote gambling through shared strategies or direct advertisements, undermining the recovery process and luring individuals back into gambling. The study identified a dual function of these online groups: they act as both supportive environments and potential traps for relapse.

Policy Implications

The implementation of effective societal interventions requires coordinated efforts across various sectors. Several policy recommendations can support these interventions.

1. Financial Institutions: Banks and financial organizations can play a vital role by developing algorithms that flag gambling-related transactions. These alerts could trigger crisis resources, offering individuals immediate access to support services when financial patterns indicate gambling transaction.
2. Regulators: Gambling platforms and online casinos should be mandated to display evidence-based warnings, such as "98% of players lose long-term." These warnings aim to provide potential gamblers with clear and factual information about the long-term risks of gambling before they engage in it.
3. Public Health: Embedding gambling literacy into national mental health initiatives is crucial for raising awareness and promoting responsible gambling behaviors. By integrating gambling education into broader public health frameworks, societies can help individuals make informed decisions and provide the necessary resources to those at risk of developing gambling disorders.

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PayAll as a Case Study of Using Decentralised IoT and AIoT to Transform Banking in Developing Countries

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Abstract:

This paper explores the potential impact of combining Decentralized Internet of Things (IoT) network infrastructure with Artificial Intelligence of Things (AIoT) in the context of fintech companies like PayAll. We examine how these technologies can contribute to the development of banking systems in developing countries, addressing challenges such as limited infrastructure, financial inclusion, and operational inefficiencies.
The study highlights the transformative potential of these technologies in creating more accessible, efficient, and secure financial services for underserved populations.

Keywords: Decentralized Internet of Things (IoT) network infrastructure, Artificial Intelligence of Things (AIoT), fintech, payment systems, financial inclusion.

1. Introduction

It is frequently very difficult for developing countries to offer their citizens full banking services. High rates of unbanked and underbanked people are caused by a lack of financial literacy, a lack of physical infrastructure, and low internet penetration. Fintech businesses have surfaced as viable means of closing this gap by using technology to deliver financial services more cheaply and effectively. The unbanked and underbanked populations face additional challenges due to the affordability and usability of financial products. High transaction costs, minimum balance requirements, and complex account management procedures may deter people from utilising formal financial services (Cull et al., 2014). Furthermore, it could be challenging for those with low financial literacy to understand and utilise the financial products that are accessible to them. These challenges highlight the need for innovative solutions to address the diverse needs of marginalised communities (Karlan & Morduch, 2008). Financial literacy, which influences people's ability to use financial services effectively, is a crucial component of financial inclusion (Hastings et al., 2013). Lack of access to financial services disproportionately affects women, low-income groups, and rural

communities, making it more difficult for them to invest, save, and effectively manage financial risks. By leveraging technology to provide underserved populations with effective, affordable, and easily accessible financial services, the rise of financial technology, or fintech, offers innovative approaches to bridging these gaps (Gomber et al., 2017).

This paper aims to analyse how the integration of Decentralized IoT network infrastructure and AIoT can enhance the capabilities of fintech companies like PayAll, enabling them to play a crucial role in developing robust banking systems in emerging economies.

2. Decentralized IoT Network Infrastructure

2.1 Overview of Decentralized IoT: Instead of depending on a centralised authority or server to manage and control the network, decentralised IoT (Internet of Things) refers to a network architecture where devices communicate and share data directly with one another. In conventional IoT networks, a central hub usually collects and processes data from sensors and devices, organises responses, and stores data. Decentralised IoT networks, on the other hand, divide these duties among several nodes, frequently utilising distributed ledger technologies like blockchain to maintain transparency and confidence.

2.2 Benefits for Developing Countries: Decentralised IoT infrastructure can offer significant advantages to developing countries, particularly in remote and underserved regions. Key benefits include: Improved connectivity in remote areas, Reduced infrastructure costs, Enhanced data privacy and security, Increased resilience to network failures.

3. Artificial Intelligence of Things (AIoT)

3.1 Definition and Capabilities AIoT: The combination of artificial intelligence (AI) and Internet of Things (IoT) devices are known as artificial intelligence of things (AIoT). AIoT makes it possible for intelligent, self-governing, and context-aware systems by fusing AI's data processing and decision-making powers with the connectivity and data

gathering capabilities of IoT. This convergence is transforming a number of industries, including banking, manufacturing, smart homes and cities, healthcare, and agriculture, by enabling more intelligent, responsive, and efficient systems (Yang et al., 2023; Pise et al., 2023; Dong et al., 2021).

3.2 Applications in Banking: At its core, AIoT is the application of artificial intelligence to the interpretation of vast amounts of raw data generated by the internet of things. IoT devices are rapidly proliferating, from banking, wearables and smart homes to smart cities and industrial machinery. These devices generate enormous amounts of data, which can be analysed to uncover new information and improve operations. But without artificial intelligence, dealing with that data is often intimidating and difficult (Rezaei and Ansary 2024; Yang et al. 2023; Pise et al. 2023; Dong et al. 2021).

4. PayAll and Similar Fintech Companies

4.1 Overview of PayAll: PayAll is a fintech business that specialises in offering digital payment solutions, mostly in developing countries. Peer-to-peer, peer-to-business, and business-to-business payments and transfers are made simple by the use of IOT devices, such as IoT devices and apps. PayAll provides incredibly creative e-Wallet payment solutions that facilitate easy payment collection and a convenient consumer experience.

4.2 Challenges Faced: Despite its potential, PayAll and related fintech businesses encounter a number of challenges that necessitate strategic planning, security and compliance investments, and flexibility in order to stay competitive (Ebrahim et al. 2021). Limited physical infrastructure, Low internet penetration, financial illiteracy, Regulatory hurdles

5. Integration of Decentralized IoT and AIoT in Fintech

5.1 Enhanced Financial Inclusion: Akerlof and Shiller (2003); Chen and Wu (2023) argue that fintech help to increase inclusivity and reduce financial disparities in the economic. Demirguc-Kunt et al. (2022) and demonstrate how Fintech can make a

significant contribution to increasing finance access in developing countries. The integration of Decentralized IoT and AIoT in fintech has the potential to significantly improve financial inclusion by expanding services to underserved populations (Akerlof and Shiller, 2003).

5.2 Improved Operational Efficiency: By combining IoT with decentralised structures and AI-driven intelligence, businesses can enhance decision-making, reduce costs, and streamline operations. Decentralised IoT and AIoT technologies offer a path to more efficient, secure, and scalable systems that are well-suited for modern demands, especially in sectors like manufacturing, agriculture, energy, logistics, and urban management (Xu et al., 2024).

5.3 Enhanced Security and Fraud Prevention: Decentralised IoT and AI combine to form a multi-layered security framework that increases the resilience of fintech services against fraud and cyberattacks. Through decentralised data management, adaptive learning, and real-time monitoring, these technologies ensure the security, confidentiality, and absence of unauthorised access to financial data and transactions. This combination helps fintech companies maintain operational efficacy and regulatory compliance in an increasingly digital economy, while also promoting consumer trust (Xu et al. 2024).

5.4 Personalized Financial Services: The combination of AI and IoT enables fintech platforms to offer tailored financial solutions, improve risk management, and engage with customers in a meaningful and proactive way. As AIoT advances, fintech companies will be able to improve their offerings, making financial services more accessible, efficient, and tailored to the requirements and preferences of individual customers (Xu et al., 2024).

6. Case Study: PayAll's Implementation of Decentralized IoT and AIoT

6.1 Deployment Strategy: PayAll has partnered with The Sefilata is a decentralised wireless network for "internet of things" devices that is powered by the Sefilata cryptocurrency. The network is made up of Sefilata hotspot nodes, which are devices with antennas that can transmit tiny amounts of data over long distances using radio

frequencies. Covering an area and managing terminal transactions on a Tangle, Directed Acyclic Graph (DAG) are how Sefilata miners get paid.

6.2 Challenges and Solutions: According to Corchado Rodríguez (2021), the deployment of decentralised IoT and AIoT in developing countries presents unique challenges that necessitate specialised solutions. To overcome these challenges, collaborations, the development of low-cost and low-power technologies, and the establishment of legislative and educational frameworks that encourage adoption will all be required.

6.3 Expected Outcomes: PayAll's deployment of Decentralised IoT and AIoT has the potential to revolutionise the financial sector in developing countries by promoting economic growth, operational efficiency, and financial inclusion. This case study demonstrates how fintech businesses can use cutting-edge technology to provide significant and long-lasting improvements in underserved markets.

7. Regulatory Considerations

7.1 Data Protection and Privacy: There are significant concerns regarding data security and privacy when IoT and AI are used in fintech. It is imperative that businesses like PayAll responsibly handle these issues because IoT devices are constantly gathering data from users, which AI systems then process to generate insights or make decisions (Xu et al. 2024).

7.2 Financial Regulations: Giudici (2018) claims that one of the most important and challenging issues facing fintech companies that incorporate AI and IoT technologies is regulatory compliance. Navigating privacy laws, cybersecurity regulations, and ethical AI standards requires initiative and often requires a significant investment in compliance infrastructure. By following legal frameworks and demonstrating a commitment to transparency, equity, and security, fintech companies can foster innovation, build trust, and successfully grow their IoT and AI solutions in the global market.

8. Future Prospects and Scalability

8.1 Potential for Expansion: Decentralised IoT and AIoT provide fintech companies with a scalable, efficient, and cost-effective framework to expand their services throughout developing countries. By addressing the unique challenges of these domains, such as decreased connectivity, a variety of financial requirements, and resource constraints, decentralised IoT and AIoT systems create new opportunities for financial inclusion. As these technologies advance, their application in fintech has the potential to transform financial services, empower marginalised communities, and promote economic growth in a number of developing countries (Rjoub et al., 2023).

8.2 Emerging Technologies: Combining 5G and edge computing with decentralised IoT and AIoT can greatly improve connectivity, data processing speed, scalability, and security. Decentralised IoT networks can now function more swiftly, efficiently, and securely thanks to these state-of-the-art technologies, which also enable complex AI-driven applications to run in real time. Communities and businesses can now access next-generation digital services thanks to the combination of 5G and edge computing, which provides a cost-effective and sustainable way to deploy innovative IoT solutions in developing countries with limited traditional infrastructure (Alahi et al., 2023).

9. Conclusion

Fintech businesses like PayAll have a revolutionary opportunity to make a substantial contribution to the advancement of banking systems in developing countries through the integration of Decentralised IoT network infrastructure and AIoT. PayAll can empower millions of underbanked and unbanked people by utilising these technologies, which will promote economic growth and enhance the standard of living in these areas. In addition to addressing current issues, this model establishes the framework for a tech-driven, inclusive, and sustainable financial ecosystem that can develop and adapt further to meet the changing demands of developing countries.

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Mapping and Evaluating Warehouse Process Phases: A Mixed-Method Study on Operational Priorities and Neglected Activities

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Abstract

The operational management of a warehouse is a crucial component in a company's supply chain, directly influencing the efficiency and competitiveness of the entire organization. A well-managed warehouse not only optimizes logistics costs but also enhances customer service quality by reducing delivery times and increasing overall satisfaction.

The fundamental elements of warehouse operations include the receiving and storage of goods, inventory management, picking, and shipment preparation. Each of these stages requires careful planning and effective execution to ensure operations are carried out efficiently and without errors. Warehouse organization involves not only establishing an effective and efficient process but also designing an environment suitable for such operations.

In this context, the paper aims to provide both academics and professionals with:

- A review of the warehouse process, highlighting the key activities necessary for the effective and efficient management of all operations from goods receipt to dispatch.
- An evaluation, conducted through a survey of a sample of companies, to identify which phases of the warehouse process are most optimized and monitored.

Based on a literature review aimed at identifying the core activities carried out in warehouses, the paper presents a comprehensive and adaptable process suitable for various business models, from manufacturing firms to commercial enterprises. The proposed new process was submitted to a sample of 25 companies to assess its robustness and to investigate which phases are most frequently monitored.

The study seeks to offer a practical guide for logistics managers and warehouse supervisors, supporting them in improving process management and achieving efficiency and effectiveness objectives, while also serving as a resource for academics interested in exploring warehouse operations in greater depth.

Keywords: warehouse management; warehouse process; warehouse performance

Introduction

In recent years, the warehouse is no longer viewed merely as a space for storing goods but has become a true profit center. The idea that a warehouse can generate value for the customer is now widely accepted (Richards, 2017; Ghosh & Shah, 2015). Errors in operations, incorrect picking, damaged goods, and delays in order preparation are just a few examples of process non-conformities that originate within the warehouse and can compromise the trust-based relationship with customers (De Koster, Le-Duc & Roodbergen, 2007).

The economic crisis and emerging international dynamics have driven companies to seek greater efficiency and flexibility. Lean and agile philosophies have led organizations to focus on effective inventory management as a way to reduce overall business costs.

The warehouse now faces multiple trends: on one hand, customers demand more frequent and smaller deliveries; on the other, sourcing from the Far East requires holding inventory that cannot be minimized. Furthermore, the shift in the production center of gravity toward Asian countries has transformed many manufacturing sites into distribution hubs. As a result, globalization has led many companies to evolve from production-focused entities into storage and shipping centers. The role of the warehouse has thus become fundamental.

Most definitions describe a warehouse as a facility where goods are received, stored, handled, and organized for subsequent shipment. Once received from a supplier, goods may remain in the warehouse for a certain period until they are needed (Kocifaj, 2019). A warehouse is also a space where various activities take place, depending on its function and its position within a company's logistics system or supply chain (Marasová & Šaderová, 2018). This implies the execution of one or more processes aimed at ensuring the physical flow of materials and products.

According to Gu et al. (2010), warehouse design problems involve five groups of decisions: defining the overall structure (conceptual design), determining size, calculating layout, selecting storage equipment, and choosing the operational strategy. Furthermore, warehouse planning must also include policies related to order fulfillment/picking, storage, and inventory turnover (Koster et al., 2007; Chan & Chan, 2011).

Warehouse management is an integrated process encompassing several key functions. Among its main objectives is to ensure an efficient and secure flow of goods from receipt to customer delivery. Another essential aspect is inventory management, which involves implementing strategies to maintain optimal stock levels and avoid both shortages and surpluses. Warehouses are increasingly seen as opportunities to improve operational and informational flow optimization, reduce inventory levels, and enable more agile distribution (Vrijhoef & Koselka, 2000).

The primary goals of effective warehouse management include: cost reduction; achieving economies of scale by moving large volumes between logistics centers (Rodríguez et al., 2007); managing variability caused by factors such as product seasonality (Gu et al., 2007); maintaining a high level of customer service (Parikh & Meller, 2008); and integrating flexibility into the supply chain to ensure better responsiveness to market changes (Amiri, 2006).

This study is conducted from a logistics and operations management perspective, with a specific focus on warehouse operations. It does not include inventory management, network design, location planning, or engineering aspects.

Warehouse Operations: Functional Phases and Process Overview

Warehouses can perform a variety of functions depending on product characteristics, customer requirements, and the level of service provided. According to De Koster and Warffemius (2005), the complexity of warehouse operations depends primarily on: (i) the number and variety of items to be handled; (ii) the daily workload; and (iii) the number, nature, and variety of processes required to meet the needs of both customers and suppliers. While operational differences exist—such as between storage warehouses and cross-docking facilities—there is broad consensus in the literature regarding a set of core activities: receiving, storage, order picking, and shipping (van den Berg & Zijm, 1999). This study excludes activities external to the warehouse area, such as transportation processes, inbound procurement, and final delivery.

A comprehensive process framework used to investigate how much attention companies devote to each phase is the one proposed by Tompkins et al. (2010), to which this study adds two additional stages:

Vehicle Access
This phase covers the path taken by transport vehicles from entry gate arrival to parking in the unloading area. Managing this step is essential for both safety and productivity. From a safety perspective, the heavy vehicle's access path must be designed to eliminate or minimize potential interferences—defined in Italian Legislative Decree no. 81/2008 as situations where activities by multiple parties (e.g., contractors and client companies) overlap in space and/or time, creating risk for workers. Poor scheduling of vehicle arrivals can lead to unloading bay congestion, resulting in productivity losses. Similar issues have been documented in maritime container terminals (Torkjazi, Huynh & Shiri, 2018), leading to the development of heuristic approaches (Huynh, Walton & Davis, 2004; Namboothiri & Erera, 2008), mathematical models (Guan & Liu, 2009a, 2009b; Zehendner & Feillet, 2014), truck appointment systems (Schulte et al., 2017), and slot allocation models (Azab, Karam & Eltawil, 2017; Huynh, 2009). Despite advances in technology, warehouse managers and transporters report a continued rise in lost hours due to unanticipated delays, schedule changes, and wait times. To mitigate this, many warehouses—especially distribution centers—implement appointment systems to evenly distribute truck arrivals by limiting the number of vehicles processed within a given time window.

Vehicle Unloading
This phase involves the transfer of goods from transport vehicles into the warehouse. It includes vehicle arrival planning, physical unloading, and goods registration and storage. A key activity here is the assignment of loading bays. Equipment such as pallet jacks, forklifts, or automated systems may be used to move materials. Efficiency in this phase is critical to minimizing cycle times and preventing product damage. De Oliveira et al. (2022) studied the receiving process in a warehouse, implementing improvements such as layout reorganization and workstation balancing, resulting in a 28% cycle time reduction and substantial operational savings.

Receiving
This phase includes all activities associated with the inbound receipt of goods ordered from suppliers. Products are visually inspected to verify packaging integrity and compliance with purchase orders. Accepted goods are then entered into the warehouse management system, updating inventory status (Gu et al., 2007).

Inspection and Quality Control
An extension of the receiving process, this step is necessary when supplier quality is inconsistent or when goods are subject to strict regulatory requirements. Full or sample-based inspections are carried out as needed.

Repackaging
Performed when products arrive in bulk and must be repackaged into single units, sales quantities, or combined into kits or assortments. Repackaging may involve changing packaging (e.g., from cardboard boxes to plastic totes), sorting mixed items into distinct storage locations, labeling incoming goods, or replacing damaged packaging.

Storage (Putaway)
This involves physically placing items into storage locations and includes material handling and positioning. Goods remain stored until requested by internal (e.g., production) or external (e.g., customer) clients. Storage methods vary depending on item size, quantity, and handling characteristics.

Replenishment
This refers to refilling picking locations by retrieving goods from storage areas and relocating them to zones suited for order picking.

Order Picking
Order picking is the core warehouse service provided to customers and garners the most attention, as fast and accurate picking increases customer satisfaction (Baker & Canessa, 2006). Described as the "top-priority activity for productivity improvement" in *World-Class Warehousing and Material Handling*, it accounts for nearly 50% of operational costs in typical warehouses and is the most labor-intensive process (De Koster et al., 2006). Most warehouse personnel are dedicated to picking, which also occupies over half of total warehouse time (Tompkins & Smith, 1998). In manual-pick systems, travel time is generally a growing function of travel distance (Jarvis & McDowell, 1991; Hall, 1993; Petersen, 1999; Roodbergen & De Koster, 2001b; Petersen & Aase, 2003), making distance minimization a key design and optimization objective.

Sorting
Sorting follows picking and is particularly relevant in high-volume or batch-picking contexts. It involves classifying and separating items or orders based on predefined criteria (e.g., customer, destination, product type, or shipping channel) to streamline packing or shipping. Sorting aims to reduce delivery errors and enhance operational efficiency (De Koster et al., 2007; Boysen et al., 2007).

Consolidation and Packing
This phase follows picking and involves preparing goods for shipment. Items picked at different times, by different operators, or from various zones are consolidated by order. Products or assortments are packaged for safe and practical transportation. This phase also includes generating labels, preparing shipping documents, and weighing orders to calculate shipping costs.

Outbound Quality Check
This final verification ensures that shipped materials and packaging are complete and accurate, and that load unit labels contain the correct information.

Vehicle Loading
This phase mirrors unloading and involves transferring goods from the warehouse to the outbound vehicle.

Vehicle Departure
The same principles described for vehicle access and unloading apply here.

This detailed breakdown of warehouse operations provides a comprehensive framework for analyzing how companies structure, prioritize, and monitor each phase within their logistics systems. Building on this operational model, the following section outlines the research methodology adopted to assess the degree of attention and control applied across these processes in real-world warehouse environments (Gu et al., 2007; Ramaa, Subramanya & Rangaswamy, 2012).

Methodology

The objective of this study is to assess which activities within the warehouse process are considered by companies to be the most strategic for improving operational performance. Companies' level of interest or sensitivity toward specific process phases is monitored through reported past investments or those planned for the near future. This research aims to identify which phases of the warehouse process are most closely monitored by companies, while also drawing attention to those phases that tend to be overlooked. The proposed model offers professionals a checklist of elements to consider when conducting comprehensive

performance analysis and improvement initiatives. For academic researchers, it provides a set of specific topics that can be individually explored to propose new solutions and develop improved process designs.

The study was carried out through the following steps:

Phase 1: Literature Review
A review of existing literature was conducted to define the full range of phases that make up a comprehensive warehouse process. The studies analyzed—published between 1996 and 2022—were sourced from the Web of Science and Scopus databases. Search terms were developed inductively, based on preliminary readings of articles focused on warehouse design and management. The final main keywords used were:

- “warehouse management”
- “warehouse storage automation”

Phase 2: Questionnaire Design and Field Interviews
A questionnaire was developed and distributed to supply chain and logistics managers. The initial contact was made via email, followed by direct outreach. Upon agreement, a structured interview was conducted with the manager, accompanied by an on-site visit. The visit followed, step-by-step, the activities outlined in the previously defined warehouse process model.

Phase 3: Assessment of Managerial Sensitivity to Process Phases
Inspired by Carter’s arguments regarding research relevance for managers, the literature review was complemented by interviews with industry professionals to incorporate their insights into the research agenda. Similar methods have been used by Baker and Canessa (2009), Thomas et al. (2011), and Sodhi et al. (2012), who combined literature studies with expert interviews or focus groups to define research opportunities with practical relevance. Many scholars in logistics and warehouse management work closely with practitioners in the field.

One key reason for this close collaboration between academia and industry is to enhance the managerial and practical relevance of academic research. By using both literature review and practitioner insight, future research directions are not solely based on gaps in the literature, but also reflect industry needs. This dual approach allows for the proposal of more practically relevant research pathways.

A total of 25 warehouse and supply chain managers were interviewed. The interviews focused on identifying the most actively monitored and managed phases within their warehouse operations (see Appendix A in the ESM). Respondents were selected to represent a diverse range of company types, enabling the identification of common process elements across various warehouse operation contexts. The sample included managers from companies operating in sectors such as food, mechanical engineering, fashion, and furniture. Convenience sampling was used, with all participants working in northern Italy. Convenience sampling is a non-probabilistic technique in which study participants are selected based on practical criteria such as accessibility, geographic proximity, availability at a given time, or willingness to participate (Etikan et al., 2016, p. 2). Most of the participating companies operate at a global level.

The questionnaire sent by email included a series of closed questions answered using a 5-point Likert scale. The follow-up in-person interview consisted of open-ended questions, allowing respondents to freely share their perspectives. Depending on their familiarity and involvement with warehouse management issues, participants were able to explore challenges from different viewpoints. All interviews were recorded, transcribed, and shared with the respondents for approval. The confirmed transcripts were analyzed to identify the key phases of managerial oversight. To identify gaps between theory and practice, the issues reported by respondents were compared with existing literature to determine whether they had already

been addressed in scholarly works. Additionally, the frequency with which these issues were mentioned was compared to the prevalence of those topics in the literature, in order to assess alignment.

Research Results

The companies involved in this study are all medium and large enterprises, as defined by the European Commission. According to Recommendation 2003/361/EC, enterprises are classified based on the number of employees and their economic scale, measured through annual turnover or total assets. Specifically, a medium-sized enterprise has fewer than 250 employees and an annual turnover not exceeding €50 million, or a balance sheet total not exceeding €43 million. Large enterprises exceed at least one of these thresholds. This classification is important not only for statistical purposes, but also for determining eligibility for funding programs, incentives, and support policies promoted at the European level. It also helps companies tailor organizational strategies based on their structure and size.

The following table lists the companies that were surveyed between mid-2023 and the end of 2024. All companies are geographically located in Northern Italy, although some operate additional warehouses or facilities in other Italian regions and abroad. The companies span various industrial sectors but are all medium- or large-sized enterprises. In addition to the number of employees (if disclosed) and reported turnover, the table includes two columns highlighting:

- WMS: This column indicates whether the company has implemented a Warehouse Management System to oversee its warehouse operations.
- Warehouse Automation: This field reports whether the company has adopted any form of warehouse automation, ranging from basic solutions such as vertical storage systems to more advanced installations like Automated Storage and Retrieval Systems (AS/RS).

The table clearly shows that WMSs are implemented across both medium and large enterprises, whereas automation solutions are primarily adopted by larger companies. Based on the interviews, the limited adoption of automation is often attributed to difficulties in calculating return on investment, or to operational constraints due to the nature of goods being stored or handled, which often lack standardization. Despite the financial incentives provided by the Industry 4.0 initiative, many firms chose to prioritize investments in production systems over warehouse optimization. On the other hand, some companies in the large-scale retail sector viewed these incentives as an opportunity to pursue automation. A key driver behind automation investments among commercial firms was the need to reduce dependency on human resource variability—both in terms of skill levels and workforce availability.

Table 1: companies involved in the research and their WMS and automation adoption

Number	Business description	Number of employees	Company dimension	Turnover	WMS	Warehouse automation
1	Production of non-woven fabrics and related articles	n/a	LARGE	41.588.595 (2023)	YES	NO
2	Industrial laundry services	n/a	LARGE	148.261.210 (2023)	YES	NO
3	Manufacture of motors, generators and electrical transformers	n/a	MEDIUM	44.924.304 (2023)	NO	NO
4	Production of plastic packaging	n/a	MEDIUM	121.757.854 (2023)	YES	NO
5	Production of furniture for dental offices	52	MEDIUM	9.328.537 (2023)	NO	NO

6	Sheet metal processing and metal components manufacturing	183	MEDIUM	43.887.610 (2023)	NO	NO
7	Non-domestic cooling and ventilation systems	1172	LARGE	272.839.436 (2024)	YES	YES
8	Equipment for poultry farming	69	MEDIUM	17.816.500 (2023)	YES	NO
9	Manufacture of light metal packaging	n/a	MEDIUM	65.940.436 (2023)	YES	NO
10	Tanning and processing of leather	521	LARGE	318.342.384 (2023)	NO	NO
11	Wholesale trade of pharmaceuticals	1351	LARGE	2.300.661.016 (2024)	YES	YES
12	Supermarket and hypermarket chain	5102	LARGE	1.418.860.066 (2023)	YES	YES
13	Supermarket and hypermarket chain	4700	LARGE	1.400.000.000 (2023)	YES	NO
14	Tanning and processing of leather	n/a	MEDIUM	113.348.033 (2023)	NO	NO
15	Trade of iron and metal goods (hardware)	69	MEDIUM	23.484.843 (2023)	YES	NO
16	Manufacture of metal structures	62	MEDIUM	11.078.980 (2023)	YES	NO
17	Production of biscuits and pastry products	358	LARGE	60.888.111 (2024)	NO	NO
18	Manufacture of kitchen furniture	103	MEDIUM	60.724.402 (2023)	YES	YES
19	Production of industrial doors and shutters	60	MEDIUM	34.792.914 (2023)	NO	NO
20	Manufacture of metal office furniture	183	MEDIUM	36.860.646 (2023)	NO	NO
21	Production of radiators and metal containers for heating	n/a	LARGE	105.146.136 (2023)	NO	NO
22	Machines and equipment for laundries and ironing facilities	101	MEDIUM	26.592.955 (2023)	NO	NO
23	Manufacture of non-domestic refrigeration and ventilation equipment	205	MEDIUM	73.965.973 (2023)	YES	NO
24	Manufacture of other plastic products n.e.c. (not elsewhere classified)	307	LARGE	186.502.764 (2023)	YES	YES
25	Manufacture of earth-moving machinery	470	LARGE	239.000.000 (2022)	YES	NO

The questionnaires and subsequent interviews conducted with the companies enabled the creation of the following table, which assesses the actual level of interest or monitoring for each phase of the warehouse process. The data reported reflects the majority of responses received.

- Procedure Standardization: Indicates whether companies have established procedures for that phase, typically communicated through training sessions and the creation of informational documents.
- Performance Indicators: Refers to the presence of metrics specifically used to monitor the corresponding warehouse phase.
- Automation: Reflects the perceived importance of adopting automation solutions in the respective phase.
- Digitalization: Reflects the perceived importance of implementing digital solutions in the respective phase.

The following table provides a synthetic overview of the main warehouse process phases and the degree of managerial attention they receive across the surveyed companies. The evaluation is based on aggregated responses from questionnaires and follow-up interviews, reflecting the most common practices and perceptions. For each phase, the table highlights whether companies have formalized procedures, implemented performance indicators, and recognized the relevance of automation and digitalization. This framework aims to identify which phases are strategically managed and which are still underdeveloped or neglected in operational practice.

Table 2: Warehouse process and level of control of process activity

Warehouse Phase	Procedure Standardization	Performance Indicators	Automation	Digitalization
Vehicle access	No	No	No	No
Unloading	Fairly	Few	Low	No
Receiving	No	No	No	Low
Inspection and quality control	High	Many	No	Fairly
Repackaging	High	No	Low	No
Storage	Very high	Many	Very high	Very high
Replenishment	Very high	Few	Low	Very high
Order picking	Very high	Very many	Very high	Very high
Sorting (only for some companies)	Fairly	Few	Very high	Very high
Consolidation and packing	No	Few	Low	Low
Loading	Fairly	Few	Low	No
Vehicle departure	No	No	No	No

The questionnaires and subsequent interviews conducted with participating companies revealed the following insights.

Vehicle Access

Nearly all companies do not consider this phase to be a core part of the warehouse process. Only a few large distribution firms have implemented structured vehicle arrival systems, such as unloading slot reservations. To improve safety, these companies have established dedicated heavy-vehicle routes to avoid interference with pedestrians and personnel not involved in unloading operations. Drivers follow specific waiting routes and are not allowed to enter maneuvering areas. Each vehicle is registered upon arrival, and drivers are provided with conduct rules for their stay on company premises. Unfortunately, such procedures have only been fully implemented in very few cases. Most companies report difficulties in scheduling vehicle arrivals due to poor communication and collaboration with suppliers or carriers. This leads to congestion in unloading areas and queues of trucks awaiting unloading. In some cases, the lack of planning and regulation results in disorganization and chaos, which can cause operational errors.

Vehicle Unloading

The unloading phase is considered crucial for performance improvement. Companies are aware that proper infrastructure and supporting information systems can accelerate the transfer of goods from vehicles to the warehouse. Common investments include the installation of dedicated unloading bays with hydraulic platforms. Some companies have enhanced safety by installing overhead cranes in unloading zones. However, no significant adoption of automated unloading systems was observed. Key performance indicators for this phase include average vehicle unloading time, number of vehicles unloaded per day, and the number of handling units (HUs) unloaded per hour.

Receiving

Although the receiving phase is considered relatively simple, there is often a lack of formal training for

personnel. Respondents noted that staff are not always trained on what to accept or reject, such as damaged or tampered goods. Without a formal receiving procedure, decisions are left to the operator's discretion. All companies dedicate appropriate space for temporary material storage, and most have differentiated areas based on material type to streamline handling. During this phase, material data is entered into the warehouse management system (WMS), making it visible to the operation. A common practice is requesting advance shipping documents from suppliers, allowing a preliminary check between purchase orders and shipped materials. This helps identify supplier errors and determine if a shipment is complete or partial. This information is passed to warehouse staff to guide acceptance decisions. The most frequently monitored KPI is the average dwell time of goods in the receiving area.

Inspection and Quality Control
Inspection activities are well-defined and assigned to trained personnel. Incoming quality inspectors are familiar with the materials and the control procedures, which are standardized and documented. Many companies use a "free-pass" system, skipping inbound inspection following agreements with reliable suppliers. Inspections are typically performed when supplier quality is inconsistent or when the product is subject to strict regulations. Controls may be performed on all items or, more commonly, on samples. Approved goods are released for subsequent operations; nonconforming goods are sent to a dedicated holding area. Performance indicators are divided into two categories: qualitative (e.g., number of nonconforming HUs and their causes) and process-control metrics (e.g., average inspection time per HU).

Repackaging
Some companies have developed formal procedures for standardizing repackaging. Most have implemented control systems to identify pallets that must be replaced due to damage or noncompliance with storage requirements. Only a few companies have automated pallet replacement. Most repackaging tasks—such as relabeling, depalletizing, or material sorting—are performed manually. No specific KPIs for this activity were reported.

Storage (Putaway)
This is one of the most closely monitored activities. Companies aim to optimize space utilization and increase storage speed. A lack of available storage space is a common challenge, especially during peak seasons, prompting some to outsource to third-party logistics providers. To address space constraints, companies have adopted solutions such as replacing storage infrastructure, using forklifts designed for narrow aisles, and investing in automated systems like vertical storage or AS/RS. In non-automated warehouses, WMS systems are considered essential for performance and for assisting operators in correct product placement. Commonly used KPIs include average saturation index (e.g., average occupied pallet positions / total pallet positions) and HUs stored per unit volume.

Replenishment
Not all companies require organized replenishment processes. However, the importance of WMS in predicting and managing replenishment—from storage to picking areas—is widely recognized for ensuring operational continuity and avoiding delays. No performance metrics or automation investments were reported for this activity.

Order Picking
As discussed earlier, this is considered the highest priority activity for warehouse productivity. Companies dedicate significant analysis to this phase. The main goal is to complete order picking quickly, accurately, and at minimal cost. To achieve this, companies have adopted software solutions that guide operators or implement algorithms to minimize travel paths. WMS systems play a key role in managing FIFO, FEFO, and serial-number tracking. Very few companies still operate without software support for picking. Many have invested in automation, from AS/RS systems to “goods-to-person” technologies, pick-to-light systems, and fully automated solutions like A-frame systems (common in pharmaceutical warehouses). Frequently

monitored KPIs include picks per hour, orders per hour, picking errors, and operator travel distance. Following the literature, companies have adopted different picking models—batch, wave, or zone picking—and have reorganized warehouse layouts and item placement to improve picking efficiency.

Sorting
Not all companies require a dedicated sorting phase. Those handling a high volume of orders have adopted or plan to adopt automated sorting systems. Performance is measured in packages sorted per hour or concurrent orders processed. Automation and digitalization are key enablers of efficiency in this phase.

Consolidation and Packing
Automation and digital solutions are still underutilized in this phase. Consolidation and packing are often performed manually. Few companies use software for pallet load simulation, and only a limited number use automated palletizers or packing machines. However, some have implemented automated stretch-wrapping machines to stabilize loads during transport. Performance indicators are scarce, typically limited to machine output (e.g., pallets packed per hour).

Outbound Quality Check
Companies apply procedures to verify load conditions, including packaging integrity and the presence of all ordered items. In some cases, weight checks are performed to ensure consistency between expected and actual shipment weights, helping to identify discrepancies. Some companies photograph packed goods before shipping to handle potential customer disputes.

Vehicle Loading
This phase mirrors unloading and shares the same considerations and challenges.

Vehicle Departure
This phase is treated in the same way as vehicle access, with similar processes and issues.

These findings offer a comprehensive overview of how companies manage and prioritize the various phases of warehouse operations, highlighting both areas of strong performance and those requiring further attention or investment. The following section presents the main conclusions drawn from the analysis and outlines potential implications for both practitioners and future research.

Conclusions

This study has highlighted several warehouse process activities that tend to be overlooked by companies. In particular, vehicle access, unloading, receiving, as well as vehicle loading and departure, are commonly perceived as phases that are not suitable for process standardization or for the application of specific technologies. This lack of awareness negatively affects warehouse performance, often resulting in bottlenecks at inbound or outbound stages.

Conversely, storage and order picking are the most closely monitored and studied phases. Most automation initiatives are aimed at better space utilization, increasing the speed of material flow, reducing errors, and enhancing the ability to prepare and ship orders efficiently. WMS implementations primarily support these functions by enabling higher warehouse saturation levels and shorter picking times.

Unsurprisingly, the company's business model significantly influences the level of control and technology adoption. For example, pharmaceutical distributors exhibit far higher levels of digitalization and automation than other industries. This is due to their need to guarantee very short lead times—typically three to four

hours—and strict regulatory requirements related to traceability and temperature control, as all logistics operations must be carried out below 25°C.

In general, after 2020, companies have accelerated the digitalization and automation of their warehouses—both to ensure operational continuity disrupted by the pandemic and to take advantage of Industry 4.0 incentives and subsidies. Nonetheless, a significant number of companies still rely on traditional warehouse management practices. Not all have implemented WMS systems, and investments in fully automated warehouses remain limited to a small subset of cases.

In addition to providing a descriptive overview of a non-statistically representative sample, this study sheds light on process phases that are often neglected in the literature—namely, vehicle entry and exit. This omission poses both safety and efficiency concerns: the lack of proper planning for vehicle movement can create hazardous conditions for other vehicles, goods, and pedestrians. Furthermore, the absence of scheduling and control mechanisms for truck arrivals leads to congestion in loading and unloading areas, which in turn undermines operational performance.

The insights gained from this study offer valuable guidance for both practitioners and researchers. For logistics and warehouse managers, the findings suggest the need to broaden the focus of performance monitoring and investment to include phases that are currently undervalued—such as vehicle access and departure—due to their impact on safety, flow continuity, and overall efficiency. Establishing standardized procedures and adopting enabling technologies in these phases could help reduce risks and improve throughput.

For academics, the research highlights an opportunity to explore underrepresented areas within warehouse process studies. Future investigations could delve deeper into the operational design of inbound and outbound traffic flows, the role of yard management systems, and the integration of external transport planning into warehouse control systems. Additionally, comparative studies across different industries and company sizes could help validate and refine the framework proposed in this paper, ultimately contributing to the development of more resilient, responsive, and efficient warehouse systems.

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Appendix A

Warehouse activity	Questions
Vehicle Access	Each incoming vehicle is registered and authorized
Vehicle Access	The driver is informed where to unload
Vehicle Access	The entry route does not interfere with pedestrians or other handling equipment
Vehicle Access	Vehicle pathways are clearly marked
Vehicle Access	The driver waits for unloading in a designated safe area
Vehicle Access	Vehicle access is scheduled through time slots
Vehicle Unloading	Vehicles are unloaded using traditional equipment (forklifts, pallet jacks)
Vehicle Unloading	Unloading times for each vehicle are monitored
Vehicle Unloading	Automation solutions have been implemented to speed up unloading operations
Receiving	The receiving area is dimensioned based on statistical unloading data
Receiving	The receiving area must be cleared by a specific time
Receiving	Unloaded material is visible in the management system even if not yet quality checked
Receiving	Staff are trained to distinguish between acceptable and unacceptable materials
Receiving	A clear procedure exists for urgent products
Inspection and Quality Control	The information system manages quality control priorities and skip-lot logic
Inspection and Quality Control	Quality control does not constitute a bottleneck in the inbound goods flow
Repackaging	The information system notifies the operator of which items require repackaging
Repackaging	Repackaging is only applied to items with visibly damaged original packaging
Repackaging	What type of repackaging is most common in your company: Labeling
Repackaging	What type of repackaging is most common in your company: Replacement of damaged packaging
Repackaging	What type of repackaging is most common in your company: Sorting into new standardized packaging

Storage (Putaway)	Automatic storage systems are in place
Storage (Putaway)	Types of automatic storage systems adopted: Vertical lift modules
Storage (Putaway)	Types of automatic storage systems adopted: Automated small-parts warehouses (Miniload, Autostore)
Storage (Putaway)	Types of automatic storage systems adopted: Semi-automatic systems (e.g., mobile racking)
Storage (Putaway)	Types of automatic storage systems adopted: Pallet AS/RS systems
Storage (Putaway)	Types of automatic storage systems adopted: Shuttle-based systems
Storage (Putaway)	Storage policies are defined in advance to maximize operational efficiency
Storage (Putaway)	The entire warehouse is mapped
Storage (Putaway)	The information system provides operators with instructions on what and where to store
Storage (Putaway)	Stock levels are actively monitored
Storage (Putaway)	A dashboard is available for warehouse stock monitoring
Replenishment	The information system determines the timing for replenishing picking locations
Replenishment	Material is managed using FIFO / FEFO rules
Order Picking	Operators are assisted by digital systems during picking
Order Picking	The picking model has been optimized to minimize time
Order Picking	Picking performance is continuously monitored
Order Picking	The WMS provides the shortest picking path
Order Picking	Automatic picking systems are in use
Order Picking	Materials are brought to the operator for picking
Order Picking	Presence of Automated Guided Vehicles (AGVs)
Order Picking	Presence of Autonomous Mobile Robots (AMRs)
Order Picking	Use of Voice Picking systems
Order Picking	Installation of Pick-to-Light systems
Order Picking	Adoption of Augmented Reality (AR) systems
Sorting	An automatic sorting system is in place
Outbound Quality Control	Random outbound quality checks are performed
Vehicle Access	EEach incoming vehicle is registered and authorized
Vehicle Access	The driver is informed where to unload
Vehicle Access	The entry route does not interfere with pedestrians or other handling equipment
Vehicle Access	Vehicle pathways are clearly marked
Vehicle Access	The driver waits for unloading in a designated safe area
Vehicle Access	Vehicle access is scheduled through time slots
Vehicle Unloading	Vehicles are unloaded using traditional equipment (forklifts, pallet jacks)
Vehicle Unloading	Unloading times for each vehicle are monitored
Vehicle Unloading	Automation solutions have been implemented to speed up unloading operations
Receiving	The receiving area is dimensioned based on statistical unloading data
Receiving	The receiving area must be cleared by a specific time
Receiving	Unloaded material is visible in the management system even if not yet quality checked
Receiving	Staff are trained to distinguish between acceptable and unacceptable materials
Receiving	A clear procedure exists for urgent products
Inspection and Quality Control	The information system manages quality control priorities and skip-lot logic

Inspection and Quality Control	Quality control does not constitute a bottleneck in the inbound goods flow
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Order Picking	Picking performance is continuously monitored
Order Picking	The WMS provides the shortest picking path
Order Picking	Automatic picking systems are in use
Order Picking	Materials are brought to the operator for picking
Order Picking	Presence of Automated Guided Vehicles (AGVs)
Order Picking	Presence of Autonomous Mobile Robots (AMRs)
Order Picking	Use of Voice Picking systems
Order Picking	Installation of Pick-to-Light systems
Order Picking	Adoption of Augmented Reality (AR) systems
Sorting	An automatic sorting system is in place
Outbound Quality Control	Random outbound quality checks are performed

DIGITAL TRANSFORMATION IN LEARNING AND TEACHING: EDUCATIONAL TECHNOLOGY IN KUWAIT

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ABSTRACT

This research explores both the current state and future potential of innovative, efficient educational technologies and open access resources in enhancing the quality and accessibility of university education in Kuwait. It aims to examine how academic communities—including faculty, students, and administrative staff—can be effectively

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engaged in the evaluation, adoption, and support of educational technologies to achieve meaningful pedagogical outcomes. The study will assess how Kuwaiti universities can align with emerging higher education demands, such as multi-modal delivery, AI-driven teaching and learning analytics, quality assurance systems, learning management platforms, student feedback mechanisms, and plagiarism detection tools (Colbran, 2013). It will also investigate the role of open access resources, evolving expectations of both students and academic staff, and the broader impact of online learning on educational practices. Ultimately, the research seeks to inform strategic planning and policy development that support the digital transformation of higher education in Kuwait. First, a systematic literature review in the form of meta-analysis will be compiled. Secondly, national mixed-methods voluntary surveys will be administered online with appropriate ethics clearance. Participants will include administrators, academics, and students of all higher education institutions in Kuwait. Qualitative and quantitative data will be collected enabling thematic and statistical analyses for each tertiary institution, benchmarking across the sector and a global analysis of the entire higher education sector. The outcomes of this study include a thematic literature review in the form of meta-analysis, insights from a comprehensive survey for each institution, benchmarking and strategies for reform of existing practice across the sector.

KEY WORDS

Educational Technology, Higher Education, Digital Transformation, Kuwait

OBJECTIVES

The primary aim of this research is to examine the current use of information technology in higher education across Kuwait and evaluate its effectiveness in supporting academic communities. The study will explore the evolving needs of academic staff, students, and administrative personnel concerning innovative educational technologies and the integration of open access resources. It will also identify practical strategies to enhance motivation, build digital competencies, and foster the adoption of emerging technologies among all stakeholders in the academic environment.

A key component of the research is a meta-analysis of existing literature, enabling a comprehensive overview of trends, challenges, and best practices drawn from hundreds of studies. This will help contextualize the findings and offer valuable insights for both academic and policy-making audiences.

Furthermore, the research will propose actionable strategies for universities and government bodies to facilitate a smooth transition toward more efficient and innovative educational technologies, ultimately aiming to improve pedagogical practices and learning outcomes aligned with national workforce and development goals.

This study will address the following research questions:

1. What are the emerging teaching and learning needs within Kuwait's higher education sector?
2. What factors affect the engagement of academic communities in evaluating, adopting, and resourcing educational technologies?
3. How can universities in Kuwait respond to future demands in teaching and learning?
4. What has been the impact of increased online learning and the reduction in practical training on higher education communities?
5. In what ways can Kuwait effectively implement and benefit from smart learning environments?

LITERATURE REVIEW

Alfelaij (2016), through a documentary analysis, argues that the integration of teaching technologies in Kuwait has been hindered by a combination of cultural, technical, and contextual challenges. Among the cultural barriers, gender segregation and traditional social norms significantly influence the use of online collaborative tools, such as discussion boards, often integral to e-learning platforms (Alfelaij, 2016). A more substantial obstacle, however, lies in the deeply embedded teacher-centered pedagogical model, which emphasizes rote learning and indoctrination over critical thinking, dialogue, and active learning (Ghaith, 2013). This approach ultimately undermines student autonomy, creativity, and engagement with digital learning tools.

Alfelaij (2016) also highlights the lack of institutional support for both academics and students in embracing educational technologies. This includes issues such as task overload (Al-Ali, 2010), inadequate administrative assistance (Almutairi, 2014), and technical deficiencies like poor internet connectivity, outdated infrastructure, and insufficient access to digital tools (Alkhezzi & Abdelmagid, 2011). Further complications arise from the absence of comprehensive training programs, limited time for professional development, and insufficient funding for e-learning initiatives. Contextual barriers identified by Alfelaij (2016) include high staff-to-student ratios, outdated lecture halls, a shortage of IT technicians, lack of maintenance, obsolete software, and misaligned preferences between academic staff and students regarding preferred technologies.

One of the critical gaps in the existing literature is its dated nature; few studies have examined the current state of educational technology usage in Kuwait or its future potential. Little attention has been paid to motivational factors needed to engage older academic staff in technology adoption or to the specific technologies students

wish to see integrated into their learning environments. Notable exceptions include studies on the educational use of social media platforms (Alenezi & Brinthaupt, 2021; Alsaied, 2017).

The COVID-19 pandemic accelerated the shift to online learning, challenging the prevailing pedagogical norms and exposing systemic gaps in digital readiness. In the UAE, Al-Karaki et al. (2021) used a mixed-methods approach to examine how educators navigated the abrupt transition to remote learning. The study revealed a preference for digital platforms among educators, with 65% agreeing that online learning offers advantages over traditional methods. However, its findings are limited by the small sample size—approximately 100 academics from five Abu Dhabi institutions—and the exclusion of student perspectives (Hodges et al., 2020). In Kuwait, Hendal (2020) observed limited engagement with digital resources among Kuwait University faculty during the pandemic, underscoring the need for deeper institutional reform.

For educational technology reform in Kuwait to succeed, it must be grounded in the local context and aligned with the aspirations of diverse stakeholders, including educators, students, policymakers, and administrators (Winokur, 2014; Mohamed, 2019; Male & Al-Bazzaz, 2015; Alhouti, 2020). Past initiatives, particularly in the school sector, have faced implementation challenges and have fostered skepticism about the feasibility of future reforms (Alhouti, 2020; AlQenaei et al., 2021).

Many universities continue to rely on outdated learning management systems (LMS) rooted in early-2000s technologies that predate the rise of social media and personalized digital engagement. These systems are increasingly misaligned with modern students' expectations for interactive, adaptive, and user-centered learning experiences. As Chen et al. (2021) suggests, there is a pressing need to transition toward smart learning environments that leverage artificial intelligence to personalize learning pathways and respond dynamically to individual learner needs.

Cheung (2021) emphasizes that smart learning environments offer numerous advantages, including greater flexibility, efficiency, engagement, and adaptability (Spector, 2014). In a later study, Cheung (2021b) highlights how these environments support personalized learning through real-time tracking of student progress, analysis of learner traits and skills, and adaptive modifications to curriculum and instruction (Kwok, 2015; Zou et al., 2021; Zou & Xie, 2018). Learning analytics embedded in such systems not only help students monitor their own development but also provide instructors with timely feedback to refine their teaching strategies (Chung et al., 2021; Gomede et al., 2021; Wang et al., 2021). Furthermore, smart environments promote autonomous, lifelong learning by

empowering students to take control of their educational journeys (Hui et al., 2020; Kwok & Hui, 2018; T. L. Wong et al., 2020).

Ultimately, the integration of educational technologies must be guided by pedagogical imperatives rather than technological trends. As Baneres et al. (2017) assert, pedagogy should lead the adoption of digital tools, ensuring that technology is used meaningfully and effectively within educational models.

METHODOLOGY

This research will utilize data collected through nationally distributed, embedded, and voluntary online surveys administered via Qualtrics, following appropriate ethics clearance and employing a mixed-methods design (Creswell & Plano Clark, 2011). Both qualitative and quantitative data will be gathered from participants across Kuwait's tertiary education sector, allowing for institution-specific and sector-wide analysis. Qualitative data will undergo thematic analysis using NVivo, while quantitative data will be analyzed statistically using SPSS. The combination of qualitative and quantitative approaches enables triangulation, enhancing the validity and reliability of the findings by capturing diverse perspectives. The study aims to provide a comprehensive snapshot of current educational technology practices—particularly in the wake of the COVID-19 pandemic—while also identifying future opportunities for development across institutions and academic disciplines. The research will target three key participant groups: academic staff, students, and university administrators. Each group will be provided with a tailored survey instrument designed to capture their unique experiences, attitudes, and expectations regarding the use and potential integration of educational technologies. Participation will be anonymous and voluntary. While the absence of sampling may introduce self-selection bias, all respondents will be drawn from active participants within Kuwait's higher education ecosystem, ensuring relevance and contextual depth in the findings.

RESULTS

Our survey's findings will highlight notable variations in how academic staff, students, and administrative staff in Kuwait's higher education sector adopt and view educational technologies. Different degrees of digital integration are likely to be reported by academic staff, and common issues include reluctance to change, a lack of institutional support, and inadequate training. It is anticipated that perceived educational value, resource accessibility, and generational issues would all have an impact on teacher opinions.

In addition to pointing out gaps between their expectations and what their institutions already provide, students are expected to demonstrate a significant passion for upcoming technologies, such as gamification, virtual/augmented reality, and simulation tools. Gaps in digital infrastructure and support services that affect teaching and learning are likely to be found by the analysis.

IMPLICATIONS

It is anticipated that the results of this study will have a major impact on institutional planning, capacity building, and educational policy in Kuwait's higher education sector. The study will help universities, policymakers, and funding agencies including the Ministry of Education, PUC, and KFAS make better decisions by offering a thorough, data-driven understanding of existing practices, needs, and expectations linked to educational technology. Additionally, it will provide a framework for matching the adoption of technology with educational objectives and user preparedness, assisting organisations in creating training, resource allocation, and support systems that are more efficient.

ORIGINALITY VALUE

By methodically evaluating the present capacities, preparedness, and future goals regarding educational technology integration in Kuwait's tertiary education sector, this study makes a fresh and pertinent contribution. In contrast to earlier research, it offers a dataset that is benchmarked across academic institutions, providing decision-makers in organisations like the Ministry of Education, PUC, and KFAS with insightful information. The suggested study tool also offers the possibility of longitudinal analysis, which might document how the environment of digital adoption changes as educators' generations change. Furthermore, by investigating cutting-edge technologies like gamification, smart learning environments, and XR-based simulation, the study specifically tackles both the advantages and disadvantages of innovation in Kuwait's higher education system.

CONTRIBUTION

This research proposal seeks to comprehensively investigate the current landscape, existing capabilities, and future intentions regarding the integration and utilization of educational technologies within Kuwait’s higher education sector. The significance of this study is multifaceted:

1. It will provide key stakeholders—including academic institutions, NGOs, government bodies such as the Public Authority for Applied Education and

Training (PUC), Kuwait Foundation for the Advancement of Sciences (KFAS), the Ministry of Education, and policymakers—with a robust dataset. This data will offer critical insights into the current technological capacities and expectations of academic staff, students, and administrative personnel, benchmarked against comparable institutions across Kuwait's tertiary sector. Such information will empower institutions to strategically plan and enhance the implementation, resourcing, and professional development related to educational technologies.

2. By administering the research instrument at regular intervals, the study establishes a framework for a longitudinal analysis of the evolving educational technology needs and priorities in Kuwait. This is especially pertinent as the academic workforce undergoes generational shifts, with traditional educators retiring and digitally proficient staff taking their place.
3. The research will also yield valuable insights into emerging technological innovations—such as smart learning environments, gamification strategies, virtual and augmented reality, and simulation tools—while identifying potential barriers to their effective adoption within the Kuwaiti educational context.

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HARMONIZATION OF MONETARY AND MULTIDIMENSIONAL POVERTY THROUGH A THRESHOLD ALIGNMENT APPROACH

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Abstract

At present, two predominant methods for calculating poverty are widely employed across various countries: direct (multidimensional) and indirect (monetary). However, empirical evidence has demonstrated that the simultaneous application of both methods results in substantial discrepancies in identification outcomes. This discrepancy can be attributed to the lack of a common threshold between the two approaches. The present study addresses this issue by implementing a threshold alignment method utilizing Receiver-operating-characteristic (ROC) analysis. This threshold alignment method also indirectly mitigates arbitrariness in determining the indicator thresholds commonly associated with the Alkire–Foster (AF) method. Furthermore, this study endeavors to eliminate arbitrariness in indicator weight determination through the application of Multiple-correspondence-analysis (MCA), thereby reducing potential researcher subjectivity in the calculation process. The study compared four methodologies: the AF method, ROC method, AF-MCA method, and ROC-MCA method. The findings indicate that the ROC-MCA method yields superior evaluation results compared to alternative methods.

Keywords: Poverty, Monetary, Multidimensional, Threshold, ROC, MCA.

1. Introduction

Poverty has become one of the primary targets of Sustainable Development Goals (SDGs), with the expectation of reducing poverty by half by 2030 (United Nations, 2015). The definition of poverty has been extensively discussed in the literature, from classics such as Rowntree (1902), Marx (1847), and Watts (1964), and experts in the 1980s, such as Townsend (1982), Sen (1981), and Streeten (1984), to more contemporary experts, such as (Ravallion, 1992, 2011), Haughton & Khandker (2009), Rojas (2015). In general, many modern economists agree that the definition of poverty is more of a multidimensional concept and cannot be represented only by income variables (Bourguignon & Chakravarty, 2003). Multidimensionality here can include many things such as clothing, food, shelter, education, health, access to public facilities, and so on (Chakravarty & Silber, 2008)).

In terms of calculating the population of poor people, there has also been a plethora of literature, ranging from the indirect approach or monetary poverty methods, such as the basic diet by Rowntree (1902), to the period of Foster et al. (1984) with their FGT formula, whose results are still widely used in many countries. On the other hand, various direct approaches or multidimensional poverty measurement methods have also gained prominence among researchers such as Atkinson (2003), Bourguignon and Chakravarty (2003), Alkire and Foster (2011a), and Sumner (2007).

To date, these two methods of poverty measurement–direct (multidimensional) and indirect (monetary)–are still dominant and widely used for poverty measurement in various countries. These two poverty measurement methods are often presented separately in literature. The formation of the deprivation threshold/cut-off, or what is commonly referred to as the poverty line, the calculation of various poverty attributes such as the head count ratio, poverty gap, and severity, often leads to significantly different poverty measurement results in the same location and time when using these two methods.

Extensive research has been conducted to demonstrate the mismatch between the results of these methods, with most studies concluding that the mismatch between the two is quite large. Some of these studies were conducted in developing countries, such as Nilsson (2010), Ruggeri Laderchi et al. (2003), Alkire and Santos (2014), Bradshaw and Finch (2003), and in developed countries, such as Perry (2002), Wagle (2009), and Alkire and Foster (2011b).

This significant mismatch is likely owing to the absence of a common threshold that links the two methods or approaches. This study aimed to provide a solution to this problem. This solution also addresses the arbitrariness gap in setting deprivation thresholds and selecting indicators in the calculation of the multidimensional poverty index (MPI) by Alkire and Foster (2011a). The solution is to align the indicator threshold with the monetary poverty line using the ROC (receiver-operating-characteristic) method.

Furthermore, in addition to eliminating arbitrariness in the threshold setting, this study also proposes the multiple-correspondence-analysis (MCA) method to address arbitrariness in determining the weights of indicators in the calculation of MPI Alkire-Foster. By aligning thresholds and eliminating arbitrariness, the identification of the poor is more accurate with a smaller mismatch.

2. Literature Review

In the background of this research, it is mentioned that many studies have compared the implementation of these two methods in various countries. Most of these studies claim that the mismatch between the results of these two methods is large (Perry, 2002).

However, all these studies performed calculations and identifications based on the two methods separately, meaning they created a poverty line for monetary poverty and a deprivation threshold for multidimensional poverty separately. Almost no attempt has been made to create a single line that can directly connect these two threshold measures. Even if there are cases in which this attempt has been made, the methods used are not clearly stated in their research.

For example, studies by Nolan and Whelan (1996) and Perry (2002), conducted in New Zealand and Ireland, used separate thresholds for their research. Similarly, Bradshaw and Finch (2003), who employed three different approaches—monetary, multidimensional, and subjective—did not describe the method used to align thresholds in detail. Roelen (2017) made adjustments to align the poverty line with the deprivation threshold; however, the determination of the deprivation threshold was still arbitrary.

This forms the basis for the argument that a single line connecting the poverty line and deprivation threshold is necessary to achieve more accurate identification of the poor with minimal mismatch. This was the primary focus of this study. By aligning these two threshold measures, it is hoped that it will be possible to eliminate arbitrariness, as seen in the method used by Alkire and Foster (2011a) to set the deprivation threshold.

Additionally, having a single common threshold is expected to result in a smaller mismatch, and thus, more accurate identification results, even when using two different methods (this aligned threshold approach will be referred to in this research as the threshold alignment approach).

Although Sen (1981) states that direct approaches, such as multidimensional poverty, are superior to indirect approaches, such as monetary poverty, the indicators used in multidimensional poverty do not have as strong data support as monetary poverty. Even if supporting data exists, they are not published as frequently as supporting data for monetary poverty. Thus, it can be said that with greater data support, guaranteed continuity, and more sophisticated calculation methods, it is not wrong to use the monetary poverty line as a reference for threshold alignment in this research.

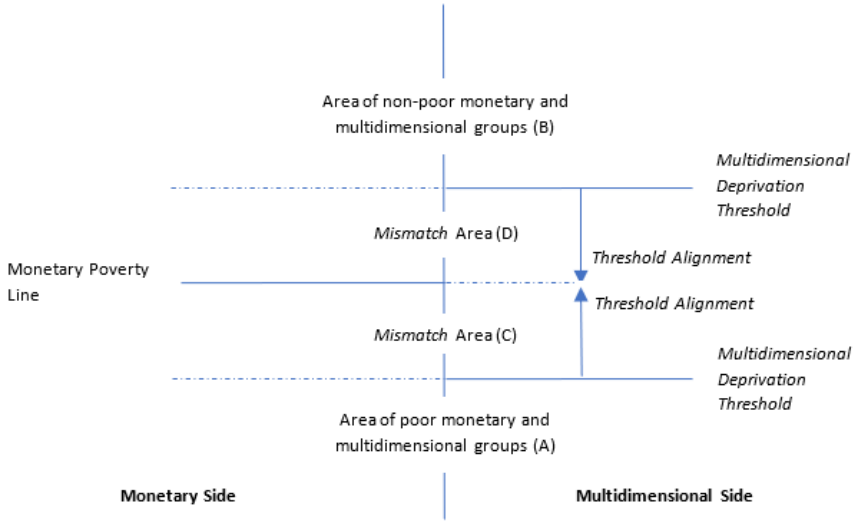
The second focus of this study is to calculate multidimensional poverty using an approach that identifies the dimensions or indicators that contribute to the classification results and simultaneously calculates the weight of each indicator. This aligns with Thorbecke's critique of arbitrariness in dimension selection and weighting (Thorbecke, 2011), as used by Alkire & Foster (2011a).

Once aligned thresholds and the elimination of arbitrariness are achieved, the results of this study are expected to provide valuable information, especially for identifying who is genuinely regarded as poor, both monetarily and multidimensionally. While a mismatch inevitably exists, it is expected to be minimized with threshold alignment.

The identification results from these methods classified the poor into four groups (detail in figure 1): poor both monetarily and multidimensionally (A), not poor both monetarily and multidimensionally (B), poor monetarily (C), and poor multidimensionally (D).

The accuracy of this identification is determined by the smaller values of C and D and the more homogeneous characteristics within each poor group based on the indicators in the dimensions of poverty. This dichotomy provides more detailed information regarding the characteristics of the poor in contrast to the usual classification of poor and non-poor groups.

Figure 1. Threshold Alignment Process



3. Research Methods

Secondary data obtained from BPS were used in this study. These data consist of the results of the March 2020 National Socioeconomic Survey/Susenas (BPS, 2020a) and data from the calculation of monetary poverty in 2020 (BPS, 2020b). Susenas is a survey with a socioeconomic theme that collects information on demographic conditions, health, education, housing, and other socioeconomic variables from sample households. This survey was conducted twice a year by Statistics Indonesia

(BPS) with different sample coverage. One of the main products of the survey is the monetary poverty rate, which is released annually.

The formation of the dimensions and indicators used in this study largely refers to the research conducted by Alkire et al. (2017), with some modifications related to data availability and analysis tool suitability. Detailed information is provided in Table 1.

Table 1 Dimensions, Indicators, Thresholds, and Weights

Dimension	Indicator	Threshold (considered poor if)	Weight
Health	Calorie consumption	Below 70% of the AKG, the actual value is relative to the needs of each household.	1/6
	Protein consumption	Below 80% of the AKG, the actual value is relative to the needs of each household.	1/6
Education	Years of schooling	Less than 6 years (processed from March 2020 Susenas)	1/6
	Literacy	The head of the household may not be able to read or write any letters (question no. 609, 610, and 611 of the March 2020 Susenas Kor Doc. code 0)	1/6
Living standards	Electricity Access	No access to electricity (question no. 1816 Susenas March 2020 Kor Doc. code 4)	1/36
	Cooking Fuel	Using briquettes or worse (question no. 1817 Susenas March 2020 Kor Doc. code ≥ 8)	1/36
	Closet Ownership	There are no facilities or using public toilets (question no. 1809A Kor Doc. Susenas March 2020 code ≥ 4)	1/36
	Closet Type	Not using a goose neck closet type (question no. 1809B Kor Doc. Susenas March 2020 code ≥ 2)	1/36
	Final Disposal of Closet	Not using a septic tank or IPAL (question no. 1809C Kor Doc. Susenas March 2020 code ≥ 3)	1/36
	Drinking Water	Not using a drilled well/pump or better (question no. 1810A kor Doc. Susenas March 2020 code ≥ 5)	1/36
	Bathing/Washing/Others Water	Not using a drilled well/pump or better (question no. 1814A Kor Doc. Susenas March 2020 code ≥ 5)	1/36
	Material of Floor	Using a dirt floor or worse (question no. 1808 Susenas March 2020 Kor Doc. code ≥ 8)	1/36
	Material of Roof	Using bamboo roofs or worse (question no. 1806 Susenas March 2020 Kor Doc. code ≥ 5)	1/36
	Material of Wall	Using woven bamboo walls or worse (question no. 1807 Kor Doc. Susenas March 2020 code ≥ 4)	1/36
	Asset Ownership	Only have a maximum of one of these assets (question no. 2001A-M. March 2020 Susenas Kor Doc. only one with code 1)	1/36

Notes: Threshold conditions are based on the information from Susenas 2020 document from BPS

Source: Processed from Alkire et al. (2017) and BPS 2020

3.1 The ROC Threshold Alignment Process

ROC analysis fundamentally classifies a research object into one of two conditions (binary choice) based on the value/classifier possessed by the research object known by the researcher. ROC analysis determines the ability of a value/classifier to be used as the basis for the classification or prediction of an object's condition. Additionally, through ROC analysis, the process can proceed to a cut-off analysis to obtain the optimal cut-off from the value/classifier. An interesting aspect of this analysis is that the value/classifier used can be on an ordinal scale (Fawcett, 2006), which aligns with the objectives of this study.

Table 2. Classification table

		Prediction Condition		
		Positive	Negative	Total
Real Condition	Positive	True positive (A)	False negative (C)	A+C
	Negative	False Positive (B)	True negative (D)	B+D
	Total	A+B	C+D	A+B+C+D

In general, the ROC analysis creates a classification table to place the condition and value/classifier choices, as presented in Table 2. Based on the above classification table, several measurements were obtained as follows: first, the true positive rate (TPR) or sensitivity, where $\mathrm{TPR} = \frac{\mathrm{A}}{(\mathrm{A+C})}$, and second, the true negative rate (TNR) or specificity, where $\mathrm{TNR} = \frac{\mathrm{D}}{(\mathrm{B+D})}$. Furthermore, to determine whether the value/classifier can classify related conditions, the following measures were used: Youden index (YI), where $\mathrm{YI} = \mathrm{TPR} + \mathrm{TNR} - 1$, and sensitivity + specificity $= \mathrm{TPR} + \mathrm{TNR}$. Higher values of the Youden Index (YI) and Sensitivity + Specificity indicate a better classifier value for classification.

One way to present ROC analysis results is through an empirical ROC curve that plots the TPR ratio to FPR or the LR+ plot for all possible cut-off values (red line). A more perfect diagnosis will have the ROC curve aligned with the ordinate axis towards 100% and then with the axis towards the top right corner. Conversely, an asymptotic or diagonal 45-degree line indicates a poor or random classifier value.

A Z-test was used to confirm the suitability of the classifier value. Despite the discrete data scales, the assumption of a normal distribution is close for large samples. A formula that works without a strong normality assumption is highly favored by researchers (DeLong et al., 1988). The formula is:

$$\mathrm{Z} = \frac{\mathrm{A} - 0.5}{\sqrt{\mathrm{V(A)}}} \tag{1}$$

where Z is the normal test statistic, and A is Area Under Curve (AUC). A is calculated as $A = \sum_{i=1}^{n} V(X_i)/n = \sum_{j=1}^{m} V(Y_j)/m$, where n is the number of positive samples, and m is the number of negative samples. $V(X_i)$ dan $V(Y_j)$ obtained from:

$$V(X_i) = \frac{1}{n}\sum_{i=1}^{n} \psi(X_i, Y_j) \quad \text{dan} \quad V(Y_j) = \frac{1}{m}\sum_{j=1}^{m} \psi(X_i, Y_j) \tag{2}$$

Under the condition $\psi(X, Y) = 0$, if $Y > X$,, or $\psi(X, Y) = \frac{1}{2}$, if $Y = X$, or $\psi(X, Y) = 1$, if $Y < X$. Then, the $V(A)$ variance of A is obtained from:

$$V(A) = \frac{1}{n} {S_X}^2 + \frac{1}{m} {S_Y}^2 \tag{3}$$

Where ${S_X}^2 = \frac{1}{n-1}\sum_{i=1}^{n}[V(X_i) - A]^2$ and ${S_Y}^2 = \frac{1}{m-1}\sum_{j=1}^{m}[V(Y_j) - A]^2$. The optimal cut-off was obtained by selecting the cut-off with the highest Youden index (YI) and Sensitivity + Specificity (Krzanowski & Hand, 2009).

3.2 The MCA Weight Formation Process

Multiple-Correspondence-Analysis (MCA) is a multivariate analysis method that analyzes the relationship patterns of categorical data indicators and does not require assumptions about the underlying data distribution. This method is an extension of Principal Component Analysis (PCA) specifically for metric/numeric data (Greenacre & Blasius, 2006).

Generally, multivariate analysis in the Principal Component Analysis (PCA) family is used for indicator reduction using a factorial approach. However, in addition to being a method for indicator reduction, it can also produce a composite measure or a new dimension from the combined indicators, including the contribution or share of each indicator to the composite measure or new dimension. In this study, this contribution is referred to as the weight of the indicator towards the new dimension formed in the MCA process.

In producing a composite measure or new dimension, MCA naturally considers the influence of all new dimensions used simultaneously and involves the entire research unit at one time. The data are spread within the indicator matrix (rows denote samples, and columns denote new dimensions) and are represented as points in a low-dimensional Euclidean space. The relationship between these new dimensions and research units was measured using the chi-square distance.

Maximizing the contrasting values among the rows and columns produces a sequence of new dimensions. The first axis (factorial axis) presents the most significant new dimension, followed by new

dimensions on the second axis. After obtaining the sequence of new dimensions, the weights of the categories in these new dimensions were obtained using the following formula (Asselin & Anh, 2008):

$$W_{J_K} = \frac{N}{N_{J_K}} = \frac{\sum_{i=1}^{N_{J_K}} \frac{F_i}{\lambda}}{N_{J_K}} \quad (4)$$

where W_{J_K}a is the weight of indicator J on the new dimension K, N is the number of observations/samples, N_{J_K} is the frequency of indicator J on the new dimension K, F_i is the value/score of observation/sample I on the factorial axis, and λ is the eigenvalue. This study used the first-dimension indicator weights obtained from this process for the subsequent calculations.

3.3 Best Method Evaluation

Two techniques were used to determine the best method in this study. First, a confusion matrix was used to obtain the accuracy measures from the identification results, including the proportion correctly classified (PCC), where $PCC = \frac{(A+D)}{(A+B+C+D)}$, proportion incorrectly classified (PIC), where $PIC = \frac{(B+C)}{(A+B+C+D)}$, and F1 score, where $F1 = 2\frac{(precission.recall)}{(precission+recall)}$. Second, we compared the dispersion measures, that is, the range and variance values of the household cumulative score and per capita expenditures.

Table 3. Confusion Matrix Concept

		Multidimensional Poverty		
		Poor	Non-Poor	Total
Monetary Poverty	Poor	Poor (A)	Poor (C)	A+C
	Non-Poor	Poor (B)	Non-Poor (D)	B+D
	Total	A+B	C+D	A+B+C+D

The accuracy measure here is considered better if it shows that more households are detected as monetarily and multidimensionally poor or non-poor, and fewer households fall into the mismatch category, that is, multidimensionally poor but not monetarily poor or vice versa. Therefore, a method with a larger PCC or F1 score is a better method.

The dispersion measure is considered better if the value is smaller. The smaller the range or variance value, the more homogeneous the households in each category in Table 3 (A, B, C, or D) are in terms of cumulative score and per capita expenditure. Therefore, a method with a smaller range and variance values is a better method.

4. Research Results and Discussion

4.1 Poor Household Identification Results Using the Alkire-Foster (AF) Method

This study employs a comprehensive methodology to assess poverty using 15 indicators distributed across three distinct dimensions, drawing data from the Susenas 2020 survey. Initially, 334,229 households participated as respondents; however, after applying the appropriate weighting techniques, this figure was adjusted to represent 72,791,519 households. When conducting individual weighting, the total population comprised 270,315,430 individuals.

In accordance with the methodological framework established for this study, it is imperative that indicators corresponding to poverty dimensions possess at least an ordinal data scale, as stipulated by (Fawcett, 2006). This requirement is fundamental to ensuring that the subsequent process of threshold alignment yields optimal cut-off values. Following the calibration of the data scales, the next step involved the determination of cut-off indicators and weights that were consistent with the existing dataset.

As previously articulated, the establishment of cut-offs in this method is predicated on an arbitrary or subjective approach shaped by specific needs or objectives delineated by the researcher. Notably, the cut-offs employed herein were adapted from the research conducted by Alkire and Foster and specifically tailored to align with the Susenas data used in this investigation. This adaptation is significant, as the multidimensional poverty calculations performed by the Oxford Poverty and Human Development Initiative (OPHI) using the Alkire-Foster methodology typically rely on data from the Demography and Health Survey (DHS).

Subsequent to the determination of cut-offs and weightings, the calculation of the individual household scores began. Households whose indicator values aligned with the designations of poverty as defined by the constructed cut-offs received a score of 1 for each pertinent indicator, whereas those that did not meet these criteria were assigned a score of 0. The cumulative score for each household was then derived by aggregating the products of the individual indicator scores multiplied by their respective weights.

Upon the completion of the cumulative score calculations for each household, an identification process regarding the household’s poverty status can be undertaken. This involves comparing the cumulative score of each household against a second cut-off, frequently referred to as the dimension cut-off. The widely accepted threshold for this second cut-off is 0.33; thus, a household is classified as non-poor if it demonstrates at least one dimension in which it does not fall into the category of poverty.

Following data processing, the results obtained provided a nuanced understanding of the prevalence and distribution of poverty within the assessed population. The ensuing analysis delves

deeper into these findings, offering insights into the implications of the established thresholds and scoring methodologies.

Table 4. Identification Results Using the AF Method

Household Status	Frequencies	Percentage
Non-Poor	49.063.916	67.40
Poor	23.728.370	32.60
Total	72.791.519	100,00

Source: Processed from BPS Susenas 2020

Based on the data presented in Table 4, it is apparent that the percentage of households classified as poor, according to the Alkire-Foster methodology, is 32.6 percent. This statistic indicates that approximately one-third of the households in Indonesia were identified as living in poverty as of March 2020, whereas the remaining two-thirds were categorized as non-poor. This finding is in line with calculations conducted by the Oxford Poverty and Human Development Initiative (OPHI), which utilized data gleaned from the Demographic and Health Survey conducted in 2017 and revealed a poverty rate of approximately 38.7 percent (UNDP and OPHI, 2023).

Furthermore, an in-depth examination of the factors contributing to this poverty classification can be achieved by scrutinizing the specific indicators employed in the study. This analysis facilitates a more nuanced understanding of the various dimensions of poverty that affect households in Indonesia. Table 5 provides a comprehensive breakdown of these indicators, thereby illuminating the underlying conditions contributing to the identified poverty rates.

Based on the threshold or cut-off criteria in Table 1, information can be obtained from Table 5, which shows that the decent standard of living dimension has three indicators with a percentage of poor households of more than 20 percent, namely drinking water sources, bathing/washing/other water sources, and asset ownership. Meanwhile, in the education dimension, only the years of schooling indicator had a percentage greater than 20 percent. On the other hand, for the health dimension, the two indicators used, namely calorie and protein consumption per capita, show a percentage of more than 20 percent.

This information shows that there are still many households that have not been able to enjoy various facilities at a decent standard of living, access sufficient educational continuity, and still not achieving ideal health standards, especially when viewed based on these indicators. This can be used as a basis for various intervention policies to reduce poverty.

Table 5. Results of Poor Household Identification Using the AF Method per Indicator

Indicator	Non-Poor	Poor
Material of Roof	98.5	1.5
Material of Wall	95.6	4.4
Material of Floor	95.9	4.1
Closet Ownership	91.8	8.2
Closet Type	95.2	4.8
Final Disposal of Closet	83.5	16.5
Drinking Water	68.3	31.7
Bathing/Washing/Others Water	58.5	41.5
Electricity Access	99.0	1.0
Cooking Fuel	87.5	12.5
Asset Ownership	75.5	24.5
Years of Schooling	77.1	22.9
Literacy	93.3	6.7
Calori Consumption	69.9	30.1
Protein Consumption	61.9	38.1

Source: Processed from BPS Susenas 2020

4.2 Poor Household Identification Results Using the ROC Method

The fundamental distinction between the method presented in this study and the Alkire-Foster method resides in the employment of an optimal cut-off or threshold derived from receiver-operating-characteristic (ROC) curve analysis, utilizing monetary poverty data as a reference point. ROC Curve analysis was effectively employed to evaluate the trade-offs between sensitivity and specificity across different threshold values, allowing for the identification of a cut-off that maximizes predictive accuracy.

In this context, SPSS version 27 software was used to conduct the ROC Curve analysis of the prepared dataset. The analysis yielded several key metrics, including the area under the curve (AUC), sensitivity, specificity, and optimal threshold value, which facilitated the classification of subjects into distinct categories based on their poverty status. The results of the data processing for the AUC and Z-test significance values broken down according to the indicators used are shown in Table 6.

Table 6. Area Under the ROC Curve

Test Result Variables	AUC	Z-test significance value [a]
Material of Roof	0.489	0.000
Material of Wall	0.596	0.000
Material of Floor	0.641	0.000
Closet Ownership	0.576	0.000
Closet Type	0.469	0.000
Final Disposal of Closet	0.500	0.465
Drinking Water	0.656	0.000
Bathing/Washing/Others Water	0.616	0.000
Electricity Access	0.566	0.000
Cooking Fuel	0.652	0.000
Asset Ownership	0.503	0.000
Years of Schooling	0.496	0.000
Literacy	0.510	0.000
Protein Consumption	0.511	0.000
Calori Consumption	0.814	0.000

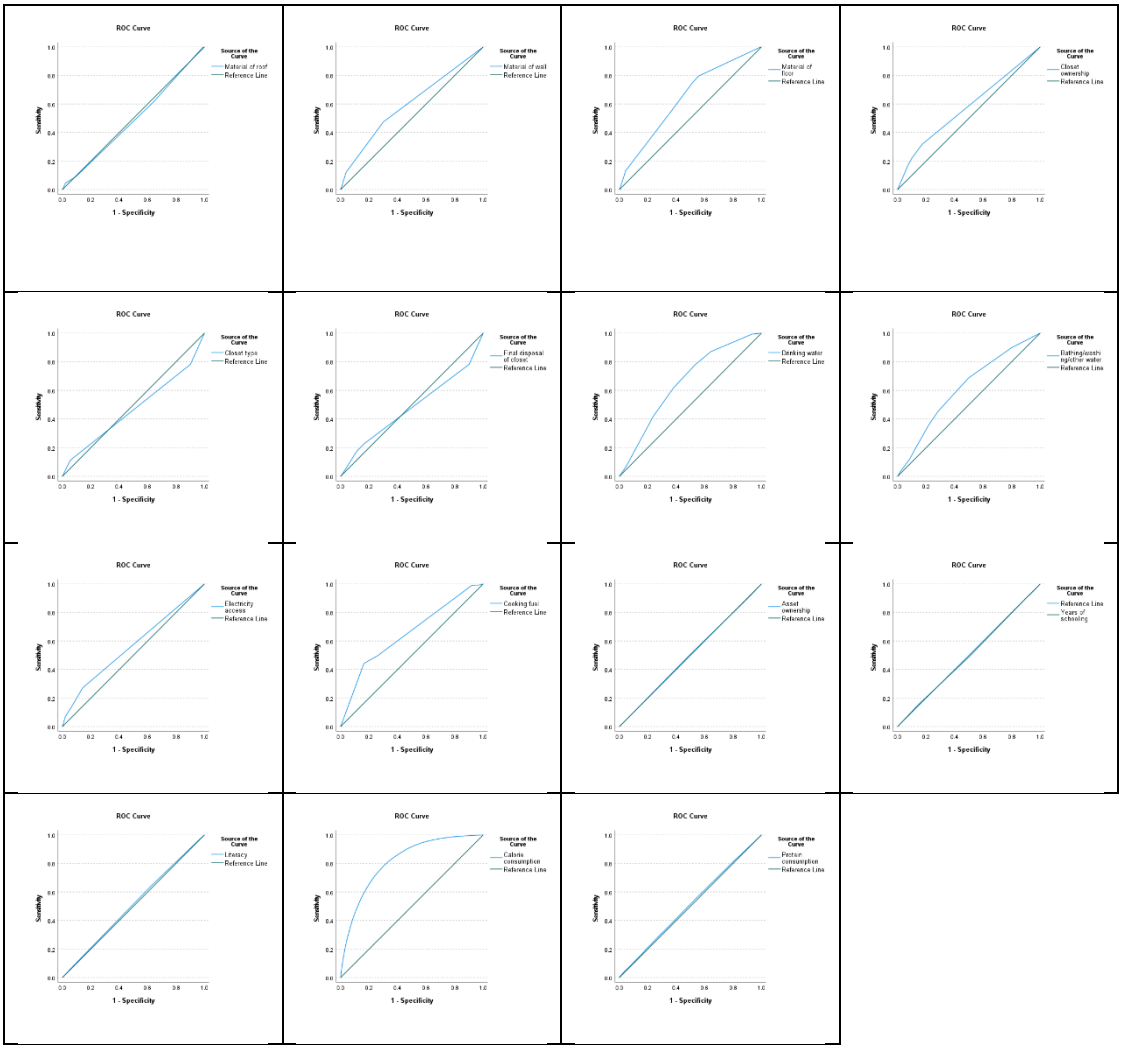
Notes: a. Null hypothesis: true area = 0.5

Source: Processed from BPS Susenas 2020

In the analysis presented in Table 6, it is evident that the indicators pertaining to the roof material, closet type, and years of schooling possess an area under the receiver-operating-characteristic (ROC) curve (AUC), which is less than 0.5. This finding suggests that the inclusion of these indicators in the subsequent identification processes is unlikely to yield accurate conclusions. Specifically, the final disposal of the closet indicator exhibited an AUC value of 0.5. However, the Z-test significance value associated with this indicator was 0.465. This value exceeds the conventional type-I error threshold ($\alpha = 0.05$), indicating insufficient evidence to reject the null hypothesis (H_0). This suggests that the AUC for this indicator is not significantly different from that of the diagonal (45-degree) line, indicating no discriminative ability.

Given these results, the four aforementioned indicators were excluded from further identification and analytical processes employing ROC methodology. Conversely, the analysis revealed that the remaining indicators had Z-test significance levels below the threshold of 0.05. This outcome allows for rejection of the null hypothesis, which asserts that the true AUC is 0.5. Therefore, these indicators were deemed appropriate for inclusion in subsequent analyses.

Figure 2. ROC Curve



Receiver-operating-characteristic (ROC) curve analysis (Figure 2) is a pivotal method for evaluating the diagnostic efficacy of various indicators in a given dataset. In this analysis, three specific indicators, namely, the material of the roof, closet type, and final disposal of the closet, exhibited ROC curves below the reference line at 0.50. This observation suggests that these indicators lack the discriminatory power necessary for inclusion in the subsequent identification processes.

Conversely, the indicators pertaining to asset ownership, years of schooling, literacy, and protein consumption display curves that align closely with the 0.50 reference line. The proximity of these curves to the reference line makes it challenging to draw definitive conclusions based solely on visual assessment. Therefore, further statistical evaluations, including the results of the Z-test, as presented in Table 6, are required to thoroughly interpret and validate the efficacy of these indicators.

Table 7. Best Cut-Off Resulting from ROC

Test Result Variable(s)	Gini Index	Cut-off
Material of Roof	-0.021	6.50
Material of Wall	0.193	2.50
Material of Floor	0.281	3.50
Closet Ownership	0.153	1.50
Closet Type	-0.062	1.50
Final Disposal of Closet	-0.041	3.50
Drinking Water	0.312	3.50
Bathing/Washing/Others Water	0.231	4.50
Electricity Access	0.133	1.50
Cooking Fuel	0.303	7.50
Asset Ownership	0.004	2.50
Years of Schooling	-0.005	2.50
Literacy	0.021	1.50
Protein Consumption	0.021	61.50
Calori Consumption	0.629	1894.50

Source: Processed from BPS Susenas 2020

From the preceding table, it is evident that four indicators are excluded from further analysis because of their negative Gini index values. The implications of these exclusions become particularly significant when examining the cut-off values delineated within the analysis. Two distinct analytical trajectories stemming from these cut-off values exist.

First, a receiver-operating-characteristic (ROC) curve analysis applied to the top ten indicators presented in Table 7 demonstrates a positive correlation between the indicator values and poverty status. Specifically, as the data values associated with these indicators increase, the probability of identifying a household as poor increases correspondingly. For instance, one may consider an indicator related to wall materials that categorizes households as poor when the data value reaches or exceeds 2.5. This highlights that an enhancement in the quality of wall materials diminishes the likelihood of poverty.

Conversely, the ROC Curve analysis for the five subsequent indicators indicated a negative correlation between the indicator values and poverty status. In this case, the identification of a household as poor becomes more probable as indicator values decrease. For example, in assessing literacy levels, a threshold of 1.5 or lower signifies a higher likelihood of poverty among households. This analysis revealed that lower literacy rates are associated with an increased incidence of poverty.

Following the identification of relevant variables and optimal cut-off values, the subsequent phase involves assigning a score to each household. The cumulative score was calculated in accordance with the standard weights specified in the Alkire-Foster method, as detailed in Table 5. This cumulative score is then juxtaposed against a dimension cut-off established through ROC analysis of the cumulative scores from the previous analysis in relation to monetary poverty status.

ROC analysis culminated in an Area Under the Curve (AUC) value of 0.688, accompanied by a significance level of 0.00. This result demonstrates the adequacy of the household cumulative score as a reliable basis to identify poverty. Furthermore, a dimension cut-off value of 0.6042 was derived from this analysis.

Upon determining the dimension cut-off, the cumulative scores of households can be assessed to classify them into poor or non-poor categories. Specifically, households with cumulative scores below the dimension cut-off were not categorized as poor, whereas those with scores equal to or exceeding this threshold were deemed poor. The findings of this classification process are systematically presented in the following table, which elucidates the outcomes of this methodological approach.

Table 8. Results of Identification Using the ROC Method

Household Status	Frequencies	Percentage
Non-Poor	53.920.873	74.07
Poor	18.871.413	25.93
Total	72.791.519	100.00

Source: Processed from BPS Susenas 2020

The information obtained from Table 8 shows that 25.93 percentage of the households were poor. This result is quite different from the result obtained from the calculation process using the Alkire-Foster method (32.6 percent), which is almost 7 percent smaller. This is due to the use of the optimal cut-off resulting from the ROC analysis, especially the dimensional cut-off. The Alkire-Foster method uses a dimensional cut-off of 0.33 while the ROC method uses an optimal cut-off of 0.6042.

The use of an optimal cut-off dimension of 0.6042 suggests that a household is considered non-poor if it does not experience deprivation in at least two dimensions. On the other hand, the Alkire-Foster method with a cut-off of 0.33 shows that a household is not poor as long as it is not deprived in at least one dimension of poverty.

4.3 Poor Household Identification Results Using the AF-MCA Method

The next step was to conduct multiple-correspondence-analysis (MCA) to obtain the best weight. Specifically, MCA analysis was conducted on the initial indicators used in the Alkire-Foster analysis. The input used in this analysis process is the result of household scorings per indicator that contains nominal (binary) data values after the indicator data value of each household is compared with the cut-off of each indicator. Then, to be processed, the data must be recoded first because the MCA analysis in SPSS software requires nominal data with values that cannot contain 0. Therefore, the score of deprived households on an indicator that should have a score of 1 is recoded to 2, and those that are not deprived are recoded from a score of 0 to 1. An important result of this analysis is presented in Table 9.

Table 9. Discrimination Measures and Contributions of MCA Results

Indicators	Dimension 1	Contribution
Material of Roof	0.100	4.07
Material of Wall	0.138	5.61
Material of Floor	0.135	5.49
Closet Ownership	0.153	6.21
Closet Type	0.153	6.22
Final Disposal of Closet	0.127	5.17
Drinking Water	0.567	23.04
Bathing/Washing/Others Water	0.521	21.20
Electricity Access	0.157	6.39
Cooking Fuel	0.401	16.29
Asset Ownership	0.000	0.001
Years of Schooling	0.000	0.01
Literacy	0.001	0.02
Calori Consumption	0.005	0.21
Protein Consumption	0.002	0.07
Active Total	2.459	100.00
% of Variance	16.396	

Source: Processed from BPS Susenas 2020

Here, 16.396% of the model's variance is explained by one dimension, this result can be said to be quite low. This implies that even the addition of subsequent dimensions shows an insignificant increase. Thus, the discrimination measures serve as weights for the subsequent identification steps. Substituting these weights into the original scores in Alkire-Foster yields the following results:

Table 10. Results of Identification Using the AF-MCA Method

Household Status	Frequencies	Percentage
Non-poor	49.030.968	67.36
Poor	23.761.318	32.64
Total	72.791.519	100.00

Source: Processed from BPS Susenas 2020

The results in Table 10 show that the poor status of households is 32.64 percent, which is almost identical to the results of the identification using the Alkire-Foster method (32.60 percent). At first glance, it seems that there is no difference between the results of the two methods; however, if we look in more detail in terms of weights, the results of the MCA process compared with the original weights of the AF method are as follows:

Table 11. Weight Comparisons of AF and AF-MCA Method

Poverty dimensions	Weight	
	AF Method	AF MCA method
Health	0.3333	0.0028
Education	0.3333	0.0003
Living standard	0.3333	0.9969

Source: Processed from BPS Susenas 2020

Table 11 shows that the decent living dimension in the AF-MCA method has a much greater weight than other dimensions. The sum of the weights of the health and education dimensions was less than 1 percent. This shows that as long as households cannot be separated from deprivation in the decent living dimension, even though the other dimensions are good, they will still be included in the category of poor households. The use of a dimension cut-off of 0.33, as is common in the AF method, is not appropriate because of the dominance of the weight of the decent living dimension.

4.4 Poor Household Identification Results Using the ROC-MCA Method

The identification process was continued by combining the previously established ROC results (validated indicators and optimal cut-off values). After the ROC analysis process at the previous stage, 11 suitable indicators and optimal cut-offs were obtained for use in the next process. As for the weights in the MCA analysis, they must be calculated again because the previous MCA method analysis used 15 indicators in accordance with the AF method, while only 11 indicators were used here. Using the 11 indicators, the MCA weights were determined, as shown in Table 12.

Table 12. Discrimination Measures and Contributions of MCA Results

Indicators	Dimension 1	Contribution
Material of Wall	0.145	6.397
Material of Floor	0.127	5.612
Closet Ownership	0.235	10.378
Drinking Water	0.619	27.345
Bathing/Washing/Others Water	0.579	25.545
Electricity Access	0.142	6.262
Cooking Fuel	0.407	17.984
Asset Ownership	0.000	0.001
Calori Consumption	0.007	0.324
Protein Consumption	0.003	0.142
Literacy	0.000	0.011
Active Total	2.783	100
% of Variance	20.592	

Source: Processed from BPS Susenas 2020

Table 12 provides information on the increase in the percentage of diversity that can be explained by the model with one dimension to 20.592 after reducing the indicators to 11 using the ROC method. This result shows that the weight generated by the MCA process was improved. The weights of each indicator used in the identification process using the ROC-MCA method are listed in table.

The cut-off dimension used in this method was also obtained from the ROC Analysis process on the cumulative score of households with monetary poverty status variables. From this process, the dimension cut-off value was 0.5313. Next, a comparison is made if the cumulative score is greater than the dimension cut-off, then the household is categorized as a poor household, and vice versa. The results of the identification process are as shown in Table 13.

Table 13. Results of Identification Using the ROC-MCA Method

Household Status	Frequencies	Percentage
Non-poor	52.888.393	72.66
Poor	19.903.893	27.34
Total	72.791.519	100.00

Source: Processed from BPS Susenas 2020

The use of the best indicators, weights, and cut-offs produces a percentage of poor households that is between the results of the AF or AF-MCA method and the ROC method. However, when viewed from the perspective of the use of weights in this method, it is also not much different from the results of the AF-MCA method, where the decent standard of living dimension has a dominant weight (more

than 99 percent). Therefore, it can be said that the use of a cut-off dimension of 0.5313 indicates that if a household can be free from deprivation in half of the decent standard of living dimensions, then the household will be free from poverty.

4.5 Best Method Evaluation

4.5.1 Accuracy Measurement

To evaluate these methods, cross-tabulations between the identification results (all four methods) and monetary poverty identification (confusion matrix creation) were performed in Table 14.

Table 14. Confusion Matrix

			Monetary poor				Total	
			Poor		Non-poor			
			Count	% of Total	Count	% of Total	Count	% of Total
Mulidimensions poor	Alkire Foster (AF) method	Poor	2156403	2.96%	21571967	29.63%	23728370	32.60%
		Non-poor	4880030	6.70%	44183886	60.70%	49063916	67.40%
		Total	7036433	9.67%	65755853	90.33%	72792286	100.00%
	ROC method	Poor	3479872	4.78%	15391541	21.14%	18871413	25.93%
		Non-poor	3556562	4.89%	50364312	69.19%	53920874	74.07%
		Total	7036434	9.67%	65755853	90.33%	72792287	100.00%
	AF MCA method	Poor	4043887	5.56%	19717431	27.09%	23761318	32.64%
		Non-poor	2992546	4.11%	46038422	63.25%	49030968	67.36%
		Total	7036433	9.67%	65755853	90.33%	72792286	100.00%
	ROC MCA method	Poor	3970265	5.45%	15933628	21.89%	19903893	27.34%
		Non-poor	3066168	4.21%	49822225	68.44%	52888393	72.66%
		Total	7036433	9.67%	65755853	90.33%	72792286	100.00%

Source: Processed from BPS Susenas 2020

The confusion matrix shows a comparison of the percentage of mismatches obtained from the identification results. In general, it can be seen that the ROC and ROC-MCA methods have a higher percentage of households that are monetarily and multidimensionally poor and not monetarily and multidimensionally poor compared to other methods. This shows that ROC analysis provides positive results in reducing existing mismatches. For more details on the accuracy of each method, refer to Table 15.

Table 15. Accuracy Measurement Results

	Alkire Foster (AF) method	ROC method	AF MCA method	ROC MCA method
PCC	0.637	0.740	0.688	0.739
PIC	0.363	0.260	0.312	0.261
F1	0.140	0.269	0.263	0.295

Source: Processed from BPS Susenas 2020

From Table 15, it can be seen that the ROC method has the largest PCC value and smallest PIC value, with only one number adrift, compared to the ROC-MCA method. However, for the F1 value, which is a harmonized measure that is much better when used on imbalanced data, where the proportion of poor and non-poor categories is not balanced, the ROC-MCA method shows a higher value. Therefore, considering that the difference in the PCC and PIC values is only one number difference, and the F1 value is greater, it can be concluded that, in the comparison of accuracy measures, the ROC-MCA method is better than the other methods.

The implementation of the ROC-MCA method only slightly increased the MCA variance value from 16.396 when using 15 indicators in the AF-MCA method to 20.592 when using 11 indicators. These results show that the effect of using the optimal weight in the ROC-MCA method is small. However, this shortcoming is covered by the use of optimal cut-off results from the ROC analysis process; thus, it still provides better results than other methods. Therefore, it can be concluded that the optimal cut-off of the ROC analysis results in better results than the arbitrary cut-off of the Alkire-Foster method.

Tabel 16 Details of Confusion Matrix

Household groups	Alkire Foster method	ROC method	AF MCA method	ROC MCA method
Group 1 (Monetary and multidimensions poor)	2.96%	4.78%	5.56%	5.45%
Group 2 (Monetary poor and multidimensions non-poor)	6.70%	4.89%	4.11%	4.21%
Group 3 (Monetary non-poor and multidimensions poor)	29.63%	21.14%	27.09%	21.89%
Group 4 (Monetary and multidimensions non-poor)	60.70%	69.19%	63.25%	68.44%
PCC	0.637	0.74	0.688	0.739
F1	0.14	0.269	0.263	0.295

Source: Processed from BPS Susenas 2020

Regarding the first and second questions in the research objectives, which want to see if the use of ROC analysis and MCA can provide better identification results than if the process was not used, the results are shown in Table 16. In addition to being seen through the PCC and F1 values, the advantages of the ROC and MCA methods can be seen from the smaller mismatch that occurs, namely the decreasing proportion of Groups 2 and 3, and the larger proportion of Groups 1 and 4 when these methods are used.

When the threshold/cut-off was aligned with the ROC Analysis, the proportion of Group 2 in the AF method (6.70%) decreased to 4.89 percent in the ROC method and 4.21 percent in the ROC-MCA method. Group 3 also experienced the same incidence; the proportion of 29.63 percent using the AF method decreased to 21.14 percent using the ROC method and 21.89 percent using the ROC-MCA method. This also resulted in an increase in the proportion of Groups 1 and 4 and an increase in the accuracy values (PCC and F1).

The use of MCA to determine the optimal weight also has a positive impact on the identification results. From Table 16, it can be seen that the proportion of Group 2 in the AF method decreased by 6.7 percent and 4.11 percent in the AF-MCA method and 4.21 percent with the ROC-MCA method, respectively. Group 3 experienced the same phenomenon, ranging from 29.63 percent in the AF method to 27.09 percent in the AF-MCA method and 21.89 percent in the ROC-MCA method.

In general, if accuracy is measured using PCC, then the use of the ROC method increases the accuracy level by 0.103, whereas the use of the MCA method increases the accuracy by 0.051, and the combination of the two methods increases the accuracy by 0.102. On the other hand, if measured using F1, the highest increase in accuracy occurred with the combination of the two methods, namely, ROC-MCA of 0.15. Therefore, it can be concluded that the use of ROC and MCA Analysis methods improves the accuracy and provides better results in the process of identifying poor households. Even when the two methods were combined, the ROC-MCA method was found to be superior.

4.5.2 Comparison of Dispersion Measures between Classification Groups

Each of the poor household identification methods used in this study categorizes households into four groups: monetarily and multidimensionally poor, monetarily poor and multidimensionally non-poor, monetarily non-poor and multidimensionally poor, and monetarily and multidimensionally non-poor. It is then possible to compare the size of the dispersion of each of these groups in each identification method, with a focus on per capita expenditure and cumulative household scores. Per capita expenditure was chosen as the focus in this case because the more homogeneous the per capita expenditure in each identification group, the easier it will be for the preparation of various government programs related to poverty alleviation to be more targeted.

Then, the cumulative score of the household illustrates its position in relation to its ability to escape deprivation in each indicator. The results of the dispersion measurement calculation are listed in Table 17.

Table 17 Comparison of Cumulative Score Dispersion Measures

Groups	AF		ROC		AF MCA		ROC MCA	
	Range	Variance	Range	Variance	Range	Variance	Range	Variance
1	0.58	0.01	**0.38**	**0.01**	0.87	0.03	0.47	0.02
2	**0.32**	**0.01**	0.58	0.02	0.33	0.01	0.53	0.03
3	0.61	0.01	**0.38**	**0.01**	0.87	0.02	0.47	0.02
4	**0.32**	**0.01**	0.58	0.03	0.33	0.01	0.53	0.03
Average	**0.45**	**0.01**	0.48	0.01	0.60	0.02	0.50	0.02

Source: Processed from BPS Susenas 2020

The results of calculating the dispersion measure for the cumulative household score in Table 17 using both range and variance measures show that the Alkire-Foster method has the smallest value for Groups 2 and 4. For Groups 1 and 3, the ROC method had a smaller range and variance than the other methods. When viewed as a whole, with the average figures of the range and variance obtained, the AF method has an advantage over the other methods because it has a smaller value.

Table 18 Comparison of Dispersion Measures of Standardized Per Capita Expenditure

Groups	AF		ROC		AF MCA		ROC MCA	
	Range	Variance	Range	Variance	Range	Variance	Range	Variance
1	0.294	0.002	0.294	0.002	0.299	0.002	0.299	0.002
2	0.299	0.002	0.299	0.002	0.297	0.002	0.297	0.002
3	41.748	1.469	33.662	0.450	31.457	0.320	**18.853**	**0.227**
4	**35.751**	**0.816**	41.748	1.189	41.748	1.285	41.748	1.239
Average	19.523	0.572	19.001	0.411	18.450	0.402	**15.299**	**0.367**

Source: Processed from BPS Susenas 2020

Next, we compare the size of the dispersion between each group of poor households based on the identification method, which refers to the per capita expenditure figure (Table 18). The per capita expenditure figure is standardized before use, with the aim of making it easier to read the comparison table without reducing the essence of the dispersion measure itself. Although the range size was compressed, it was still possible to obtain intuition from the results.

The range and variance figures obtained for Groups 1 and 2 were almost the same, with very small differences for all identification methods. For Group 3, the range and variance values obtained using the ROC-MCA method were much smaller than those obtained using the other methods, with a fairly significant distance. For Group 4, the Alkire-Foster method had a smaller value than the other

methods. Overall, it can be seen from the average of both range and variance that the ROC-MCA method has a smaller advantage than other methods.

The conclusions from the comparisons in Tables 14, 15, and 16 indicate that the AF and ROC-MCA methods have their respective advantages. In Table 15, even though the ROC-MCA method has no advantage, the difference in numbers is quite small compared to the results of the AF method. Therefore, it can be said that for the comparison of dispersion measures, the ROC-MCA method has advantages compared to other methods. This is also in accordance with the results of a previous comparison of accuracy measures. Therefore, it can be concluded that the best method is the ROC-MCA method.

4.6 Unique features of ROC-MCA analysis

The identification method for poor households using ROC-MCA, as used in this study, has a unique feature that cannot be found in other identification methods. This unique feature is the existence of a cut-off analysis, which can compare the optimal cut-off owned by this method with various cut-offs arbitrarily set by other identification methods. This unique feature is also supported by the unique requirement of running this analysis method, which is to have data containing the various indicators used in this multidimensional poverty analysis, as well as monetary poverty data in the same package.

Based on the results of this study, the optimal cut-off of the ROC-MCA method can be compared with the arbitrary cut-off set in the AF method. The results of the comparison are shown in the table below:

Table 19 Comparison of ROC-MCA and AF Method Cut-offs

Test Result Variable(s)	Material of Roof	Material of Wall	Material of Floor	Closet Ownership	Closet Type	Final Disposal of Closet	Drinking Water	Bathing/Washing/Others Water	Electricity Access	Cooking Fuel	Asset Ownership	Years of Schooling	Literacy
Cut-off ROC-MCA	6.5	2.5	3.5	1.5	1.5	3.5	3.5	4.5	1.5	7.5	2.5	2.5	1.5
Cut-off AF	5	4	8	4	2	3	5	5	4	8	1	5	0

Source: Processed from BPS Susenas 2020

The information in Table 19 shows that the education dimension had a difference between the optimal cut-off of ROC-MCA and AF. The average years of schooling in the AF method uses a cut-off of below 6 years or a maximum of 5 years to be considered poor, while the results from ROC show 2.5 or a maximum of 2 years to be considered poor. This discrepancy shows the gap between the identification of monetarily poor households represented by the optimal cut-off of ROC-MCA and the

multidimensionality of AF. This means that it can be assumed that 6 or even 9 years of basic education of the household head cannot prevent poverty in the entire household.

The literacy indicator also exhibited the same phenomenon. The optimal ROC-MCA cut-off is below 1.5 or a maximum of 1, which means that household heads who can read and write one type of language fall into the poor category. Therefore, it can be concluded that the ability to read and write to the head of the household is not expected to prevent poverty in the entire household. The indicators of the living-standards dimension also showed significant differences, where the majority of the cut-off numbers from the AF method were higher than the ROC-MCA optimal cut-off.

4.7 Multidimensional Poverty Index

Based on the previously explained formula for calculating the multidimensional poverty index using the MPI method (Alkire and Foster, 2011), the multidimensional poverty index can be calculated using the results of the identification process. The results of the multidimensional poverty index calculation are as follows:

Table 20. Multidimensional Poverty Index

Identification methods	Head count ratio (H)	Poverty intensity (A)	Multidimensional poverty index (MPI)
AF	23,77%	41,87%	9,95%
ROC	27,50%	71,96%	19,79%
AF MCA	32,59%	54,43%	17,74%
ROC MCA	27,49%	69,59%	19,13%

Source: Processed from BPS Susenas 2020

The multidimensional poverty rate, commonly known as the headcount ratio (H), describes the proportion of multidimensional poor population to the total population. Table 20 shows that the headcount ratio (H) for the AF method is the lowest compared to the other methods. This is due to the use of individual weights, because the H value here has a unit of people. Therefore, this figure is quite different from the large proportion of poor households, where the ROC and ROC-MCA methods have a smaller proportion of poor households than the AF and AF-MCA methods do. It is suspected that households identified as poor using the AF method had fewer household members.

Similarly, the intensity of multidimensional poverty or intensity of poverty (A) describes the average amount of deprivation experienced by individuals in the indicators used. The intensity of poverty (A) in the method using ROC Analysis tended to be greater. This is thought to be due to the use of ROC Analysis in the formation of cut-off indicators and dimension cut-offs, which makes the calculation of the A value more sensitive. The majority of the cut-off indicators formed had smaller

values compared to the arbitrary cut-off methods AF or AF-MCA, causing more individuals to be identified as multidimensionally poor and have a higher average deprivation.

The MPI figure, or the multidimensional poverty index, shows that the method using ROC Analysis has a higher MPI value. This figure is higher than other methods due to the high value of A. This MPI figure is more suitable for use in spatial and temporal comparisons because it includes element A in its calculation formula. By entering element A, the MPI value fulfills the axiom of dimensional monotonicity (Asselin and Anh, 2008), meaning that the more an individual is deprived of the indicators used, the higher the MPI value.

4.8 Results of Provincial Level Poor Household Decomposition

The results of poverty analysis using the ROC-MCA method can be decomposed to a lower regional level. This research uses the national level as a reference for the analysis, so the decomposition can be performed at the provincial level or even at the district level. The results of the decomposition at the provincial level, as well as its comparison with various analysis results from other sources, are shown in Table 21.

As shown in Table 21, the highest MPI was found in Papua Province. The results of the ROC-MCA decomposition calculations were confirmed by various results obtained using other methods. Interestingly, the results show that Papua Province had the highest poverty intensity value (A). This figure shows that individuals in Papua Province have a higher experience of being trapped in poverty in various indicators or dimensions than those in other regions. This information provides more insight for policymakers to formulate the right policy direction for reducing poverty.

The numbers displayed by the ROC-MCA method tended to be larger compared to the results from other methods. This is due to the use of more dimensions or indicators when compared to the monetary poverty method as well as the use of the ROC method, which produces different cut-offs when compared to the AF method.

Meanwhile, the lowest MPI number from the ROC-MCA results was in the DKI Province. This result is not different from the calculation of the AF method using the 2017 DHS data conducted by Alkire et al. (2017). The AF method using Susenas 2020 data and monetary poverty showed different results. In general, the decomposition results of the multidimensional poverty calculation using the ROC-MCA method are still good and reasonable for use as a reference in formulating provincial or lower-level policies.

Table 21 Comparison of the Percentage of Monetary and Multidimensional Multidimensional Poverty

Provinsi	MPI ROC-MCA			MPI AF (Susenas 2020)			Percentage of Monetarily Poor Population (BPS 2020)	MPI AF (SDKI 2017)		
	H	A	MPI	H	A	MPI		H	A	MPI
Aceh	39.19%	67.59%	0.26	12.92%	41.49%	0.05	14.99%	3.04%	38.81%	0.012
Sumatera Utara	24.70%	72.93%	0.18	17.85%	40.10%	0.07	8.75%	4.95%	42.09%	0.021
Sumatera Barat	33.84%	70.20%	0.24	11.84%	41.07%	0.05	6.28%	3.42%	36.41%	0.012
Riau	24.96%	66.99%	0.17	14.41%	39.77%	0.06	6.82%	2.31%	38.91%	0.009
Jambi	44.17%	66.89%	0.30	16.93%	41.81%	0.07	7.58%	1.81%	36.75%	0.007
Sumatera Selatan	40.13%	66.98%	0.27	22.49%	42.84%	0.10	12.66%	3.74%	40.60%	0.015
Bengkulu	47.31%	65.63%	0.31	23.65%	43.88%	0.10	15.03%	2.20%	36.18%	0.008
Lampung	49.06%	65.04%	0.32	26.35%	44.79%	0.12	12.34%	3.39%	37.49%	0.013
Bangka Belitung	17.66%	62.15%	0.11	25.03%	40.96%	0.10	4.53%	3.94%	37.19%	0.015
Kepulauan Riau	12.25%	63.38%	0.08	26.13%	40.27%	0.11	5.92%	1.41%	36.69%	0.005
DKI Jakarta	0.29%	57.97%	0.00	34.27%	39.43%	0.14	4.53%	1.49%	35.01%	0.005
Jawa Barat	18.26%	67.32%	0.12	33.56%	42.00%	0.14	7.88%	2.39%	37.02%	0.009
Jawa Tengah	28.99%	65.20%	0.19	27.30%	42.48%	0.12	11.41%	2.76%	36.20%	0.010
DI Yogyakarta	30.66%	65.55%	0.20	28.91%	42.28%	0.12	12.28%	2.29%	35.40%	0.008
Jawa Timur	25.00%	67.26%	0.17	22.92%	41.39%	0.09	11.09%	2.95%	36.76%	0.011
Banten	11.85%	72.37%	0.09	12.67%	40.11%	0.05	5.92%	3.91%	38.95%	0.015
Bali	14.81%	69.54%	0.10	16.17%	39.07%	0.06	3.78%	2.19%	35.97%	0.008
Nusa Tenggara Barat	33.46%	71.76%	0.24	28.17%	42.98%	0.12	13.97%	4.53%	37.04%	0.017
Nusa Tenggara Timur	71.29%	82.58%	0.59	22.58%	46.35%	0.10	20.90%	16.12%	40.69%	0.066
Kalimantan Barat	53.78%	66.99%	0.36	18.80%	43.69%	0.08	7.17%	5.35%	39.34%	0.021
Kalimantan Tengah	31.11%	73.53%	0.23	17.23%	41.82%	0.07	4.82%	4.68%	36.96%	0.017
Kalimantan Selatan	28.04%	69.89%	0.20	13.94%	40.43%	0.06	4.38%	4.95%	37.63%	0.019
Kalimantan Timur	8.93%	68.93%	0.06	20.68%	38.89%	0.08	6.10%	2.36%	37.04%	0.009
Kalimantan Utara	19.62%	74.22%	0.15	25.57%	42.10%	0.11	6.80%	6.19%	39.09%	0.024
Sulawesi Utara	28.30%	67.40%	0.19	38.40%	42.40%	0.16	7.62%	2.07%	38.12%	0.008
Sulawesi Tengah	40.13%	76.30%	0.31	17.02%	42.67%	0.07	12.92%	6.63%	37.88%	0.025
Sulawesi Selatan	28.09%	69.60%	0.20	13.01%	40.45%	0.05	8.72%	2.88%	37.86%	0.011
Sulawesi Tenggara	35.42%	71.83%	0.25	11.91%	40.46%	0.05	11.00%	5.18%	40.32%	0.021
Gorontalo	23.01%	70.49%	0.16	10.77%	39.47%	0.04	15.22%	8.88%	40.00%	0.036
Sulawesi Barat	49.96%	72.69%	0.36	13.56%	44.16%	0.06	10.87%	7.13%	39.37%	0.028
Maluku	54.15%	74.38%	0.40	10.93%	42.57%	0.05	17.44%	5.36%	39.14%	0.021
Maluku Utara	51.59%	77.83%	0.40	14.16%	42.51%	0.06	6.78%	7.75%	43.01%	0.033
Papua Barat	38.40%	77.67%	0.30	13.75%	42.04%	0.06	21.37%	9.58%	43.25%	0.041
Papua	65.98%	90.91%	0.60	30.34%	45.93%	0.14	26.64%	17.93%	46.21%	0.083

Source: Processed from BPS Susenas 2020

5. Conclusions and Suggestions

The main objective of this study is to obtain an accurate method for identifying the poor that can connect two approaches to poverty calculation: monetary and multidimensional poverty calculation. Therefore, two analytical methods were proposed in this study: ROC and MCA. In addition, these two analyses are expected to reduce the shortcomings of the multidimensional poverty calculation proposed by Alkire-Foster. Four types of poor household identification methods were compared: the Alkire-Foster (AF) method, ROC method, AF-MCA method, and ROC CMA method.

After evaluating the entire analysis process by comparing all the types of identification methods, it was concluded that the ROC-MCA method was the best. This evaluation process consists of a comparison of accuracy and dispersion measures, where the result is that the ROC-MCA method has a higher level of accuracy using the F1 score, which is very suitable for imbalanced cases. In general, based on the F1 score, the use of the ROC-MCA method increased the accuracy percentage by 0.15, which is the highest number compared to the improvement using the other methods. Therefore, it can be concluded that the use of ROC and MCA Analysis methods improves the accuracy and provides better results in the process of identifying poor households and can significantly reduce the mismatch between the two approaches to poverty calculation, namely monetary and multidimensional poverty.

Furthermore, the results of the ROC-MCA Analysis show that the proportion of Group 3 households, namely households that are not monetary poor but multidimensional poor, is larger than that of Group 2 households, or households that are monetary poor but not multidimensional poor. This shows that many people are still detected as living above the monetary poverty line but are still unable to enjoy the lowest standards of education, health, and living. Therefore, Group 3 should be targeted for conditional government assistance programs in dimensions that are in accordance with the conditions of poor households. As for households classified as Group 1, namely the monetary and multidimensional poor, it is hoped that they can also be the main target of all government assistance programs because from two different perspectives, there is no contradiction in the status of these households.

However, the ROC-MCA method provides reliable results in identifying poor households, regardless of the quality of the indicators used. Better results can be obtained using more appropriate indicators. This is evidenced by the percentage of diversity that can be explained by the MCA analysis, which is quite small (around 20 percent) but can still show the best evaluation results.

The decomposition results of the ROC-MCA method were also reasonable. Supported by a unique feature, namely, cut-off analysis, the results of the ROC-MCA analysis can be used as a reference to support various government policies in alleviating poverty.

Suggestions for further research and, at the same time, discussion materials that can be taken from this study include the following: First, as seen from the results of the MCA analysis, which shows

that the percentage of diversity that can be explained by the model is only 16.396 percent for 15 variables and 20.592 for 11 variables. This means that the indicators used were not suitable for the analysis; therefore, it is possible to obtain indicators that are more suitable for future research.

Second, the problem of aligning the indirect approach to poverty, which is short-term, with a direct approach to poverty, which is measured by multidimensionality and focuses on outcomes, will be very rough if measured only at one point in time. It would be better if measured with time-series or panel data because it can capture consumption smoothing and approach aggregate whole-lifetime consumption.

In addition, this method of alignment can be used not only for monetary poverty and multidimensional poverty. This method can also be used for comparison with other poverty calculation approaches such as subjective poverty and social exclusion. Therefore, the method developed in this study can be applied to other types of poverty identification approaches.

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A Qualitative Exploration of the Views of Entrepreneurship Educators in Assessing Educational Impact on Potential Graduate Entrepreneurs

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Abstract

Entrepreneurship is a key component of a growing economy, and graduate entrepreneurs are seen as valuable contributors to these economic goals. To facilitate this, entrepreneurship education is widespread at universities encompassing both on-curricular courses and extracurricular activities. However, there is not a uniform approach to entrepreneurship education with different topics, different objectives, and different metrics for success, taught by educators from vastly different backgrounds. An entrepreneurship course could conceivably have an objective of knowledge acquisition, upskilling, changing mindset, increasing entrepreneurial intention, venture creation, or simply the awareness of entrepreneurship as a career. There are also a variety of metrics that are used to measure the success of entrepreneurship education interventions from venture creation to entrepreneurial intention and self-efficacy. This paper attempts to understand the views of current educators and suggests what can be done to improve entrepreneurship education from an understanding what is effective. To this end, entrepreneurship educators working at UK universities were interviewed consisting of research focussed lecturers, teaching focussed lecturers, senior managers, support staff, and incubator managers. The findings suggest that there are a wide variety of backgrounds for entrepreneurship educators, with very few from an academic business strategy background as others have found, but from physical and biological sciences, economics, sociology as well as a small number from business areas such as marketing. They have transitioned into entrepreneurship through a variety of means e.g. an interest in sustainability, or from an experience of science spinouts

and a surprisingly large number had family members who were entrepreneurs. Many have come from a practical background and use this as part of their educational offering. Educators generally believed in experiential learning rather than theory, and mostly suggested they wanted to give students skills that can be applied during the course and afterwards, although most also included teaching some theoretical models. Staff showed evidence of tuning their offerings to their audience with case studies or live company projects where appropriate, with early years courses often focused on raising awareness of entrepreneurship as a career, whilst later years build skills for starting a venture or encourage venture creation itself. We conclude by understanding the motivations that entrepreneurship educators have for undertaking entrepreneurship education, discussing how these differing backgrounds can be utilised effectively and what part of the background, and suggest what activities and approaches they take are most effective in helping entrepreneurship educators enable successful student entrepreneurship.

Introduction

Entrepreneurship education grew markedly from the 1970s to mid-2000s in the US (Kuratko, 2005) and worldwide and it is now considered an essential component of the universities offering and key to a nation's economic growth. Entrepreneurship education covers a wide spectrum of activity, taught and managed by educators from very different backgrounds, teaching courses with varying objectives, and a variety of metrics used to determine success. With this heterogenous mix we seek to understand the backgrounds of the entrepreneurship educators and how they view entrepreneurship education with the intention of understanding what different backgrounds can bring and what might work best for the students. Those that have had experience starting their own business, those that have worked in support roles such as technology transfer, those with a research focus on a range of topics from innovation management, entrepreneurship, general business to risk management and dealing with uncertainty. The support mechanisms on offer to encourage and support entrepreneurship cover a wide range of interventions from standalone units, accelerators, and incubators (Wu et al, 2022) and cover research students also (Phillips, 2010).

There is not always consensus on what enterprise or entrepreneurship might mean (Pittaway & Cope, 2007), even between staff in the same institution. An entrepreneurship

education course could conceivably have a range of aims – knowledge acquisition (as a standard university module might do), changing a student's mindset and awareness of entrepreneurship and entrepreneurial intention, gaining skills, providing practical support, starting a business in some cases, and understanding how to create value for an employer. One of the aims can also be to reduce the fear of failure in students who are thinking about starting a business (Chapman & Phillips, 2022; Mathur & Phillips, 2025). There are a variety of metrics that are used to measure the success of entrepreneurship education interventions. These include metrics such as self-efficacy, venture creation, and entrepreneurial intention. These can be difficult to measure requiring pre and post activity questionnaires, tracking alumni over many years (Papadopoulou et al., 2022), and relatively few students start a business on graduation despite the increase in entrepreneurship education available (Phillips, 2018). Nabi et al (2017) found in their review that research in entrepreneurship education impact still mainly focuses on short-term and subjective outcome measures to determine success and found some contradictory findings regarding the success of different entrepreneurship education programmes. Fayolle (2018) suggests we need to do more to capture what is working, whilst some have found in fact that entrepreneurship doesn't always have its intended effect on students (Oosterbeek et al., 2010), with von Graevenitz et al., (2010) finding that intentions to start a business declined after a course of entrepreneurship education somewhat although the course had significant positive effects on students' self-assessed entrepreneurial skills. Wraae et al (2021) in their review found few papers that examine the perceptions of educators, and those that do focus on students in training to become educators.

Literature Review

The entrepreneurship educator can take many forms at the university, from research focused lecturer drawing on their knowledge of the field to teach "about" entrepreneurship, teaching focused lecturers using different pedagogic approaches to teach "for "entrepreneurship, to those teaching extracurricular practical support activities. Zappe et al (2013) found that faculty believed that entrepreneurial mindset could be developed through teaching using experiential learning, practice, and mentorship. Jones and Matley (2011) explain there are a variety of educators ranging from a business school background, and from arts and science faculties, with different ages and experiences, and with different

teaching qualifications. However, they suggest this great diversity is a strength, and advise against everything becoming standardised, such as a set curriculum imposed by universities and quality agencies. Seikkula-Leino et al (2010) found that in schools that the aims of entrepreneurship education were often unclear, and the practices, aims and the results not necessarily connected. In addition, entrepreneurship education was not confined to any particular subject area, and the teachers themselves often do not see themselves as doing entrepreneurship education. Samwel Mwasalwiba (2010) describe that there is a non-alignment between what educators and other stakeholders want to achieve in entrepreneurship education for students with the pedagogical approaches used, and success indicators which is compounded by the time lag between the moment that impact is assessed and when entrepreneurial action is expected to occur by the impact measurements, as data shows that often students start a business many years after graduation having worked in their industry for several years, so lengthy longitudinal studies are needed. They also point to the absence of a generally accepted framework for evaluating and assessing the outcomes of the entrepreneurship education process, and that programmes and pedagogy don't always match to the audience or to the desired objectives. Wraae & Walmsley (2020) even suggest that for some that it is precisely the ill-defined, multifaceted nature of teaching entrepreneurship that appeals to educators, from being a supervisor, coach and mentor and facilitator of learning. They also report the educators believed that it was more than just imparting subject knowledge, and that entrepreneurship education was about personal development and reflection also, which also involves going outside the comfort zone of both the teacher and students. Neck and Corbett suggest there is a continuum of activity and involvement of educators (Neck & Corbett, 2018) and how they teach based amongst other things on the student audience and course objectives, ranging from "Old School" lecturing with passive students and the aim of simply raising the awareness of entrepreneurship, to a more ideal entrepreneurship education involving the students in active learning, learning how to apply knowledge with the educator acting more as a facilitator, with a startup venture the outcome. They also suggest there is a high level of self-directed learning, to encourage students to learn how to learn and develop the capabilities to do so. However, the extent to which undergraduates can take control of their own learning is variable. San-Martin et al (2021) found the most important effect of entrepreneurship education according to students is the elimination of existing barriers and

fears to start a business, while teachers highlighted the impact on students' self-esteem, self-confidence, and creativity. This effectiveness will be improved if students perceive the teacher as a role model, which might be boosted if the teacher is has started their own business previously, one of the many routes that entrepreneurship educators might have taken during their career. Experiential learning is considered the favoured approach for entrepreneurial education as it contributes to a positive impact on entrepreneurial intention of the student and to the development of entrepreneurial skills and competences (Motta & Galina, 2023). Experiential learning coupled with an interdisciplinary approach is also a popular choice (Sanchez-Romaguera & Phillips, 2018). Henry (2020) discusses the content choices in entrepreneurship courses – there is a sense educators are trying to please too many people with content choices, and it would be better that educators take on the role of a 'unique aggregator' of entrepreneurship content, which comes from their own personal experience and perspective, and that teaching from this experience could be the most effective way and not necessarily using a standard curriculum using standard topics and models with an understanding that there is no one size fits all solution for students. Conversely, Fiet (2001) suggests that since we cannot predict the future, a grounding in theory and application of the theory is the best approach. Hannon (2018) discusses being an entrepreneurship educator from personal experience having started a business on graduation and suggests educators will be better having experienced entrepreneurship for themselves. Kabongo & McCaskey (2011) found in their study in the USA that only 20% of entrepreneurship educators had a PhD in entrepreneurship and most came from a business strategy background. Related to this, Roslan et al (2022) found that lack of experience from teaching staff and issues around curricula design are a particular problem, and that university-industry collaborations are recommended to aid student and staff understanding of social entrepreneurship.

The aim of this paper was therefore to try to understand the motivations that entrepreneurship educators have for undertaking entrepreneurship education, the backgrounds they have and how these differing backgrounds can be utilised effectively and what part of the background is most effective in helping entrepreneurship educators enable student entrepreneurship.

Methodology

As this was an exploratory study, it was decided semi-structured interviews were the most appropriate method to collect primary data. The interviewees were 7 entrepreneurship educators directly working with students in entrepreneurship education. The interviewees consisted of teaching focussed lecturers, senior managers, support staff running workshops and competitions, and accelerator/incubator managers. All the interviewees currently work at a UK university delivering entrepreneurship education. Interviews were carried out online, recorded, transcribed and themes identified. The university's ethical approval tool was used, and further ethical approval was deemed as not required.

Table 1: The themes and questions used as the basis for the semi-structured interviews

Theme	Questions used for the basis of discussion
Background	What is your background in terms of university education?
	Were you interested in entrepreneurship at university?
	Did you have any on curricular entrepreneurship education at university?
	Did you do any extracurricular activities in entrepreneurship and was this compulsory or optional?
	What did you think of these? What was your overall experience of entrepreneurship education at university?
	When do you think your interest in entrepreneurship first materialised?
Prior to University	Do you have any family or friends who are entrepreneurs that you knew prior to university?
	Did you do any entrepreneurial activities at school?
While at University	Did you start a business yourself while at university? What happened to it? Did you learn anything from this?
	Did you undertake any work experience at university? What was that? Did you learn anything from this? What was it - an internship, summer job, year in industry etc?
	Have you had a job since leaving university and prior to your current appointment – was this relevant to entrepreneurship?
	Was any of your work experience with startups or any organisation that support startups such as technology transfer, banking, funding, accelerators etc?
Your role now	Whats your job and main role now?
	What do you think is the aim of entrepreneurship education? what is the aim of your courses?
	How would you describe your teaching style?

	What sort of topics do you think an entrepreneurship education course should include? What specific topics should be covered?
	What skills should a student expect to have at the end of your courses?
General thoughts on entrepreneurship education	What do you feel works in terms of entrepreneurship education?
	Do you measure any outputs/outcomes from your entrepreneurship education?
	What metrics do you think we should be measuring – if anything?
	Is there any pragmatism in your teaching – do you feel held back by the university in terms of what you do/would like to do (e.g. content, structure of course or assessment)?
	What do you think we should be offering that we don't offer at the moment?
	What skills do you think entrepreneurship should teach?
	What % of students do you think should be coming out of university and starting a business?
	Have any activities you have done or organised changed your views on entrepreneurship education?
	How do you keep up to date with entrepreneurship education?

Results and Discussion

A summary of the interviewees responses who took part in the study is show in table 2, including their institutional position, educational and work background, teaching style, and whether they had any family members who were entrepreneurs.

Table 2: Interviewees who took part in the study

Participant	Position	Education and Work Background	Teaching and Teaching Style	Any Entrepreneur relatives
A	Teaching focused lecturer	Physical sciences PhD, worked in industry, then an MBA	Hands on teaching style, including sustainability	No
B	Teaching focused lecturer	Sociology and psychology PhD, then working at a sustainability charity working with a range of companies	Consultancy projects, business plans – more active real-world cases	No

C	Ecosystem manager	Business degree, interested in entrepreneurship through working with entrepreneurial people in the music industry	Extracurricular programmes	Yes
D	Business development manger	Chemistry degree and PhD, postdoc, partook in consultancy work whilst a postdoc	Extracurricular programmes	Yes
E	Digital enterprise manager	Economics degree, became interested in entrepreneurship whilst working at the university in another role	Extracurricular programmes	Yes
F	Teaching focused lecturer	Economics and politics undergraduate degree, worked in a social enterprise foundation, then a PhD in sustainability	Experiential learning with industry live projects where possible	No
G	Teaching focused lecturer	Computer engineering degree, e- commerce masters, worked with a startup support organisation, then a PhD in tech startups	Case studies and experiential where possible	Yes

From the interviews, the first observation was that there is a range of different backgrounds and subject areas in this set of entrepreneurship educators. Whilst others, especially in the US have found that educators are generally from a business strategy background we found that educators came from a range of backgrounds – this included physical and biological science PhDs, management, economics, sustainability, and sociology. What was surprising was that almost all had done no entrepreneurship education whilst at university, and had moved into entrepreneurship education by different routes, such as from an interest in sustainability, or by working with startups at a government agency. Interest in entrepreneurship also came often by chance such as working with startups via consulting opportunities for money which were offered by their academic supervisor whilst at

university, or with holiday jobs working with enterprising businesses and people (e.g. from the music industry), or from other roles at the university.

The varying backgrounds has been perceived as a positive, as students themselves also come from a variety of backgrounds and will continue to do so if entrepreneurship education is open to all students. It also increases the multidisciplinarity of entrepreneurship courses and allows cross-fertilisation of ideas between different subject areas. Student have suggested that they prefer being taught entrepreneurship by role models, and this can benefit educators from their own subject area who might teach entrepreneurship. As well as this role model aspect, much research suggests that entrepreneurship education is not as successful with generic concepts as it makes it more difficult to relate to, and students prefer lecturers from their own background. This can be augmented further by bringing in examples and speakers from specific industries.

Most of the participants have worked before becoming entrepreneurship educators, but interestingly despite its potential usefulness for an entrepreneur, those interviewed said industry experience didn't necessarily help them think of entrepreneurship at the time – instead believing that industry experience was simply useful experience for a corporate industry job (rather than an academic job). We observed that many of the educators have come to entrepreneurship education from some form of practical experience rather than straight from academia.

Similarly, like many entrepreneurs, over half of the entrepreneurship educators had relatives who were entrepreneurs, even if they did not necessarily attribute this to their journey to being an entrepreneurship educator – it simply seemed to give them awareness that entrepreneurship was a possible career but seemed to give them no particular additional motivation to be an entrepreneur or an entrepreneurship educator.

However, despite the heterogeneity of the backgrounds of entrepreneurship educators, there were very similar views on how entrepreneurship should be taught i.e. it should be taught in an experiential way, if possible, in line with the QAA guidelines (QAA, 2018) and learning "for entrepreneurship" or "through entrepreneurship" rather than simply learning "about entrepreneurship" although it was agreed that learning "through" entrepreneurship could be harder to do authentically as part of a university module with the time available

and assessment options. Consultancy projects with entrepreneurial companies were seen as a good compromise to allow a structured course and assessment yet with a good degree of experiential learning. All participants generally believed in experiential learning rather than simply teaching theory, and most suggested as course outcomes they wanted to give students entrepreneurial skills such as models that can be applied both during the course and afterwards should they decide to continue with entrepreneurship. However, this was hedged partially by teaching some theoretical models also. i.e. teaching models and skills that students can use after the course. Fiet (2001) suggests that educators often teach from their own world view, which can make the syllabus very diverse as different educators prioritise different elements of entrepreneurship. This appears to be reflected in the views of the participants who included a range of topics on their courses from mindset to practical skills. This is positive for Entrepreneurship education since Jones and Matlay (2011) suggest that a diverse range of educators and techniques is a good thing and attempts to standardise everything with regulations should be resisted.

As entrepreneurship is less of a traditional subject by virtue of the need for a more experiential experience, when asked whether the university can be a barrier to instigating the type of course that might work more successfully, interviewees suggested that the university could be a barrier in terms of the choices of assessments that could be used and the standardisation of the frameworks in which the courses are built (such as lecture rooms, timetabling, and length of course), with it often difficult to move outside this administrative framework and with major changes having a long lead time. However, in terms of the actual course content, no restriction was reported by interviewees with lecturers feeling free to use different materials and topics and teaching methods as required, which agrees with the findings of Wraae et al (2020) who reported educators overall felt supported by their institutions and able to make changes to their teaching practice without too many institutional constraints. However, some mentioned university restrictions on the amount of online compared to in person teaching that was offered which could impact on course design.

Evidence suggests that educators did adapt their courses to fit their audience and were not simply teaching generic “about entrepreneurship” courses, and this was helped by the varied backgrounds of the educators. To help link entrepreneurship to specific subject areas,

educators used case studies or live company projects in those fields. In addition, educators often considered early years courses should simply be about generating awareness of entrepreneurship as a career for students, whilst later years course have a focus on the skills needed for starting a venture.

It was also observed that in terms of metrics for analysing the success of courses by the educators, most were simply using the university questionnaire for student feedback on completion of the course, although some attempted to list startups by their students that they knew about. Those running extracurricular activities generally did more to collect data such as numbers of startups, which was incentivised as this data was often needed for some reporting for the university and some specific grants.

Conclusion

The research has shown that rather than educators coming from a mainly business strategy background, in fact active entrepreneurship educators came from very varied backgrounds and reflects the varied student body that they teach. Positively, the university is generally open to the freedom of content, but changes take a long time especially changing the assessment and format and there is less incentive to make long term changes.

However, in terms of metrics, little data was collected regarding any aspect of venture creation, mindset, or efficacy by lecturers for on-curricular courses, with standard feedback sheets for course quality the only measurement. Those running extracurricular activities were more inclined to collect data, generally around venture creation, which was needed for university reporting. Educators suggested the entrepreneurial ecosystem at university needs more joining up – such as using the building of awareness of entrepreneurship through on curricular courses and linking to extracurricular activities which have practical support. This could form a clear pipeline clear signposting from courses to what next, as courses at best just equip you with some skills and models to apply if you decide to start a business, ultimately linking students who become aware of entrepreneurship, develop an idea, then need to develop the skills to take it forward and finally practical support such as incubators, accelerators, and funding to establish a successful startup.

Further work will investigate more direct linkages between the backgrounds of the educators, the teaching style, and the success of the courses in terms of improving mindset, self-efficacy, and venture creation.

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Stakeholders of Infrastructure Development Projects for Business Support: Fuzzy Logic Case Study

Abstract. During the implementation of the project, the list of stakeholders and their impact on the project may change. Therefore, methods based on a dynamic and unpredictable approach are needed. Cooperation with stakeholders allows for a synergy effect that ensures the achievement of the common good. One of the main tasks of stakeholder participation is to maximize the consistency of interests, minimize the risks of various destructive conflicts in cases where there is a disparity in mutual expectations, or the interests of individual stakeholders are ignored.

The author suggests a fuzzy logic model that allows defining the most suitable strategy for involving stakeholders. The decision on choosing a more appropriate strategy is based on fuzzy logic, which allows building models for rational decision-making in conditions of uncertainty and incomplete information. The analysis is based on case study of infrastructure development projects.

In the study, a model based on the Mendelow matrix supplemented with a risk criterion is used to classify and prioritize stakeholders. This matrix is used to obtain the degree of involvement and influence for each stakeholder. This approach provides an opportunity to create and visualize the profile of the main stakeholders in infrastructure development projects to ensure business development.

The developed model allows it to be used by both researchers and practitioners who are involved in decision-making during the planning and implementation of such projects daily.

The problem addressed in this study is the complex decision-making process that concerns determining the roles and involvement of stakeholders. It is important to note that stakeholder involvement operates under conditions of uncertainty. This is mainly because the process of stakeholder participation depends on the influence, interests and risks of the stakeholders. It is also important to be aware that these conditions are variable and can be contradictory and even exclusive for different stakeholders. At the same time, it should be emphasized that the success of the implementation of an infrastructure development project and the achievement of appropriate planned results depend on whether the stakeholders meet their expectations and achieve their goals.

The aim of the research is to develop a methodological tool based on fuzzy logic for identifying, analysing and evaluating stakeholders in the implementation of infrastructure development projects. Fuzzy logic can play a significant role in decision-making and assessment, as well as supporting forecasting and decision support algorithms. In essence, the developed method is a decision support system. This tool will help assess the interests, impacts and risks of various stakeholders using uncertain and subjective data, thereby facilitating decision-making and helping to maximize project success.

Research objectives: to develop fuzzy logic models that allow assessing the priorities and influence of stakeholders, taking into account their interests and risks; to create a method based on the Mendelian matrix to classify and analyse the relationships of stakeholders, taking into account their degree of influence and risks; to verify the effectiveness of the developed method by applying it to examples of infrastructure development programs funded by the European Union.

Significance of the study: The study offers a new approach that can help improve the management of infrastructure development projects, especially considering that projects often have conflicting interests and uncertainty.

Practical significance of the study: The developed fuzzy logic method can be used practically to improve the prioritization of stakeholders and help better manage project risks and conflicts.

Application of the methodology: The methodologies used in the study can also be adapted to other infrastructure projects and various industries that face similar challenges with stakeholder management and decision-making under uncertainty.
The main conclusion of the research is: Fuzzy logic is an effective tool for decision-making under uncertainty. The fuzzy logic approach allows for the interpretation of data in conditions where there is a lack of clarity or unambiguousness. It helps to objectively assess the influence of stakeholders and make data-based decisions; therefore, it is recommended to develop digital tools for data analysis and decision support in the management of infrastructure projects; the influence of stakeholders is uneven and gradual.
Keywords: Fuzzy Logic, Infrastructure Development Projects, Stakeholders.

1. Introduction

The concept of stakeholders was first introduced in the management literature in 1963 by the Stanford Research Institute. Freeman defined stakeholders as those who can influence an organization or are influenced by it (Freeman, 1984). In the context of this study, stakeholders are organizations that influence or can influence the implementation of a project or those who are influenced or can be influenced by the implementation of that project.

Project stakeholders are groups of individuals or entities that have an interest or expectations regarding the implementation of a project and include clients, project managers, designers, subcontractors, suppliers, funding agencies, users, and society at large (Bongo & Sy, 2024). They are interrelated, dependent, and in one way or another influence each other during the implementation of a program/project. The interests and interdependence of stakeholder's change depending on the different stages of project development (Bahadorestani et al., 2020). Since the emergence of stakeholder theory, principles have evolved that are applicable to various fields, including infrastructure construction and development projects, to manage stakeholder relationships and improve the success of these projects (Eyieyien el al., 2024).

Based on stakeholder theory, project stakeholder management begins with the assumption that a project should meet the expectations of all stakeholders, creating value for them (Freeman et al., 2004). However, in practice, when the project implementation period and resources are limited, this is very unlikely. Thus, prioritizing stakeholders has become common practice (Bahadorestani et al., 2020). The viability of many organizations depends on the stakeholder theory approach. Although stakeholder theory has achieved some development and acceptance, the application of this theory in the background of project management is still in its early stages (Zarghami & Dumrak, 2021).

The application of the principles of stakeholder theory in infrastructure development projects is important because it agrees for the proper implementation of the project. Such projects have many stakeholders. It is important to note that the interests of these stakeholders

can be conflicting, even exclusive. The level of influence, interests and risks of these parties also differ. Mismanagement of these interests can have disastrous consequences for projects, such as litigation and time overruns (Bongo & Sy, 2014). It is important that the project objectives are consistent with the objectives of the stakeholders. It is important that the objectives continue to meet the interests of the stakeholders as long as the project is planned and implemented, although circumstances may change (Eyieyien et al., 2024). Stakeholders are a key factor in the success of projects. This has created the need to manage stakeholders in a organised way. It is important to identify and understand the stakeholders involved in the project, manage these stakeholders and understand how to deal with possible aspects of different interests (Olaniran et al., 2024). To ensure the development of a sustainable infrastructure project, it is important to assess the interests of the stakeholders. This will facilitate the implementation of the project while satisfying the needs of the stakeholders (Bongo & Sy, 2024).

Stakeholder participation can be a crucial factor that can either make or break a project. Stakeholders in a project have expectations. When these expectations conflict, project managers need to be aware of potentially dangerous situations. The cause of these conflicts is not always obvious (Eyieyien et al., 2010). Stakeholder engagement is the most important asset that managers must manage. It is the ultimate source of organizational wealth (Bongo & Sy, 2024). Infrastructure is known as a high-profile industry because it involves many stakeholders. These types of projects can have a significant impact on the environment. El-Gohany, Osman and El-Diraby classified the stakeholders of infrastructure projects as follows: Responsible Stakeholder - refers to an organization or individual who has some degree of responsibility or liability with regard to the development process; an Impacted Stakeholder - refers to an organization or individual who is directly or indirectly affected by the development process; and an Interested Stakeholder - refers to an organization or individual who is not directly impacted by the project, but who would like to participate and provide his opinion in the infrastructure development process (El-Gohary et al., 2006).

The interests of the stakeholders are diverse and often contradictory. There is an obvious conflict that creates an even more confused situation between the stakeholders. Despite the introduction of several analytical and optimization tools to balance the perspectives of the stakeholders, there seems to be no sufficient system that objectively includes the interests of the stakeholders in a single indicator. Failure to recognize the dynamics and uncertainty of the stakeholders can significantly jeopardize the objectives and implementation of the program/project. The successful implementation of infrastructure construction or

reconstruction projects depends on the fulfilment of the aspirations and expectations of the stakeholders (Bongo & Sy 2024). Usually, the infrastructure development process involves numerous topical issues, such as access to the construction area. To ensure the appropriate necessary access, local authorities must also be involved (Bahadorestani et al., 2020). In state-funded or co-funded infrastructure development projects, it is also necessary to consider that citizens are interested not only in environmental development in general, but also in cost-effectiveness.

2. Literature Review

The foundations of fuzzy logic were laid in the late 1960s in the works of the American mathematician Lotfi Zadeh to create systems that can adequately interact with people, as they are able to convert ambiguous statements into a clear and formal mathematical construction. Fuzzy logic is based on the Fuzzy set theory, developed by Zadeh (Zadeh, 1965) as a conceptual approach that allows solving problems in conditions of imprecision. Fuzzy set theory is considered analogous to probability theory in the processing of subjective and qualitative information in conditions of uncertainty. Fuzzy set provides answers to questions related to financial and economic decision-making (Lambovska, 2022). This theory extends set theory by allowing elements to belong to a set partially with a certain degree of belonging.

Fuzzy logic allows to create models for rational decision-making in conditions of uncertainty, subjectivity and incomplete information. Fuzzy logic is the logic of exact inaccuracy and approximate logic. Linguistic variables are those whose values are words and phrases in natural or artificial language" (Zadeh, 1975). It is a method that allows calculations and conclusions to be made using linguistic variables (Zadeh, 2008). A fuzzy conditional statement consists of two parts: "if…, and "then…". The first is the condition, and the second is the conclusion (Lambovska, 2022). Fuzzy rules use logical operations to describe imprecise dependencies between input and output variables (Zadeh, 1975). Fuzzy logic, using linguistic terms, allows for easier analysis and interpretation of imprecise information.

The use of linguistic terms in fuzzy logic can reduce the complexity of system modelling, as there may be less need for extensive mathematical formulas. The field of fuzzy logic and its applications have developed significantly in recent decades with many published studies and applications (Solo & Gupta 2022). The term "certainty" or "precision" does not exist in human perception. Albert Einstein wrote: "As far as the laws of mathematics refer to reality, they are not certain. And as far as they are certain, they do not refer to reality" (Molinsky, 2021). Fuzzy logic allows the inclusion of uncertain human judgments in calculations. This approach is effective for resolving conflicts between multiple criteria.

Computational methods based on fuzzy logic can be used for decision identification, decision making, optimization, and control (Solo & Gupta, 2022). Fuzzy logic enables the processing of information that is unclear, uncertain, imprecise, partially true, or without clear boundaries.

3. Research Methodology

The research methodology used is based on a case study approach. The case study is based on a state co-financed program for business infrastructure to support entrepreneurship. The following program "Infrastructure for Business Support" co-financed by European Union fund is being implemented in Latvia. The goal of the program is to develop public business infrastructure and increase the capacity of private investment in functional areas of cities by making investments in business development in accordance with local government development programs (Ministry of Cabinet, 2024).

The research includes several steps. Initially, stakeholders are identified that directly influence or may influence the implementation of the project or those that are affected or may be affected by the implementation of the project. This approach allows for a clear definition of all the most important stakeholders. To simplify data processing and work with stakeholder analysis, stakeholder clusters are created, combining stakeholders according to their interests and roles. For example, all state institutions and ministries are combined into one cluster called "government". In the next stage, a stakeholder analysis is performed using the Mendelow matrix (Aaltonen et al., 2021) criteria - interest and influence, supplemented by another criterion - risk. This also allows us to assess which stakeholders are those whose decisions are decisive or even critically affect the project's implementation. The assessment of stakeholders is carried out based on the opinions of purposive sampling experts. The study involved four experts representing different groups (one expert each from the public sector, private sector, academia and NGO) ensuring a diverse perspective, holistic and diverse data collection. All experts have at least 15 years of practical experience and higher education.

Experts assess the importance of each cluster by assessing interest, involvement and risks. The assessment is carried out according to the Linkert scale. In the next stage, fuzzy logic is used to consider unclear and subjective assessments. Fuzzy scores are calculated in three intervals: the lowest, average, and highest. This allows us to understand the potential of each stakeholder cluster. Fuzzy logic is used to assess the extent to which each specific value belongs to each cluster. The study also includes the creation of if-then rules. This helps to predict the outcome, according to various factors. The rules regarding decision-making, influence, public awareness and monitoring provide an idea of how different assessments of the parties involved can influence decisions. To obtain specific values from fuzzy assessments, defuzzification was

used, using the Centroid Method to obtain final values, which reflect the impact of each cluster on the implementation of the project. Finally, the results were analysed and summarized. See figure 1 for a schematic representation of the research methodology.

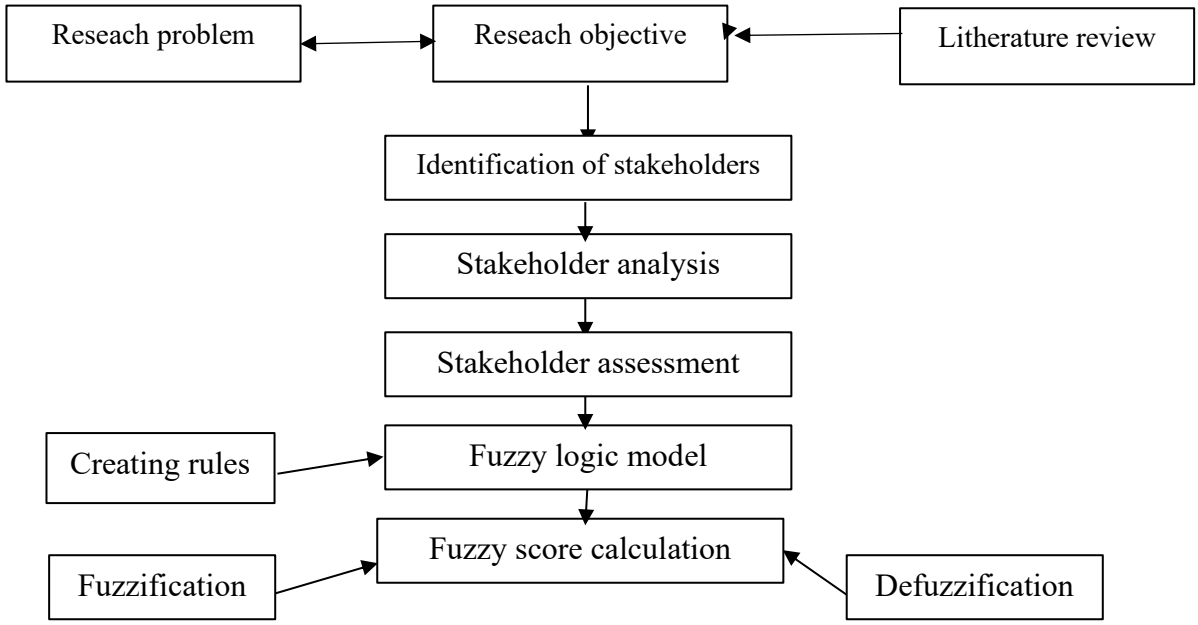

Figure 1. Research methodology (created by the author).

The application of fuzzy logic allows for the assessment of the uncertainty of various stakeholders and the potential changes that may affect them. The use of such a methodology provides a more nuanced understanding of the implementation of infrastructure development projects, helping to identify key risks and opportunities that can be used to ensure successful project implementation.

4. Results

4.1. Identification of stakeholders

Stakeholders are all the participants in an organization, both internal and external, as well as economic and social partners. The activities of the organization have a direct or indirect impact on these participants, and these participants have a greater or lesser impact on the organization. They are complex networks of influence, relationships, partnerships, power and interdependence: to some extent, the survival of the organization depends on each stakeholder, and vice versa. It is necessary to be aware of the main influences that the stakeholders exert. They can both help and hinder the implementation of the project (Oppong et al., 2021).

The process of identifying stakeholders consists of identifying individuals or groups that influence or can influence the implementation of the project or are influenced or can be influenced by it. The identification of stakeholders is based on data obtained from various

program/project documentation and the analysis of the internal and external environment of the project.

Given that the project is closely related to the surrounding environment and its participants, it can be concluded that it operates within a certain system. This statement allows us to apply systems theory, the foundations of which were laid by Ludwig von Bertalanffy (1968) in the mid-20th century, to the identification of stakeholders. Systems theory is an essential tool in project management, as it provides a holistic approach to their management (Adams, 2022).

Stakeholder clusters have greater potential (Zarghami & Dumrak, 2021). To facilitate the work with stakeholders and reduce their number, stakeholder clusters are created. The division of communities has a long history, for example, audience segmentation is used in marketing. The basis of target audience segmentation can be motivation, behaviour, etc. This Stakeholder clustering means the systematic structuring of the diversity of stakeholders (Wu et al., 2023).

Considering the above, the following stakeholders have been identified (see table 1).

Table 1. Stakeholders and their clusters of the "Infrastructure for Business Support" program (created by the author).

Stakeholder	Stakeholder cluster
Ministries (economic, financial, regional development)	Government
Municipality	
Investors who will use the infrastructure	Private sector
Companies who will build the infrastructure	
Residents	Society and local community
Public, non-governmental organizations	
State institution that administers the implementation of the program	Funder
Institutions supervising the construction process	Supervisory authorities
Institutions supervising environmental protection issues	
Institutions supervising the preservation of cultural heritage	
Media that informs the public	Media and Influence Participants
Local Voices	
Social Media Ambassadors	
Influencers	

4.2. Stakeholder analysis

The Mendelow matrix is supplemented with a risk criterion, because the author believes that adding the stakeholder risk criterion makes the analysis more complete. The Mendelow matrix traditionally reflects two stakeholder criteria - influence and interest. Adding the risk criterion

allows you to add another dimension to the calculations - how big the threat is from the stakeholder to the project.

Organizations that prioritize ensuring stakeholder involvement and use various proactive risk mitigation methods not only improve project sustainability, but also achieve sustainable results (Eyieyien et al., 2024). Thus, the author suggests using criteria for stakeholder analysis (see table 2).

Table 2. Stakeholder analysis criteria for the "Infrastructure for Business Support" program (created by the author).

Criterion	Interest	Impact	Risk
Description	Stakeholder's interest and level of involvement	Stakeholder's ability to influence the outcome of the program/project	Stakeholder's potential to create an event that may threaten the implementation of the program/project
Characteristic	Positive Neutral Negative	Positive Neutral Negative	Negative
Instruments	Support Activity Communication	Power Role Resources	Feasibility Impact
Time	The entire term of the program/project implementation May change during the program/project implementation - both increase and decrease	The entire term of the program/project implementation May change during the program/project implementation - both increase and decrease	If the risk materializes

It should be highlighted that the activities of the parties listed, mentioned in the table, may be both deliberate and inadvertent; that is, they may, even inadvertently and unplanned, produce an incident that could seriously impair or jeopardize the program's or project's execution.

4.3. Stakeholder assessment

The expert survey was showed using goal-directed sample, which keeps resources by relying on experts with a wide range of expertise. The focus of this method is on the depth of expert knowledge, not the sample size. Morse (2020) argues that purposive sampling is effective in achieving data saturation in qualitative research (Morse, 2020). Respondents assess the size of each stakeholder based on three criteria: interest, involvement, and risks. The assessment is

made according to a Likert scale, which offers a range of attitudes from 0 (not at all) to 3 (high), with intermediate values of 1 (low) and 2 (medium) (Joshi, 2015).

Table 3. Summary of expert assessments (created by the author).

Stakeholder cluster	Expert assessment											
	Risk				Impact				Risk			
	1	2	3	4	1	2	3	4	1	2	3	4
Government	3	3	3	3	3	3	3	3	0	1	0	0
Private sector	3	2	2	2	0	1	2	2	3	2	2	3
Society and local community	1	2	1	2	2	1	2	2	0	1	0	0
Funder	3	3	3	3	3	3	3	3	3	2	2	1
Supervisory authorities	2	2	1	2	2	3	3	2	3	2	3	3
Media and influence participants	1	2	2	3	2	2	2	2	0	1	0	1

4.4. Fuzzy logic model: creating rules

If-then rules are the basis of fuzzy logic. These rules allow modelling of ambiguous or uncertain information, transforming it into specific actions or decisions. If-then rules are used in expert systems and are suitable for controlling complex processes in which it is not possible to determine precise boundaries (Solo & Gupta, 2022). For the if-then rules for this case study, see table 4.

Table 4. If-then rules (created by the author).

1. Impact on decision-making
If the Government fuzzy score is High and the Funder fuzzy score is High, then the impact on decision-making is High
If the Government fuzzy score is Medium and the Funder fuzzy score is High, then the impact on decision-making is Medium
If the Government fuzzy score is Low and the Funder fuzzy score is Low, then the impact on decision-making is Low
2. Private sector and public influence
If the Private Sector fuzzy score is High and the Society and local community fuzzy score is High, then the public policy acceptance is High
If the Private Sector fuzzy score is Medium and the Society fuzzy score is Medium, then the public policy acceptance is Medium
If the Private Sector fuzzy score is Low and the Society fuzzy score is Low, then the public policy acceptance is Low
3. Media and Public Awareness
If the Media and Influence Participants fuzzy score is High and the Public fuzzy score is High, then public awareness is High
If the Media and Influence Participants fuzzy score is Medium and the Public fuzzy score is Medium, then public awareness is Medium

If the Media and Influence Participants fuzzy score is Low and the Public fuzzy score is Low, then public awareness is Low
4. Stringency of supervision and regulation
If the Supervisory Authority's fuzzy score is High, then the compliance check is Stringent
If the Supervisory Authority's fuzzy score is Medium, then the compliance check is Moderate
If the Supervisory Authority's fuzzy score is Low, then the compliance check is Weak
5. Availability of Funding
If the Funder fuzzy score is High and the Private Sector fuzzy score is High, then the availability of investment is High
If the Funder fuzzy score is Medium and the Private Sector fuzzy score is Medium, then the availability of investment is Medium
If the Funder fuzzy score is Low and the Private Sector fuzzy score is Low, then the availability of investment is Low

4.5. Fuzzy score calculation

To summarize the respondents' ratings, fuzzy logic methodology was used to calculate fuzzy ratings within three intervals (lowest, average, highest) (Zarghami, & Dumrak, 2021). This method is often used to analyse subjective observations with uncertain or variable factors (see table 5).

$$(\text{Lower}, \text{Mean}, \text{Upper}) = \left(\frac{\text{Lower}_1 + \text{Lower}_2 + \text{Lower}_3 + \text{Lower}_4}{4}, \frac{\text{Mean}_1 + \text{Mean}_2 + \text{Mean}_3 + \text{Mean}_4}{4}, \frac{\text{Upper}_1 + \text{Upper}_2 + \text{Upper}_3 + \text{Upper}_4}{4} \right)$$

Table 5. Fuzzy score (created by the author).

Stakeholder cluster	Fuzzy score
Government	(2.0, 2.083, 2.333)
Private sector	(1.333, 2.0, 2.667)
Society and local community	(0.667, 1.167, 1.667)
Funder	(2.333, 2.667, 3.0)
Supervisory authorities	(1.667, 2.333, 2.667)
Media and influence participants	(1.0, 1.5, 2.0)

4.6. Fuzzification

Considering that it is not possible to calculate an exact threshold for each attribute, fuzzification is performed. Based on the calculations, a Fuzzy logic membership function is created. Each segment represents a fuzzy score for each cluster of stakeholders (see Figure 2).

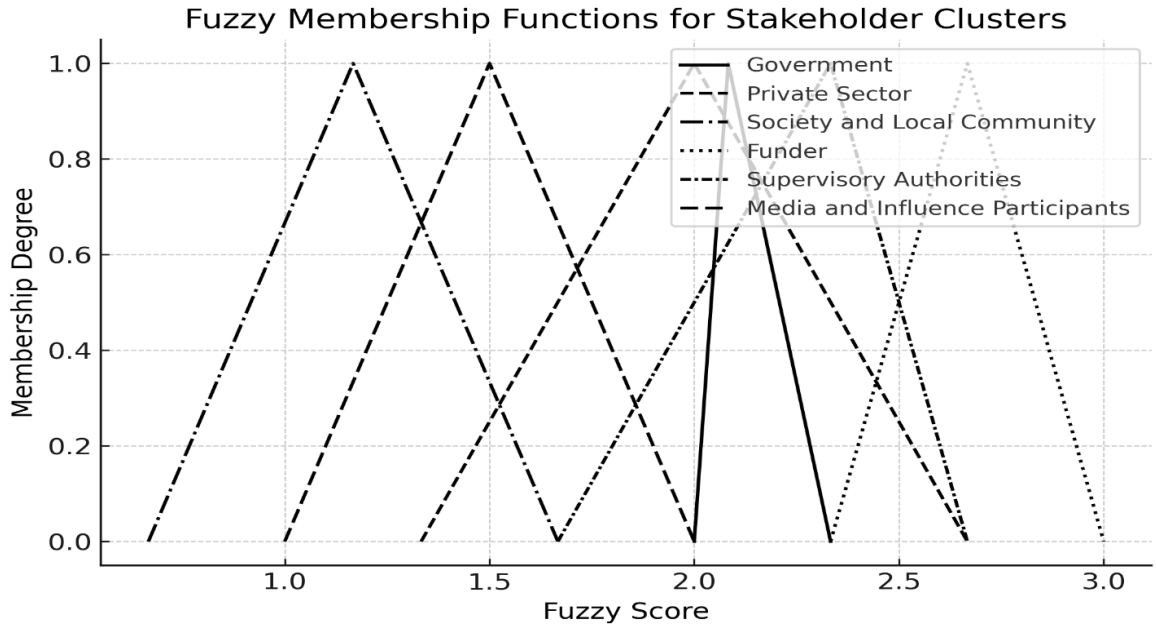

Figure 2. Fuzzy logic membership function (created by the author).

The chart shows fuzzification and shows how clusters of stakeholders are signified as sets of fuzzy membership functions. The fuzzy score represents the range of fuzzy scores assigned to each cluster. The membership degree shows the extent to which a value belongs to a particular cluster. This fuzzy logic model shows how precise numbers can be transformed into fuzzy areas.

4.7. Defuzzification

Defuzzification is the process of obtaining specific numerical values from fuzzy functions. This study uses the Centroid Method (Sohaib, 2024).

The following formula was used

$$C = \frac{\sum \mu(x) \cdot x}{\sum \mu(x)}$$

where:
μ(x) – membership function for the value x
x – fuzzy value,
C – final numerical value (Sohaib, 2024).

The calculation results are summarized in table 6

Table 6. Defuzzification (created by the author).

Stakeholder cluster	Defuzzification
Government	2.139
Private sector	2.000
Society and local community	1.167
Funder	2.667
Supervisory authorities	2.222

Media and influence participants	1.500

5. Results and findings

The conducted research allows us to conclude that in business-friendly infrastructure development projects, the influence of all involved parties is not evenly distributed. This diversity of influence is justified by various uncertainty factors. The results obtained during the research indicate that the greatest influence falls on state institutions and project financiers, which was also expected, since these are clearly the involved parties whose decisions have the greatest impact on the implementation of the project. The public and local communities have a relatively small impact.

Any decision-making process in the implementation of infrastructure development projects takes place under conditions of high uncertainty. This is facilitated by the different interests, influence and risks of the involved parties, which result in different levels of influence. The use of the fuzzy logic approach confirms that the influence of the involved parties is not binary, i.e. it is not possible or impossible. This influence is variable and can be gradual. This type of approach allows for data-based decisions.

The obtained defuzzification data show that the government (2.139) and the funder (2.667) play a decisive role in the development and implementation of such projects. This confirms that the availability of funding and the regulation set by the state significantly affect the implementation of such projects. This conclusion is consistent with previous studies, which prove that the support of the state administration and public financing are a significant factor in the progress of infrastructure projects (Saaty, 2008). Given this fact, it is essential to ensure appropriate decision-making in the public sector, ensuring the transparency and validity of these decisions.

The value obtained in the calculations of various supervisory authorities (2.222) indicates a relatively moderate impact. Nevertheless, it indicates that such regulatory influence is important. Such authorities can play an important role, but it is not decisive for the implementation of the project.

The defuzzification value of the private sector (2.000) and the society and local community (1.167) indicates a comparatively lower influence on decision-making. The role of the private sector in infrastructure development projects and decision-making should be increased. Insufficiently regulated mechanisms and uncertainty factors hinder this stakeholder involvement. The relatively low indicator of the public indicates that public involvement and

participation in the implementation of such projects. This can negatively affect the sustainability of the project and social acceptance of financing such projects (Munda, 2004).

The value obtained for media and influence participants (1.500) indicates that communication and public information issues are not in the first project implementation plan. The lack of such information can create various uncertainties and resistance in the public, which can be realized with various negative effects during the project implementation.

The most important proposals that emerge from this study are related to the need to ensure greater public involvement and transparency of decisions. The public should be actively involved already during the project planning. Strengthening the role of Media and Influence Participants can ensure an increase in the level of public involvement. It is important to promote the involvement of the private sector. To promote this, one of the models that can be used in the implementation of infrastructure projects is the public-private partnership model (PPP). The use of such a model allows attracting not only additional investments, but also knowledge from the private sector. It is important to create a stable and reliable regulatory environment, ensuring a more understandable and favourable environment for private investors. Such an environment should be as free from bureaucracy as possible. Such an environment would promote the trust and interest of the private sector in the implementation of such projects.

Fuzzy logic models are a tool that allows making data-based decisions. This model allows understanding the involvement of stakeholders in conditions of uncertainty. Digital tools should be created for data processing and analysis.

Conclusions and proposals can serve as practical recommendations for improving the management of infrastructure development projects and making effective decisions.

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Beyond Numbers: Demographic Dynamics Shaping Ethics and Sustainability in SMEs

Abstract

This study explores the impact of demographic characteristics on the perceptions of ethics and sustainability among accountants in small and medium-sized enterprises (SMEs). SMEs often struggle to adopt eco-friendly practices due to resource constraints and focus on short-term gains. Accountants in SMEs, pivotal in formulating sustainability policies, make informed, long-term decisions using their financial analysis skills and business understanding. Using the PRESOR scale, the study evaluates accountants' perspectives on sustainability and ethics and conducts cluster and moderation analyses to explore relationships between demographic influences on ethical and sustainability views, promoting a culture of ethical decision-making in SMEs.

Keywords: Accountants, Sustainability, Ethics, SME, Kohlberg's theory

Decleration:*The authors declare that they have no conflicts of interest. This article does not contain any studies involving animals performed by any of the authors. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of the Ozyegin University (Date: 2.11.2022, No:2022/15, Confirmation Code: 2022/15/03). Due to the ethically sensitive nature of the research, no interviewees consented to their data being retained or shared.*

1. Introduction

Small and medium-sized enterprises (SMEs) can play a significant role in promoting sustainability and ethical practices through their operations and business performance (Johnson & Schaltegger, 2016). Sustainability refers to the ability to meet the needs of the present without compromising the ability of future generations (Nguyen et al. 2023). Additionally, ethics refers to the principles and values that guide the behavior of individuals and organizations (Jenkins, 2006). This study was conducted on accountants in SMEs. It is critical to focus SMEs, with 332.99 million expected globally by 2023, comprising over 90 % of all businesses and employing around half of the global workforce (Dyvik, 2024). The sustainability of SMEs refers to the impact that these businesses have on society and the environment. This can include the resources that they consume, the waste that they generate, the emissions they produce, and the social and economic impacts they have on their communities.

Accountants play a vital role in helping businesses and organizations make informed decisions about their financial operations, including decisions related to sustainability. In many SMEs, the owners lack deep accounting knowledge, hence the importance of accountants. SME owners should work closely with accountants for long-term sustainability. SMEs typically do not have their own sustainability units. Hence, whether a SME adopts a sustainability policy may be dependent on certain personnel. Employees in SMEs, like accountants, are influential in formulating sustainability (Girschik, 2020). This assertation is supported by International Federation of Accountants (IFAC). IFAC has emphasized the significant influence accountants have in the strategic decision-making processes within businesses, including SMEs. They argue that accountants' skills in financial analysis and their understanding of the business's overall operations uniquely equip them to help organizations navigate the complexities of sustainability. Also, the IFAC supports the assertion that accountants in SMEs have a crucial role in the formulation and creation of sustainability policies, particularly given the absence of dedicated sustainability units in these businesses (IFAC, 2011; 2013).

This study offers significant societal and theoretical contributions. From a theoretical perspective, it extends Kohlberg's moral development theory by empirically linking demographic factors such as gender, education, and experience to ethical reasoning within a professional context. This approach bridges the gap between individual moral development and organizational practices, demonstrating how accountants' moral reasoning shapes their prioritization of long-term sustainability over short-term objectives. From a societal standpoint, this research addresses broader sustainable development goals by exploring how accountants' ethical decisions impact SME operations, customers,

and communities. Improving ethical and sustainability practices in SMEs can drive inclusive economic growth, environmental stewardship, and social equity.

Thus, the purpose of the study is to investigate the impacts of demographic characteristics on perceived ethics and sustainability of accountants at SMEs. In this study, data from accountants in SMEs were evaluated using the PRESOR scale by adapting it to sustainability. The scale has been divided into two factors: long-term gain, which features the significance of ethics and sustainability from the perspective of the long-term success of a SME, and short-term gain, which highlights the output's performance, rather than ethics and sustainability, that is used as the basis for a SME's immediate success. Additionally, both cluster analysis and moderation analysis were conducted to further explore the relationships between demographic characteristics and the perception of ethics and sustainability.

The motivation stems from the pivotal role accountants play in the ethical and sustainability landscape of SMEs, which often face challenges integrating these practices due to limited resources and a focus on immediate profitability. In this intricate scenario, accountant in SMEs are not just financial gatekeepers but also key influencers of ethical decision-making and sustainable practices. This focus is particularly pertinent given the dynamic and evolving business landscape in Turkey, a context that mirrors many emerging economies. By delving into these aspects, the research aims to illuminate the multifaceted role of accountants in SMEs, contributing to the broader discourse on the integration of ethical and sustainable practices in business operations.

This study integrates Kohlberg's theory of moral development to understand the ethical perceptions and decision-making processes of accountants in SMEs, particularly in the context of sustainability. Kohlberg's theory, which delineates the progression through different stages of moral reasoning, is traditionally associated with individual development from childhood to adolescence. However, its applicability extends to adult moral cognition, especially in professional settings. In the realm of SMEs, accountants often face complex ethical dilemmas where their decisions can have lasting impacts on sustainability. The application of Kohlberg's framework allows us to explore how accountants at different stages of moral development perceive and respond to these ethical challenges. By applying this theory, this study provides a novel perspective on the interplay between moral development and sustainability decision-making in a professional setting, thereby enriching the discourse on ethical practices in SMEs. This theoretical approach not only aligns with the research objectives but also offers valuable insights into enhancing ethical and sustainable practices in the dynamic and challenging environment of SMEs.

By focusing on Turkish SMEs, the study also provides insights applicable to emerging economies, highlighting the universal challenges faced by SMEs in balancing economic performance with sustainability imperatives. The findings aim to guide stakeholders—including SME owners, employees, policymakers, and local communities—in fostering a culture of ethical decision-making and sustainable growth.

The structure of the paper is as follows. The second section explains the ethics and sustainability concepts in SMEs. The third section develops the hypothesis. The fourth section displays the methodology. The fifth section presents the results and discussion. The sixth section presents discussion. The last section provides conclusion.

2. Ethics and Sustainability Concepts in SMEs

The perception of ethics and sustainability in SMEs varies based on factors like industry, product nature, and company policies. According to Jones (1991), ethical perception is related to the person's awareness of moral dilemmas and their consciousness as moral agents. Social influences significantly impact these perceptions (Bandura, 1999), highlighting their personal nature. Thus, in this study, ethical perception refers to the ability to recognize situations with moral implications.

Sustainability is defined as integrating an entity’s social, environmental, ethical, and humanitarian duties into its operations and strategies, involving key stakeholders (Nguyen et al., 2023). Employees, as critical stakeholders, act as both users and agents of sustainability. Girschik (2020) found that individual employees' (un)ethical behavior determines whether organizational output is perceived as (un)ethical. Consequently, sustainability in this study refers to SMEs’ practices addressing broader societal concerns and emphasizing long-term welfare.

Existing research highlights accountants' pivotal role in navigating sustainability challenges within SMEs. Johnstone (2020) analyzed accountants' roles in environmental systems and identified gaps in their support for sustainability. Javed et al. (2022) examined environmental management accounting barriers in Chinese SMEs, revealing challenges like limited technological and financial resources. Kimanzi and Gamede (2020) emphasized the importance of financial planning in achieving sustainability goals and advocated for accountants’ leadership in this effort. Ortiz-Martínez and Marín-Hernández (2022) focused on European SMEs, emphasizing accountants' roles in managing non-financial aspects like environmental impact. These studies collectively highlight accountants’ evolving responsibilities from traditional financial reporting to strategic involvement in sustainability efforts (Garcia-Sanchez et al., 2022).

However, methodological and contextual limitations persist in this body of literature. Many studies, such as Rogosic and Bakotic (2019), overemphasize demographic factors like age and gender while neglecting behavioral and contextual variables. Johnson and Schaltegger (2016), for example, relied solely on survey data, which often fail to account for the dynamic interplay between individual and organizational factors. Similarly, Ortiz-Martínez and Marín-Hernández (2022) focused exclusively on European SMEs, limiting the generalizability of their findings to diverse socio-economic contexts.

Methodological advancements have sought to address these gaps. Nguyen et al. (2023) adopted a mixed-methods approach, combining qualitative and quantitative data to explore sustainability perceptions in developing economies. However, their work did not specifically investigate accountants as sustainability agents, leaving a gap in understanding their unique contributions. Additionally, despite frameworks such as Kohlberg's moral development theory being utilized in theoretical research (Kassinis et al., 2016), few empirical studies have operationalized these frameworks to examine accountants' ethical decision-making.

This study seeks to address these gaps by employing robust statistical methods, including cluster and moderation analyses, alongside integrating Kohlberg's moral development theory as a theoretical lens. By focusing on Turkish SMEs, this research provides a contextualized understanding of how demographic characteristics interact with ethical and sustainability perceptions, offering a richer discourse on accounting ethics in SMEs.

Ethics and sustainability are increasingly recognized as integral to business success. Ethical behavior involves moral agency and the ability to discern and act on ethical dilemmas (Bandura, 1999). SMEs, which constitute over 90% of global enterprises (Dyvik, 2024), face unique challenges in adopting these principles due to resource constraints and limited access to expertise (Johnson & Schaltegger, 2016). While earlier studies, such as Jenkins (2006), emphasize SMEs' roles in corporate social responsibility, more recent research highlights accountants' strategic contributions to sustainability initiatives. Garcia-Sanchez et al. (2022) illustrate how accountants' financial analysis skills enable them to lead sustainability efforts. Similarly, Girschik (2020) underscores employees' critical roles in shaping sustainable outcomes through organizational ethics.

In Turkey, SMEs account for 99% of all enterprises and employ approximately 70% of the workforce (KOSGEB, 2023). The Turkish government promotes sustainable business practices through financial support and educational campaigns, aiming to address issues such as access to finance, lack of skilled labor, and regulatory barriers

(Yalçın & Çetin, 2021). Ethical and sustainable practices help SMEs reduce costs, increase efficiency, and achieve long-term financial benefits.

Accountants' perceptions of ethics and sustainability are particularly vital in SMEs. SME owners in Turkey often lack advanced accounting knowledge, making accountants key players in ensuring financial transparency and addressing ethical or sustainability issues. This transparency is essential for stakeholders, including investors, customers, and employees, to make informed decisions.

The International Federation of Accountants (IFAC, 2011, 2013) underscores accountants' strategic roles in promoting long-term sustainability. Beyond financial reporting, accountants advocate for ethical practices and resource-efficient strategies (Kimanzi & Gamede, 2020). Ortiz-Martínez and Marín-Hernández (2022) further emphasize accountants' influence on non-financial metrics like environmental impact. Despite these insights, existing research on behavioral determinants of accountants' ethical decision-making is limited. This study addresses this gap by examining how accountants' demographic characteristics interact with their perceptions of ethics and sustainability.

Although focused on Turkish SMEs, the findings have global implications. SMEs across emerging and developed economies face shared challenges, such as limited financial resources and pressure to adopt sustainable practices. By situating the analysis in Turkey, this research offers a case study for understanding how accountants navigate sustainability challenges in resource-constrained settings, contributing to globally relevant insights.

3. Hypothesis

This study is built on Kohlberg's theory, which suggests individuals progress through moral reasoning stages as they mature. The theory comprises three levels of morality which are preconventional (focused on avoiding punishment and seeking rewards), conventional (adhering to societal expectations and rules), and postconventional (guided by individual principles and the greater good) (Kohlberg, 1971). Thus, in this study, several demographic characteristics, such as gender, education level, and degree of experience, have been studied in relation to moral development and Kohlberg's theory.

The theory posits that individuals progress through a series of stages in their understanding of moral principles. Gender has been shown to play a role in moral development according to this theory. At pre-conventional phase, moral decisions are often made based on immediate consequences, and understanding of societal norms is rudimentary. Female accountants in this stage might prioritize decisions avoiding harm for immediate rewards. Their

tendency to nurture and care might guide them towards ethical practices, to avoid hurting others, even if their understanding of ethics is yet undeveloped. Conventional phase is characterized by an adherence to social rules and expectations. Female accountants in this stage might uphold ethical accounting practices for harmony and positive relationships. In post-conventional phase moral decisions are guided by principles that transcend societal norms. Female accountants might emphasize long-term sustainability and ethics from a universal standpoint, not merely a societal or organizational one. Their inclination towards empathy and care might make them more likely to perceive the interconnectedness of their actions with the wider world, thus understanding and advocating for decisions that ensure long-term gains for all stakeholders, not just their immediate organization.

Kohlberg's moral development theory directly informs the hypotheses by providing a foundation for linking demographic characteristics to ethical reasoning. For example, gender is hypothesized to influence accountants' ethical and sustainability perceptions based on the different moral emphases traditionally associated with males and females at various stages. This theoretical underpinning allows the hypothesis to explore the nuanced ways gender shapes professional decisions regarding ethics and sustainability.

There are some studies that indicate that female accountants may have a stronger focus on ethical considerations and sustainability in their decision-making (Shtudiner & Klein, 2020; Nguyen et al., 2021). A few studies have shown that women tend to prioritize ethical considerations and social responsibility in their decision-making, and women are more likely to prioritize environmental concerns and sustainability in decision making (Kassinis et al., 2016; Shoham et al., 2017). Furthermore, in SMEs, the relationship between the business and its stakeholders tends to be more personal, the close relationship may foster the perception of ethics and responsibility among female accountants in SMEs. Therefore, the following hypothesis was developed.

H_1. Females has a positive impact on accountants' perceived ethics and sustainability in achieving long-term gain.

The theoretical framework also emphasizes the role of education in advancing individuals through Kohlberg's stages. This connection is reflected in H2, where education level is expected to influence ethical perceptions. Specifically, the framework supports the notion that higher education fosters the cognitive complexity necessary for post-conventional moral reasoning, aligning with the long-term sustainability dimension of the PRESOR model.

The theory proposes that as individuals mature and gain more cognitive and life experience, they progress through a series of stages in their understanding and reasoning about moral issues. Higher education at pre-

conventional phase can have a profound impact on accountants' understanding of ethical behavior. With exposure to coursework in ethics, regulations, and sustainability, accountants may begin to recognize the immediate benefits of ethical conduct, such as avoiding legal consequences or disciplinary actions. According to conventional phase, as education level increases, accountants are likely to acquire a more nuanced understanding of professional and societal norms. They might learn the importance of upholding industry standards, maintaining the reputation of their firm, and meeting stakeholders' expectations. At post-conventional phase higher education can significantly impact accountants' ability to engage in abstract moral reasoning. They might learn to appreciate ethical considerations beyond their immediate professional context, acknowledging their role in upholding societal welfare and sustainability.

Su et al. (2018) discovered that higher education can positively influence the development of ethical attitudes among SMEs. Similarly, Peake et al. (2017) concluded that the level of education has a significant impact on the social responsibility of small businesses. Education may also encompass sustainability and environmental education, which can provide individuals with a deeper understanding of environmental issues and the impact of human actions on the environment (Avelar et al., 2019). Likewise, accountants with higher levels of education and experience may be more likely to have a broader understanding of ethical and sustainable practices (Rogosic & Bakotic, 2019), which can contribute to a higher perceived level of ethics and sustainability in SMEs. This understanding may cultivate a sense of responsibility and stewardship towards the environment, which can lead to sustainable decision-making and actions. Consequently, a hypothesis was developed to investigate whether the level of education among accountants in SMEs impacts their perceived ethics and sustainability in achieving long-term gain.

H_2. Education level has a positive impact on accountants' perceived ethics and sustainability in achieving long-term gain.

Kohlberg's framework further informs H3 by explaining how work experience enables progression to higher stages of moral development. This hypothesis explores how cumulative professional encounters refine accountants' ethical reasoning, aligning their priorities with long-term sustainability goals. The theory suggests that as individuals encounter complex ethical dilemmas over time, their moral reasoning evolves, enabling them to make more nuanced decisions about sustainability.

The theory can be applied to the work experience of accountants in terms of ethics and sustainability. According to the theory, as accountants gain more experience in their field, they may progress through different stages of moral reasoning. According to the pre-conventional phase, in the earliest stages of an accountant's career,

experiences may mostly serve to reinforce understanding of the immediate consequences of ethical and unethical actions. As accountants gain experience in the conventional phase, they grow more used to societal and professional conventions. Accountants with lengthy experience may have come across a range of ethical conundrums and seen the long-term effects of different acts throughout the post-conventional phase. They might have acquired a comprehensive knowledge of how their choices might affect people outside of their own professional environment. At this point, accountants may understand the crucial role that ethics and sustainability play in attaining long-term success, not only for their company but for society.

Experience can lead to a better understanding of the ethical implications of different actions and decisions, and may foster greater empathy and concern for others, which may lead to greater perceived ethics in decision making and actions in SMEs (Rogosic & Bakotic, 2019). Experience may also lead to a greater understanding of the long-term consequences of actions and may foster a sense of responsibility and stewardship towards the environment, leading to greater sustainability in decision making and actions (Garcia-Sanchez & Garcia-Sanchez, 2020). Additionally, through the experiences that come with age, individuals may gain a better understanding of the ethical and social implications of different actions, which may lead to a greater awareness of ethical considerations and can help individuals to make more ethical decisions (Nguyen et al., 2021). Therefore, the following hypothesis was developed to find out whether degree of experience difference in SMEs has an impact on accountants' perceived ethics and sustainability in achieving long-term gain.

H_3. Degree of experience has a positive impact on accountants' perceived ethics and sustainability in achieving long-term gain.

No hypothesis has been formulated for "age" in this study, as older people are typically associated with more experience.

4. Methodology

This study uses Turkish data. Turkish statistics depict an institutional environment that is more like that of many emerging countries. Turkey strives to be one of the major developing economies in the world since it is a guiding and dynamic emerging economy. As the Turkish economy grows, it also needs to address a wide variety of ethical issues that affect all enterprises. The most notable issue of these is sustainability. Other emerging countries should take note of Turkey's experiences, and development of the sustainability idea. Like many other developing nations,

Turkey has only lately begun to value the idea sustainability. Investors in other emerging economies with comparable profiles to Turkey will find the findings of this study to be helpful.

The data collected from male or female accountants over the age of 18 working in SMEs. E-mail and telephone method used to reach the participants. The contact information[1] of the companies is accessed via the Istanbul Chamber of Commerce data bank and the collective information system, ISTOB Istanbul Tuzla Organized Industrial Zone, Turkish Business Directory, Turkey Firms Directory, and the MODOKO furnituremakers website that shares member information publicly. A total of 500 professionals were reached, and 204 professionals participated in the survey[2]. A 7-point Likert scale was utilized in the study, with 1 representing strongly disagree and 7 representing strongly agree. Factor, correlation, reliability, and regression analyzes were performed using SPSS 29.0 program to test the variables' relationship.

Kohlberg's moral development theory informed the methodological framework of this study by shaping both the selection of variables and the design of the PRESOR scale. The variables of education level, gender, and experience were chosen because they align with Kohlberg's stages of moral reasoning. Education level was included to capture its influence on advancing individuals through moral stages—from recognizing immediate consequences (pre-conventional stage) to understanding societal norms (conventional stage) and ultimately abstract moral reasoning guided by universal principles (post-conventional stage). Gender was analyzed to explore whether societal norms tied to gender roles influence ethical decision-making, while experience was selected to examine how cumulative exposure to ethical dilemmas fosters progression to higher moral reasoning stages. This theoretical alignment allowed the study to explore how demographic factors shape ethical and sustainability perceptions.

In this study, the PRESOR model is employed to assess accountants' perceptions of ethics and sustainability in SMEs. This model is particularly relevant to the study objectives, as it provides a comprehensive framework for understanding how accountant perceive the role of ethics and social responsibility in the context of their professional responsibilities. Singhapakdi et al. (1996) developed the PRESOR instrument to fill the demand for a valid and reliable

[1] The contact information of the companies referred to in the methodology section can be accessed through the following websites: bt@ito.org.tr, https://www.itosb.org.tr/firmalar, https://www.turkticaretrehberi.com/sehir-firmalari/34/istanbul, https://www.modoko.com.tr/, https://www.frmbul.com/sehir/istanbul.

[2] The study was approved by the Human Research Ethics Committee of the (~~x~~) University (Date: 2.11.2022, No:2022/15, Confirmation Code: 2022/15/03). The approved form is submitted to the journal.

scale to assess managers' perceptions of the relevance of ethics and social responsibility in attaining organizational success. By adapting this model to focus on sustainability, the study could delve into the specific aspects of ethical reasoning and sustainability consciousness among accountants in SMEs. This approach allows us to explore how demographic factors influence these perceptions. The PRESOR model's focus on both short-term and long-term gains aligns with the aim to understand the balance accountants strike between immediate financial objectives and long-term sustainable practices. This the application of the PRESOR model is not only methodologically sound but also critically enhances the understanding of the ethical and sustainability dimensions in the decision-making processes of accountants. The PRESOR instrument was made up of 16 components chosen from an instrument created by Kraft & Jauch (1992).

Kohlberg's theory and the PRESOR model are both theories that aim to explain how people make moral judgments. The PRESOR model can be used to help accountants understand how they make moral judgments in their work and how people make decisions that balance short-term gain and long-term gain. The scale includes the following items:

(1) ''*The most important thing an accountant can do is to work with business ethics and with the principle of sustainability''*. This statement is related to long term gain. Accountants can ensure that the financial decisions they make are fair, honest, and transparent, which can help to build trust with clients.

(2) ''*Output quality (ex. financial reports etc.), not ethics and sustainability, is essential to an accountant's professional success*es''. This statement is a narrow view that is focused primarily on short-term gain. In the short term, a focus on output quality may lead to immediate gains.

(3) ''*For me, communication is more important than working with business ethics and sustainability*''. An accountant must effectively communicate complex financial data to clients. This statement is related to short term gain. Overemphasizing short-term communication goals while disregarding ethics and sustainability might yield quick gains.

(4) ''*The accountant should evaluate his/her actions within the framework of ethics and sustainability while practicing his/her profession"*. According to this statement, both short-term and long-term gain are vital parts of an accountant's professional success.

(5) ‘‘*The most important thing for an accountant is to earn (increase) even if it is not by moral rules*’’. The statement refers to a short-term gain. The premise is that an accountant may attain short-term financial advantage by emphasizing generating money before morals.

(6) ‘‘*The ethics and sustainability of an accountant are essential to their long-term professional success*’’. The statement is about a long-term gain. Ethical behavior and a focus on sustainability can aid in the development of a reputation for integrity and social responsibility, which can lead to increased professional prospects and success in the long run.

(7) ‘‘*An accountant's level of ethics and sustainability is a crucial factor in his professional success*’’. The statement is about a long-term gain. In the long run, an accountant who acts in an ethical and sustainable manner has a better chance of establishing a favorable reputation within his profession.

(8) ‘‘*For the accountant to compete in today's conditions, he/she must compromise on business ethics and sustainability*’’. This statement is related to short-term gain. Compromising on business ethics and sustainability may yield immediate benefits, such as increased profits or competitive advantage.

(9) ‘‘*While making a profit, on the other hand, importance can be given to sustainability*’’. This statement is related to long-term gain. The idea is that by prioritizing sustainability, a company can continue to be profitable in the long-term.

(10) ‘‘*Ethics and sustainability are very important for the continuity of the accountant’s career*’’. This statement is related to long- term gain. An accountant's professional success is not just about the financial gain, but also about the continuity of their career.

(11) ‘‘*The priority of the accountant is to act ethically*’’. This statement is related to long-term gain. Ethical behavior by an accountant can lead to a variety of long-term benefits for the individual, the accounting profession, and the organizations that employ or rely on the services of the accountant.

(12) ‘‘*The accountant's emphasis on sustainability is more important than profit-making*’’. This statement is related to long-term gain. While profit-making is important, it should not come at the expense of ethical and sustainable practices.

(13) ‘‘*If you are under serious threat (risk) in business life, you can push business ethics and sustainability into the background*’’. This statement is related to short-term gain. In situations of severe risk, it may be tempting to take shortcuts to mitigate the risk.

(14) ‘‘*For an accountant, effectiveness is far more important than the appearance of his/her actions in line with business ethics or sustainability*’’. This statement is related to short-term gain. If an accountant prioritizes achieving results over adhering to ethical or sustainable practices, it may result in achieving immediate success.

(15) ‘‘*Having a work ethic often means doing good deeds*’’. This statement is related to long-term gain. It suggests that a strong work ethic is associated with behaving ethically and doing good deeds, and that it can be a way to achieve long-term gain.

(16) ‘‘*Every way is permissible to ensure customer satisfaction*’’. This statement is related to short-term gain. Such actions may result in short-term satisfaction for the customer.

Cluster analysis was employed to classify respondents into groups reflecting different stages of moral reasoning based on their answers to the PRESOR scale. This method captures the differentiation in moral development stages among accountants with varying demographic characteristics. For example, respondents in the high cluster, characterized by advanced education and extensive experience, align with Kohlberg's post-conventional stage, prioritizing universal ethical principles and long-term sustainability. Those in the low cluster, with limited education and experience, correspond to the pre-conventional stage, where decisions are guided by immediate rewards or penalties. This analysis highlights how education and experience influence the ethical priorities accountants exhibit.

Moderation analysis was conducted to explore the interaction effects between key demographic variables such as education, experience, and gender, and their influence on ethical and sustainability perceptions. For instance, the analysis revealed that experience amplifies the effect of education, enabling individuals with higher education levels to progress from conventional reasoning, which emphasizes societal norms, to post-conventional reasoning, characterized by universal ethical principles. Additionally, the findings demonstrated that gender alone does not significantly affect moral development but that its interaction with experience results in consistent ethical reasoning across genders. These findings align with Kohlberg’s assertion that moral development is shaped by the interplay of cognitive and experiential factors.

The theoretical framework, rooted in Kohlberg's moral development theory, shapes the study's mixed-methods approach by providing a structured lens through which both qualitative and quantitative data are interpreted. Kohlberg's stages of moral reasoning guide the development of the PRESOR scale, with questions designed to probe accountants' ethical priorities at different moral reasoning levels. This alignment ensures that the hypotheses formulated are empirically testable and deeply connected to theoretical constructs. By employing cluster and

moderation analyses, the study integrates Kohlberg's theoretical framework into its methodology. Cluster analysis reveals how demographic characteristics map onto different stages of moral reasoning, such as pre-conventional, conventional, and post-conventional stages, providing insights into how education, experience, and gender influence ethical and sustainability perceptions. Moderation analysis further uncovers how these demographic factors interact, illustrating the dynamic progression through moral reasoning stages. This approach reflects Kohlberg's emphasis on individual progression and provides a nuanced understanding of the factors shaping accountants' decision-making processes, offering valuable insights into the ethical and sustainability dimensions of SMEs.

5. Results

The findings of this study have significant implications for organizations, individuals, and policy makers who seek to improve the impact of their activities on sustainable development. Demographic variables provide valuable information about accountants in SMEs. Basic statistics show a gender imbalance, with a majority being male (12.74% female), highlighting the need for further research into this disparity in the field. Most accountants hold a bachelor's degree, while a small fraction (4.41%) have doctorates, underscoring the need for advanced education and training promotion in the field. Furthermore, a considerable portion (40.69%) of professional members have 15 or more years of experience, while 22.05% have 1-5 years of experience. The accountants' degree of work experience covers not only the current place of employment, but total years of employment. This emphasizes the value of establishing mentoring and career development opportunities for early-career professionals. By considering the demographic factors, customized approaches can be devised to address the unique needs and challenges encountered by various groups within the accounting profession.

Table1-Basic Statistics

Characteristics		**Number of Professional Members**	**Valid % Rate**
Gender	Female	26	12.74
	Male	178	87.25
	High school	12	5.88

Education level	University-Bachelor	105	51.47
	Master's	78	38.24
	Doctorate	9	4.41
Degree of experience	1-5 years	45	22.05
	5-15 years	76	37.26
	15/up	83	40.69

The data set is suitable for factor analysis since the KMO test is 0,811. Also, the Barlett test is statistically significant (chi-square: 3250,721; $p<0.001$). Two factors were achieved by the factor analysis: short-term gain and long-term gain. Table 2 displays the variables that were subjected to factor analysis and the scales used to measure them with their factor loads. These factors represent distinct viewpoints regarding the significance of business ethics and sustainability in the accounting profession.

The results classify accountants' views on ethics and sustainability into two categories. Factor 1, short-term gain, includes questions highlighting the immediate advantages and outcomes of an accountant's actions. Questions Q3, Q5, Q14, and Q16 belong to this category. Factor 2, long-term gain, centers on questions stressing the lasting influence of an accountant's choices on their professional success and career longevity. Questions Q1, Q7, Q10, and Q11 relate to this factor. This framework helps understand diverse perspectives within the profession and can influence future discussions, policy making, and education in accounting ethics and sustainability. Emphasizing the balance between short-term and long-term considerations can promote ethical behavior and sustainable practices, thereby improving the SMEs integrity and reputation.

Table2-Factor Analysis Results

Questions	**Factor 1** **Short-term gain**	**Factor 2** **Long-term gain**
Q3: For me, communication is more important than working with business ethics and sustainability.	,877	
	,789	

Q5: The most important thing for an accountant is to earn (increase) even if it is not by moral rules.		
Q14: For an accountant, effectiveness is far more important than the appearance of his actions in line with business ethics or sustainability.	,645	
Q16: Every way is permissible to ensure customer satisfaction.	,576	
Q1: The most important thing an accountant can do is to work with business ethics and with the principle of sustainability.		,896
Q7: An accountant's level of ethics and sustainability is a crucial factor in his professional success.		,880
Q10: Ethics and sustainability are very important for the continuity of the accountant's career.		,734
Q11: The priority of the accountant is to act ethically.		,678

The scale is highly reliable according to the Cronbach alfa values which are 0,831 for short term gain and 0,828 for long term gain dimensions. Pearson correlation analysis was used to explore relationships between demographic variables and these gains. The results of the correlation analysis are given in Table 3. The findings show a negative and statistically significant ($r=-,486$; $p<0.01$) relationship between short-term gain and education level; and a positive and statistically significant ($r=,536$; $p<0.01$) relationship between long-term gain and degree of experience.

The negative correlation between education level and short-term gain suggests that higher education levels may be associated with a decreased focus on short-term gains. In contrast, the positive correlations between long-term gain and degree of experience indicate that as individuals age and gain more experience in their field, they are more likely to prioritize long-term gains related to ethical behavior and sustainable practices. Moreover, the relationships observed in the table underscore the significance of incorporating sustainability into the mindset of the accounting profession. By pinpointing the links between education level, experience, and the prioritization of short-term and long-term gains, it becomes clear that placing emphasis on sustainability within accounting education and continuous professional development programs can impact accountants' decision-making processes.

Table3-Correlations Between Variables

Variables	Gender	Education level	Degree of experience	Short-term gain	Long-term gain
Gender	1				
Education level	-0,074	1			
Degree of experience	0,329*	0,213	1		
Short-term gain	0,087	-0,486**	-0,053	1	
Long-term gain	-0,064	-0,014	0,536**	-0,054	1

*p<0.05 **p<0.01

A regression model was built to test the hypotheses. The hypotheses within the scope of the study were tested using multiple regression analysis. The results and the testing of the hypotheses are given below. The results of 2 regression equations that examine the perceived ethical and sustainability level in two dimensions are presented in Table 4. Equations:

Short-term Gain = $\beta_0 + \beta_1 x\text{Gender} + \beta_2 x\text{Educational Level} + \beta_3 x\text{Experience} + \varepsilon$

Long-term Gain = $\beta'_0 + \beta'_1 x\text{Gender} + \beta'_2 x\text{Educational Level} + \beta'_3 x\text{Experience} + \varepsilon$

Table4-The Effect of Personal Characteristics on Perceived Ethics and Sustainability

Independent Variables	Model 1 Short-term gain		Model 2 Long-term gain	
	Stand β	T	Stand β′	t
Constant	,629	,917	,901	1,342
Gender	,089	1,053	-,016	-,201
Education level	-,425	-5,456***	-0,21	-,212
Degree of experience	,081	,689	,178	2,325*

Adj R^2	,307	,310
F	6,879***	6,929***
N	204	204

*p<0.05 **p<0.01 ***p<0.001

It was found that Model 1, which examines the effects of demographic characteristics on short-term gain, is statistically significant (F=6.879; p<0.01). It is seen that education level has a negative and statistically significant impact on short-term gain (β=,-425; t=5.456; p<0.001). This finding indicates that education level can provide individuals with the knowledge and skills necessary to understand and address complex problems, which can lead to more sustainable decision making and actions. So H_2 is supported.

A statistically significant effect was revealed for Model 2, which examines the effects of demographic characteristics on long-term gain (F=6,929; p<0.01). The degree of experience was another independent variable that was identified as having a positive and statistically significant impact on long-term gain (β′=.178; t=2.325; p<0.05). So H_3 is supported. It is seen that the other variables in Model 1 and Model 2 are revealed to have no statistically significant impact on gender. Therefore, the H_1 hypothesis was not supported. Figure 1 displays the analysis results.

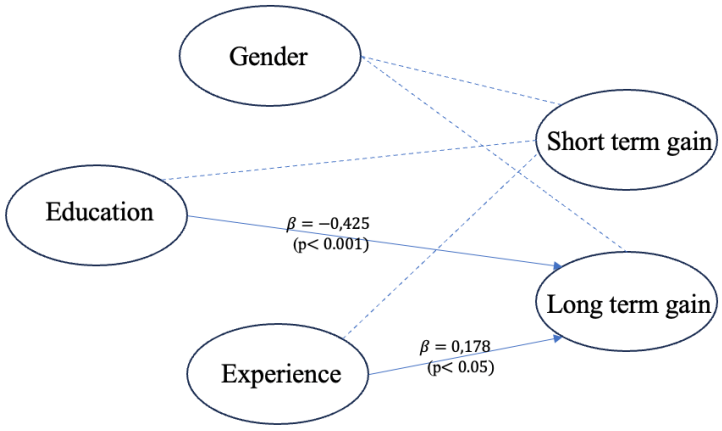
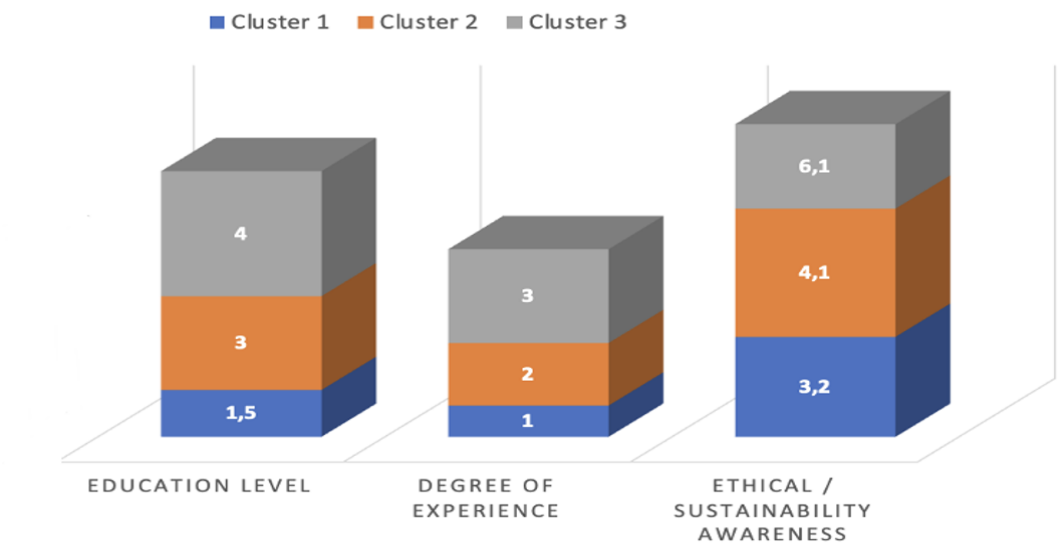


Figure1-Analysis Results

Moreover, cluster analysis is performed. Cluster analysis is a statistical method used to group objects or individuals based on their similarities across multiple variables. In the context of information above, we can use cluster analysis to identify groups of accountants with similar demographic characteristics and their perceptions of ethics and sustainability. Since there is no statistically significant impact on gender, the cluster analysis variables are chosen as education level, degree of experience, ethical awareness, and sustainability awareness. Using these variables, we can conduct a cluster analysis to identify different groups of accountants. Table 5 provides a provides a summary of the demographic characteristics and attitudes towards ethics and sustainability for each cluster. Figure 2 displays the cluster bar chart. Cluster 1 comprises accountants with lower educational attainment and minimal experience. Cluster 2 consists of accountants with a variety of education levels and moderate experience. Cluster 3 encompasses accountants with higher education levels and considerable experience.

Table-5-Cluster Analysis Summary Table

Cluster	**Education Level**	**Degree of Experience**	**Ethical/sustainability Awareness**
Cluster1	Lower mostly high school or bachelor's degree	Limited mean: 3 years	Low average score: 3.2 out of 7 scale
Cluster2	Mixed mostly bachelor's degrees, some master's degrees	Moderate mean: 10 years	Moderate average score: 4.1 out of 7 scale
Cluster3	Higher mostly master's degrees or higher	Extensive mean: 20 years	High average score: 6.1 out of 7 scale



*Ordinal Scale: Education Level (high school diploma=1, bachelor's degree=2, master's degree=3, doctorate degree=4); Degree of Experience (1-5years=1, 5-15years=2, 15/up=3); Ethical/Sustainability Awareness (out of 7-point scale).

Figure-2-Cluster Bar Chart

The cluster analysis on accountants reveals three distinct groups differentiated by education level, experience, ethical consciousness, and sustainability mindfulness. Key distinguishing factors are education and experience, which significantly influence ethical and sustainability awareness. The most educated and experienced accountants (Cluster 3) show the highest awareness levels in these areas. In contrast, less educated and less experienced accountants (Cluster 1) demonstrate the lowest awareness. Accountants in Cluster 2 exhibit intermediate levels of awareness across all categories.

The cluster analysis results emphasize the importance of adopting a comprehensive strategy for integrating ethics and sustainability within the accounting field. Tailored interventions can be devised for each identified cluster to address the specific challenges and opportunities associated with sustainability. For accountants in Cluster 1, educational and training initiatives could concentrate on the core principles of sustainability, illustrating how ethical decision-making and sustainable practices lead to enduring business achievements and societal well-being. In Cluster 2, accountants might benefit from real-world examples that showcase the advantages of Sustainability in gaining a competitive edge, promoting innovation, and strengthening stakeholder relations. For accountants in Cluster 3, could focus on emerging trends and best practices in sustainable accounting, such as incorporating environmental, social,

and governance aspects into financial reporting and implementing sustainable management strategies. These accountants could also mentor younger colleagues, promoting a culture that values ethical behavior and sustainability.

Lastly, to explore whether the relationships between demographic characteristics and the perception of ethics and sustainability were contingent on other factors, moderation analyses were conducted. Referring to the information above two more hypotheses developed to perform moderation analysis.

H_4. Gender does not moderate the relationship between degree of experience and the perception of ethics and sustainability among accountants.

H_5. Degree of experience moderates the relationship between education level and the perception of ethics and sustainability among accountants.

Table6-Moderation Analysis Results

Variable	B	SE(B)	β	t-value	p-value	95%CI
(Constant)	1.357	0.632		2.147	0.032	(0.116, 2.598)
Gender (Male=0, Female=1)	-0.119	0.208	-0.041	-0.572	0.568	(-0.528, 0.290)
Education Level	-0.281	0.117	-0.425	-2.400	0.017	(-0.511, -0.051)
Degree of Experience	0.189	0.081	0.178	2.325	0.021	(0.029, 0.349)
Degree of Experience*Gender	0.001	0.004	0.021	0.285	0.776	(-0.006, 0.008)
Education Level*Degree of Experience	0.043	0.021	0.120	2.050	0.041	(0.001, 0.085)

Table 6 summaries the moderation analysis results. The moderation analysis results provide a more nuanced understanding of the relationships between demographic characteristics and the perception of ethics and sustainability among accountants working in SMEs. H_4 is accepted ($\beta = 0.021$, $p = 0.776$). The non-significant interaction between degree of experience and gender suggests that the effect of degree of experience on the perception of ethics and

sustainability is not contingent on gender. This result indicates that degree of experience has a consistent impact on the perception of ethics and sustainability, regardless of the gender of the accountant. Therefore, the finding supports the general conclusion that more experienced accountants are more focused on ethical considerations and sustainability in their decision-making, regardless of their gender.

H_5 is accepted ($\beta = 0.120$, $p = 0.041$). This indicates that the effect of education level on the perception of ethics and sustainability is stronger for accountants with a higher degree of experience. In other words, higher education level combined with more experience leads to a greater focus on ethical and sustainable practices among accountants. The significant interaction between education level and degree of experience suggests that the impact of education level on accountants' perception of ethics and sustainability is more pronounced for those with a higher degree of experience. This finding implies that a combination of higher education and greater experience could lead to more robust ethical and sustainable decision-making in accountants, as they are better equipped to recognize and address ethical dilemmas and sustainability concerns in their work.

6. Discussion

This study utilized Kohlberg's theory, which delineates three main stages of moral development: preconventional, conventional, and postconventional. By applying this framework to the accounting profession, the study provides a nuanced understanding of how demographic factors influence ethical decision-making and sustainability perceptions among accountants in SMEs.

The preconventional phase focuses on avoiding punishment and seeking rewards. It was hypothesized (H1) that female accountants might be more likely to make ethical decisions to avoid harmful outcomes. However, the findings did not support H1. There was no statistically significant impact of gender on short-term or long-term gains, suggesting that gender may not play a significant role in ethical decision-making within accounting. This challenges the assumption within Kohlberg's framework that gender inherently influences moral development. Instead, the findings suggest that professional environments may neutralize traditional gender differences, emphasizing the contextual factors shaping ethical reasoning.

The conventional phase centers around conforming to societal norms and rules. It was hypothesized (H2) that accountants with higher education levels would have a more sophisticated understanding of societal and professional norms. The study's findings supported H2, revealing that education level negatively impacted short-term

gain but positively influenced long-term gain. This suggests that education plays a critical role in shaping accountants' ability to prioritize the long-term implications of their decisions, thereby encouraging ethical and sustainable decision-making. For example, accountants with advanced degrees consistently emphasized the importance of long-term sustainability, aligning with the conventional stage where societal norms and professional expectations guide behavior. Moreover, the findings indicate that education not only facilitates progression to higher stages of moral reasoning but also equips accountants to internalize professional ethics, thus bridging individual moral development with organizational decision-making. This highlights the role of education in operationalizing abstract ethical principles in practical, workplace-oriented contexts.

The significant influence of education underlines the importance of higher education in equipping accountants with the cognitive and experiential tools necessary for advancing through moral development stages. SMEs should prioritize hiring accountants with advanced degrees, as they are more likely to integrate ethical considerations and sustainability into their decision-making processes. Additionally, exposing accountants to interdisciplinary fields, such as philosophy or social sciences, could further enhance their ethical reasoning capabilities by providing diverse perspectives and fostering cognitive disequilibrium—a catalyst for moral development.

The postconventional phase is characterized by decisions guided by universal ethical principles that transcend societal norms. It was hypothesized (H3) that accountants with extensive work experience would have a deeper understanding of ethics and sustainability, leading to more ethical decisions. The findings supported H3, showing that more experienced accountants prioritized long-term gains, aligning with postconventional reasoning. Notably, the interaction between education and experience amplified the progression through Kohlberg's stages. Accountants with both higher education and significant professional exposure demonstrated a robust commitment to sustainability, embodying postconventional reasoning in their ability to balance organizational objectives with societal and environmental responsibilities. This novel insight underscores the interplay of cognitive and experiential factors in fostering ethical behavior, advancing theoretical understanding of moral development in professional settings.

By linking these findings to Kohlberg's framework, this study validates, refines, and challenges aspects of his theory. The role of education in fostering long-term sustainability aligns with both conventional and postconventional stages, demonstrating how education equips accountants to internalize societal norms while progressing toward abstract ethical principles. In contrast, the lack of gender-based differences challenges traditional assumptions, suggesting a need to reassess the framework's applicability to diverse professional contexts.

Additionally, the progression from preconventional to postconventional reasoning is evidenced by the concrete examples of how experienced accountants prioritize long-term sustainability over short-term gains, illustrating the practical evolution of moral reasoning in organizational settings. This integration of individual moral development with organizational decision-making adds a practical dimension to Kohlberg's theory, emphasizing its relevance in applied contexts such as sustainability and ethics in SMEs.

For SME Owners, the findings highlight the importance of hiring accountants with advanced education and substantial experience to drive long-term ethical and sustainability-focused strategies. Such professionals can help SMEs balance short-term profitability with long-term goals, fostering trust and transparency within the organization.

For Policymakers, these insights can inform the development of targeted interventions, such as financial incentives or regulatory frameworks, to promote ethical and sustainable practices in SMEs. Policymakers could also design training programs to enhance accountants' capabilities in addressing ethical dilemmas and sustainability challenges.

For Communities and Customers, ethical leadership within SMEs positively impacts local communities by aligning organizational goals with broader social and environmental well-being. Customers benefit from transparent practices, reinforcing trust and loyalty.

This study advances Kohlberg's theory by bridging individual moral reasoning with organizational impact. It demonstrates how education and experience foster progression through moral reasoning stages, offering practical insights into how individual attributes translate into professional behaviors. By situating moral development within organizational practices, the study offers an empirical basis for integrating ethical frameworks into professional training and development programs.

Theoretically, this research extends Kohlberg's framework by demonstrating its applicability in organizational ethics and sustainability. It highlights how education and experience foster ethical maturity, emphasizing the dynamic and evolving nature of moral reasoning. This contribution not only validates Kohlberg's stages but also provides a roadmap for their operationalization in professional settings, particularly in SMEs. These findings underline the necessity of interdisciplinary and experiential learning in advancing ethical priorities.

From a societal perspective, the study underscores the role of accountants as ethical stewards who influence organizational and community outcomes. Ethical practices in SMEs enhance trust, reduce operational risks, and contribute to social and environmental welfare. Policymakers can leverage these insights to design holistic strategies

that align ethical business practices with broader societal goals, such as the Sustainable Development Goals (SDGs). By emphasizing the interplay between individual moral development and collective well-being, the study bridges theoretical constructs with practical societal impact.

Despite its contributions, this study has limitations. The sample size, focused exclusively on Turkish SMEs, may limit generalizability to other contexts. Future research could expand the scope to include SMEs from diverse geographical and economic settings. Additionally, the reliance on cross-sectional data provides only a snapshot of ethical perceptions and sustainability practices. Longitudinal studies could capture the evolution of these dynamics over time.

Finally, self-reported data introduces potential biases, such as social desirability bias. Future studies could incorporate objective measures or triangulate findings using qualitative methods, such as in-depth interviews, to provide a more comprehensive understanding of accountants' roles in promoting ethics and sustainability.

By addressing these limitations, future research can build on this study to deepen our understanding of the interplay between individual attributes and organizational sustainability outcomes, fostering a culture of ethics and sustainability in SMEs globally.

7. Conclusion

This study examines the relationship between accountants' characteristics and their perceptions of ethics and sustainability in SMEs. It suggests that ethical behavior in SMEs may be more influenced by individual approaches in specific ethical situations than by a shared moral philosophy. By hiring accountants knowledgeable about sustainable practices and promoting continuous learning, SMEs can enhance their ethical conduct and sustainability. Moreover, understanding how demographic characteristics may affect perceptions of ethics and sustainability can help SMEs to better engage with diverse stakeholders and build a positive reputation as ethical and sustainable organizations, which can further contribute to the overall well-being of their communities and the planet.

This study has an impact on various stakeholders, including SME owners, policymakers, and accountants themselves. For SME owners, the insights encourage strategic hiring practices and investment in professional development initiatives to enhance long-term sustainability outcomes. Policymakers are informed about the need for targeted interventions to foster ethical and sustainable practices, such as providing financial incentives, regulatory frameworks, and technical support. Accountants are directly impacted by the study's emphasis on the importance of

education and experience in shaping ethical decision-making, encouraging them to pursue continuous professional growth.

This study contributes to the literature in several ways. Drawing inspiration from Johnstone (2020), who explored the determinants of environmental sustainability in SMEs, this research specifically investigates the role of accountants in SMEs, addressing a gap in the literature and shedding light on a sector that is often underrepresented in sustainability research. By identifying the connections between factors such as gender, education level, and experience with ethical and sustainable decision-making, this research provides a novel perspective on the individual-level determinants of sustainable practices, like the approach taken by Hinze and Sump (2019) in studying the role of financial analysts' in promoting sustainability practices. This study contributes to the literature by explicitly connecting Kohlberg's theory to the context of sustainability. The research provides empirical evidence supporting the idea that individuals progress through different stages of moral reasoning, which in turn affects their understanding and implementation of sustainable practices in SMEs. This connection is similar to the theoretical link between individual values and corporate social responsibility explored by Perkins et al. (2021).

The findings align with studies like Rogosic and Bakotic (2019), which highlight the role of education in shaping ethical decision-making. However, this study goes further by demonstrating how education fosters long-term ethical priorities within professional settings, particularly in SMEs. The results also support Nguyen et al. (2023), who identified the critical role of professional experience in advancing sustainability practices. However, unlike Nguyen et al., this research focuses specifically on accountants, offering nuanced insights into their unique role as mediators between financial objectives and ethical responsibilities. In contrast to studies like Ortiz-Martínez and Marín-Hernández (2022), which emphasize organizational-level factors, this research underscores the importance of individual attributes (e.g., education and experience) in driving ethical and sustainability practices. This individual-level focus adds a new dimension to the existing literature on ethical behavior in SMEs. By integrating individual and organizational perspectives, this study contributes to bridging the gap between micro-level decision-making processes and macro-level sustainability outcomes, paving the way for more comprehensive analyses in future research.

The findings of this research carry practical consequences. By utilizing the insights gained from this study, SMEs can strategically hire accountants whose demographic attributes are positively associated with ethical and eco-friendly decision-making. Additionally, SMEs should emphasize providing extensive professional development

initiatives that focus on ethics, sustainability, and corporate accountability. This method enables their accountants to make knowledgeable, responsible choices that are in line with the company's green objectives.

The study's alignment with its objectives and hypotheses further underscores its significance. By confirming the impact of education and experience on long-term sustainability and ethical decision-making (H2 and H3), the research validates its theoretical foundation and provides actionable insights for SMEs. Although H1 was not supported, the findings contribute to a broader understanding of gender's role, emphasizing inclusivity and diversity in ethical perceptions within accounting practices.

This research informs policymakers and regulatory authorities about fostering ethical and eco-friendly decision-making in SMEs. It suggests creating targeted interventions based on the study's findings, addressing challenges SMEs face in adopting responsible practices. Policymakers are advised to develop a regulatory environment that supports ethical and sustainable practices in SMEs, potentially including financial incentives, technical support, and transparent sustainability reporting standards. These measures aim to help SMEs thrive while fulfilling their societal and ecological responsibilities.

While centered on Turkish SMEs, this study's insights have broad global applicability, emphasizing the universality of accounting and demographic factors like gender, education, and experience in shaping ethical and sustainable business practices. The findings serve as a strategic guide for enterprises worldwide, particularly in emerging economies that mirror Turkey's dynamic and evolving business landscape. As Turkey navigates growth and sustainability challenges, its experiences offer valuable lessons for other developing countries. This study highlights the significance of ethical and sustainable operations as pivotal elements in global economic development, providing a roadmap for businesses in similar context to foster responsible and progressive practices.

The research sample consisted of accountants in SMEs. The most important limitation of this study is that accountants in SMEs are not willing to take the survey involving questions on ethics and sustainability. Therefore, it was conducted with only a limited number of participants due to time and resource limitations. It is important to note that gender, age, education level and degree of experience alone are not a guarantee for moral and ethical decision-making and sustainability as other factors such as culture, individual values, perspectives, and beliefs also play a role. Future research should explore the role of cultural and socio-economic influences on ethical perceptions within SMEs across diverse regions. Expanding the scope of research to include longitudinal studies could provide deeper insights into how moral reasoning evolves over time and its sustained impact on sustainability practices. Additionally,

exploring the interplay between organizational culture and individual moral development could yield valuable perspectives for both academia and practice.

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Relevance of Accounting Service-Learning for Micro, Small, and Medium Enterprises: Owner-Managers' Insights

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Abstract

The service-learning concept is well recognized in higher education, with the community partner being its most pivotal stakeholder. A service-learning project that fails to address the community partner's needs is essentially ineffective. However, the majority of existing research has predominantly focused on the impact of service-learning on students' academic performance. This study aims to fill this gap by offering empirical insights into the relevance of service-learning for community partners, particularly small businesses. Specifically, we examine an accounting service-learning program at a Malaysian public university, which has been running since 2020 and involves micro, small, and medium enterprises (MSMEs). MSMEs were selected as the target community because they often lack the financial resources to afford credible financial management and business performance advice. In response, final-year accounting students provided complimentary business advisory services to these MSMEs through the service-learning program. Based on survey responses from 63 MSME owner-managers who participated between October 2020 and July 2024, the study finds that participants perceived the service-learning initiative as relevant and beneficial to their businesses. They reported improvements in business acumen and innovation, as well as practical solutions to key challenges. Additionally, participants offered valuable suggestions for further enhancing the program. This study adds to the limited empirical literature on the impact of service-

learning on community partners, particularly in the context of developing economies, and offers a practical model for how universities can meaningfully engage with small businesses.

Keywords Service-learning · Accounting · Higher education · Malaysia

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Introduction

Service-learning is an instructional method that integrates theory and practice, connecting classrooms with communities, and balancing cognitive and affective learning (Butin, 2005). This approach offers profound learning opportunities for students (Grobbelaar et al., 2017; Jenkins & Sheehey, 2011), with critical self-reflection being a vital component of the learning process (Asghar & Rowe,2017; Rinaldo et al., 2022). However, the reciprocal nature of service-learning pedagogy means that it is equally important to ensure that community partners find the service-learning experience meaningful (Asghar & Rowe, 2017; Grobbelaar et al., 2017; Rinaldo et al., 2022; Tyndall et al., 2020). Community partners invest significant time in planning, implementing, and evaluating these projects (Jordaan & Mennega, 2022; Rinaldo et al., 2022) and are considered the most crucial stakeholders in any service-learning initiative (Bowie & Cassim, 2016). Therefore, projects that fail to meet the community's needs may need to be reconsidered or even halted (Rinaldo et al., 2022).

Despite the recognized importance of reciprocity in service-learning, research on the role of service-learning in higher education remains limited, particularly from the perspective of community partners (Compare et al., 2022; Salam et al., 2019a; Rinaldo et al., 2022; Tyndall et al., 2020). In their

systematic review, Salam et al. (2019a) identified only a handful of studies that focus on community partners' perspectives including Coleman and Danks (2015), Jarrel et al. (2014), Marshall et al. (2015), Simola (2009), and Weiler et al. (2013). While some additional studies have been published since 2020 (Compare et al., 2022; Doughty, 2020; Jordaan & Mennega, 2022; Mohd Naufal et al., 2024), the majority of research still tends to focus on the impact of service-learning on students rather than on the communities they serve. This study seeks to address this gap by exploring the relevance of accounting service-learning for the participating MSMEs. Relevance is one of the key components of successful service-learning, alongside respect, reflexivity, and reciprocity, as outlined by Kirkness and Barnhardt (1991) and later emphasized by Butin (2003). Activities must be relevant both for students and communities, addressing real community needs while expanding students' comprehension of the world (Kirkness & Barnhardt, 1991). Specifically, this study responds to the need for more research on the outcomes of service-learning for small business owners, as Simola (2009) highlighted.

In Malaysia, service-learning was first introduced in 1977 through an innovative project known as the Learning-Service Plan with the rural community, spearheaded by the University of Science, Malaysia (USM) (Mohd Naufal et al., 2024). In 2017, the concept underwent rebranding and redefinition by the Ministry of Higher Education (MOHE). On 5 March 2019, the Service-Learning Malaysia University for Society (SULAM) was officially launched by the former Minister of Education, Dr. Maszlee Malik, as part of Malaysia's educational Shift 1 initiative. Since its inception, the Ministry of Higher Education has mandated the implementation of SULAM across both public and private universities in Malaysia. SULAM aims to bridge the gap between academic learning and community engagement, nurturing practical skills and social responsibility among students (Department of Higher Education, Ministry of Education, 2019). Despite its ambitious goals, the extent to which SULAM has effectively impacted its community partners remains unclear. While

there are positive anecdotes and success stories, comprehensive data and evaluations are essential to gauge the overall effectiveness and reach of the program in benefiting the communities it serves. Existing literature has explored service-learning from the community's perspective (Mohd Naufal et al., 2024; Jordaan & Mennega, 2022), focusing on their self-perceived roles and identifying key success factors. However, there remains a gap in research directly measuring the perceived impact of SULAM on the community.

In light of the above, this study examines the relevance of the SULAM project embedded in a capstone course of the accounting degree program at Universiti Teknologi MARA (UiTM), Malaysia, from the community partner's perspective. The specific course in focus is the Integrated Case Study (coded MAF671). The MAF671 SULAM initiative involves the transfer of knowledge from students to MSMEs through the provision of complimentary business advisory services. Given the myriad of challenges faced by MSMEs (Abd Aziz, Awang & Zaiton 2012; Hashim, 1999; Mohd Sallem et al., 2017; Saleh & Ndubisi, 2006; Selvarajah, Meyer & Sarasvathy, 2016; Soon, 2011; Ting, 2004) and their critical need for credible advice, the support from students can be invaluable. While the best option for MSMEs would be to seek advice from professional consultants, their limited financial resources often make this unaffordable due to the typically high cost of such services. By evaluating the MSME viewpoints, this study seeks to understand the real-world impact of student-led business advisory services on these enterprises, providing insights into the practical benefits and potential areas for improvement in the SULAM initiative. Specifically, the questions this study attempts to address are:

RQ1: How does the MAF671 SULAM project benefits MSME?

RQ2: How do participants perceive the organization, coordination, and outputs of the MAF671 SULAM project?

RQ3: What are the recommendations deemed most beneficial and practical by the MAF671 SULAM participants?

RQ4: What are areas for improvement suggested by the MAF671 SULAM participants?

This paper contributes the following to the literature. First, we provide evidence as to how the accounting service-learning impacts the community members. Using self-reported surveys, we document that MSMEs perceived the project as beneficial to their business management acumen and attitude. The project is also viewed to have a positive impact on their innovativeness and business performance. The MSMEs were also satisfied with the effectiveness of the project, quality of the reports as well as the innovativeness and practicality of the solutions proposed to the identified issues. Our findings extend the scarce empirical evidence on the benefits of service-learning to the community documented in prior works (Coleman & Danks, 2015; Doughty, 2020; Jarrel et al., 2014; Marshall et al., 2015; Simola, 2009; Weiler et al., 2013).

Second, feedback from the owner-managers of participating MSMEs provides valuable insights into how the SULAM project can be refined for greater effectiveness. While some suggestions are specific to future MAF671 SULAM projects, others are more broadly applicable to various service-learning initiatives. Notable general recommendations include securing funding and government support, as well as operational improvements, such as using more accessible and less academic language.

The remainder of the paper proceeds as follows. The next section provides the review of relevant literature in understanding the background and development of service-learning pedagogy. Next, the method of this study is described followed by the presentation and discussion of findings. Finally, the paper concludes with implications of our findings, study limitations, and recommendations for future research.

Literature Review

Service-learning Background and Development

Service-learning was established around a century ago as part of Dewey's (1938) experiential learning concept, and it has since achieved broad acceptance. It is currently extensively implemented in higher education across various domains. It is reported as most widespread in health sciences and nursing, business and economics, computer and information science, sociology and criminal justice, teacher education studies, geography and environmental studies, language and communication, and art studies (Salam et al., 2019a).

Service-learning can be described as an educational approach that combines academic learning and community service, in which students participate in organized service activities to address community needs, thereby improving their understanding of course content, applying theoretical knowledge in real-world scenarios, providing students with practical experience, and instilling a sense of civic responsibility (Bringle & Hatcher, 1996; Bringle & Hatcher, 2002; Butin, 2005; Salam et al., 2019a). Bassi (2011) notes that this approach supports students' learning by integrating various interpersonal skills while making meaningful service to society.

It is important to note that service-learning is distinct from volunteerism and internship. The differences of these three educational activities are encapsulated in Figure 1. According to Ferrari and Chapman (2014), service-learning focuses on enhancing students' theoretical knowledge through community service and reflection. In contrast, internships emphasize developing career-specific skills, primarily benefiting the service providers (Bringle & Hatcher, 1996; Furco, 1996), while volunteerism centers on providing services to those in need (Furco, 1996). Service learning uniquely

combines academic learning with community service to give practical experience and enhance knowledge of classroom subject (Bringle & Hatcher, 2002).

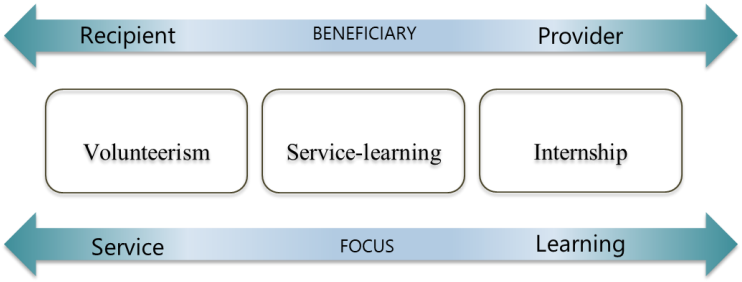

Figure 1 Volunteerism, service-learning, and internship (Source: Salam et al. (2019a)).

Approaches, Key Stakeholders, and Outcomes of Service-learning in Higher Education

Service-learning can be implemented in higher education through various approaches, including course-based, program-based, community-based, and extracurricular models (Bringle & Hatcher, 1996; Nejmeh, 2012; Holland & Furco, 1996). In course-based service-learning, service projects are embedded into academic courses, connecting theoretical knowledge with practical application. Program-based service-learning, on the other hand, involves structured programs or dedicated centres that coordinate service-learning experiences across multiple courses or disciplines. Community-based service-learning integrates research projects with service-learning to address specific community needs. Extracurricular service-learning occurs outside of the academic curriculum, allowing students to engage in community service through clubs, organizations, or independent projects.

Service-learning outcomes have been assessed from the perspectives of its stakeholders; students, educators, and community partners (Astin & Sax, 1998; Celio et al., 2011). However, the literature has largely focused on student outcomes, both academically and personally. Academically, students often show improved understanding and retention of course material when applied in real-world settings. Service-learning encourages critical and reflective thinking, fostering deeper engagement

with the subject matter, which enhances critical thinking skills (Mtawa et al., 2021; Murakami et al., 2003). Research such as Markus et al. (1993) and Salam et al. (2017) have shown that service-learning leads to higher academic performance and more positive course evaluations from students.

The personal impacts of service-learning on students are broad, encompassing attitudinal, moral, social, and cognitive development (Bringle & Hatcher, 1996; Coquyt, 2020; Giles & Eyler, 1994; Soria et al., 2023; Yoon et al., 2022). A bibliometric review by Martínez-Heredia et al. (2022) highlights that most studies view service-learning as a powerful tool for developing awareness, commitment, and responsibility toward social issues and inequalities. In addition to greater empathy, and heightened political, social, and cultural awareness, students often report increased self-confidence, and enhanced problem-solving abilities (Coquyt, 2020; Higuera & Martín, 2023; Soria et al., 2023; Yoon et al., 2022). Service-learning also supports career development by providing students with practical skills such as teamwork, leadership, and communication, all of which are valuable for future career success (Dixon, 2011; Mtawa et al., 2021).

Educators play a crucial role in building healthy relationships between community members and students (Salam et al., 2017). They often act as initiators, designing service-learning courses and projects, while also serving as collaborators and facilitators to ensure smooth implementation at service delivery sites (Salam et al., 2019b). Additionally, educators supervise and guide students throughout their service-learning projects (Voss et al., 2015). Service-learning offers several benefits to educators. It revitalizes classroom dynamics, making teaching more enjoyable (Bringle & Hatcher, 1996), and provides opportunities for action research and professional growth by fostering a sense of self-efficacy (Leon et al., 2017; Stewart, 2012). It also raises awareness about community needs, helping educators design more effective learning activities that align with course objectives (Stewart, 2012). By actively participating in fieldwork alongside students, educators can enhance their teaching

abilities and instructional productivity (Kinloch et al., 2015). Service-learning projects encourage educators to rethink their teaching styles, apply existing theories to real-life examples, and foster critical thinking (Carrington et al., 2015; Lasen et al., 2015). By incorporating relevant and practical examples, instructors can make clearer, more logical connections between theoretical knowledge and workplace realities (Lasen et al., 2015). This connection helps students better understand new concepts and theories, ultimately supporting the achievement of learning outcomes. Interestingly, Leon et al. (2017) note that service-learning fosters key learning outcomes for instructors similar to those observed in students, including enhanced community building, reflective practice, a sense of connectedness, and critical engagement.

Community members, as recipients of service and key stakeholders in service-learning, are expected to benefit significantly from these projects, though some critics argue that mutual benefits are not always achieved (Compare et al., 2022; Rinaldo et al., 2022; Tyndall et al., 2020). While research on the value of service-learning for community partners is limited, existing studies and anecdotal evidence suggest that service-learning addresses a variety of community needs, from improving local infrastructure to providing essential social services. These benefits vary depending on the scope and nature of the projects and may include free business consultations and advisory services (Simola, 2009), psychological support (Marshall et al., 2015; Weiler et al., 2013), as well as complimentary nutrition consultancy, medical checkups, and medications (Jarrell et al., 2014). Interviews with community organizations by Rinaldo et al. (2022) highlight both direct and indirect benefits. Direct benefits include additional volunteers to support daily operations, access to expertise beyond their own capabilities, and the opportunity to engage with and recruit creative young minds. Indirect benefits include achieving their organizational missions. Service-learning may also result in increased social, reputational, and financial capital (Schwartz & Fontenot, 2007; Compare et al., 2022) and indirectly foster a sense of self-efficacy within the community (Gerholz et al., 2017; Sanders et al.,

2015), while strengthening relationships between universities and community organizations. These collaborations often lead to long-term partnerships, promoting mutual benefit and sustained cooperation.

The preceding discussion suggests that service-learning in higher education represents a dynamic and evolving approach to integrating academic learning with community service. While it offers numerous benefits for students, educators, and communities, ongoing attention to best practices, sustainability, and impact assessment is essential for maximizing its effectiveness and addressing challenges.

Challenges and Issues of Service-learning in Higher Education

Service-learning offers a powerful tool in higher education, enhancing student learning, promoting social participation, and addressing local concerns. Unfortunately, embedding service-learning as a standard practice across higher education institutions remains a significant challenge, demanding full integration at all levels (Gill, 2023). Among others, service-learning has been criticized for its pedagogical, political, and institutional limitations (Jelinčić et al., 2022).

One major challenge is institutionalizing civic engagement through service-learning, which can be hindered by conflicting educational priorities. This issue raises concerns about aligning service-learning with broader educational objectives (Lounsbury & Pollack, 2001). While service-learning can be adapted to different socio-cultural contexts to enhance student competencies and improve higher education practices (Gruslytė, 2020), some argue that students, particularly in rural areas, need exposure to innovative teaching methods to improve the quality of education and employability (Campillo et al., 2019). These methods may not always align with service-learning, especially when addressing diverse student needs.

Another issue is that service-learning has been criticized as potentially exploitative, as it may fail to give students a critical understanding of power dynamics and inequality, particularly when working with marginalized communities (Asghar & Rowe, 2017). Balancing student development with social justice objectives remains a challenge (Odame & Oram, 2012).

In Malaysia, service-learning faces additional obstacles to effective implementation in higher education. Despite being mandated as part of academic programs, several barriers persist, including self-imposed, pedagogical, technical, financial, and organizational challenges (Lassoued et al., 2020; Yusof et al., 2020). Further challenges in Malaysia include limited internet access, technical skills gaps, and inadequate data (Behak et al., 2022). To overcome these issues, it is suggested that universities improve infrastructure and training to support service-learning programs (Behak et al., 2022). The Covid-19 pandemic further complicated these challenges, as the sudden shift to online learning disrupted service-learning activities (Atan, 2023; Ghafar et al., 2022). The lack of face-to-face interaction weakened experiential learning through community engagement (Lin & Shek, 2021), forcing universities to adapt by incorporating distance learning and ensuring the quality of online education (Ramírez-Hurtado et al., 2021). To address these challenges, Wahi (2024) proposes a quadruple collaboration model, where universities partner with communities, government bodies, and industries. Additionally, the Service-Learning Malaysia (SULAM) Playbook recommends a three-phase reflection process—before, during, and after projects—to enhance service-learning effectiveness (Hassan, 2023).

In conclusion, service-learning is a valuable approach that integrates community-based projects with academic learning. However, its full potential is often limited by obstacles such as institutionalization,

curriculum integration, and catering to diverse student needs. Addressing these challenges is crucial to fully leverage the benefits of service-learning in higher education.

Theoretical Frameworks

Service-learning, rooted in the early 20th century with contributions from educators like John Dewey, is part of a rich educational tradition. Dewey's (1938) work on experiential learning laid the foundation for this approach, which gained significant momentum in the 1960s and 1970s as educators sought to integrate learning with community engagement. One of the most influential theoretical frameworks in experiential learning is Kolb's (1984) experiential learning cycle, which describes learning as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984). Kolb's model outlines four stages of learning: concrete experience, reflective observation, abstract conceptualization, and active experimentation. According to Petkus (2000) and Durbin and Marchel (2015), service-learning provides a platform for students to engage in all four stages of this cycle. As such, Kolb's (1984) pedagogy implies that service-learning is an ideal approach for experiential learning.

With service-learning recognized as an effective tool for student experiential learning, the next question arising is how to assess its effectiveness holistically for all stakeholders involved. To ensure service-learning is legitimate, ethical, and valuable, scholars have proposed four key criteria: respect, relevance, reflexivity, and reciprocity (Butin, 2003; Kirkness & Barnhardt, 1991). This study focuses on 'relevance,' as it is a critical measure of the usefulness of service-learning for community partners. Relevance refers to the alignment of service-learning projects with both student learning objectives and community needs, addressing real-world issues while broadening students' understanding of their environment (Kirkness & Barnhardt, 1991). In line with this definition, we argue that a service-learning project is relevant to MSMEs if it enhances the business competencies and innovativeness of key personnel while providing effective solutions to the challenges they face. MSMEs often lack

expertise and resources, making credible advice and practical support crucial to their growth and sustainability.

Method

To fully grasp the method of this study, it is essential to have a comprehensive understanding of the context of the MAF671 SULAM project, which is elaborated upon in the following sections.

The MAF671 SULAM: Community Partner

MSMEs play a pivotal role in propelling economic growth on a global scale. This significance is mirrored in Malaysia, where MSMEs form a vital backbone of the economy. In fact, they constitute a substantial 97.4% out of a total of 1,204,929 registered businesses nationwide (SME Corporation, 2023). As of 2022, MSMEs accounted for 48.2% of employment and contributed 38.4% to the overall national Gross Domestic Product (GDP) (Department of Statistics Malaysia, 2023). However, despite their substantial presence in the business landscape, MSMEs' contribution to the national GDP remains relatively modest, although it is steadily increasing. Worryingly, the MSMEs' contribution to GDP is still well short of the 45% projection by 2025 (SME Corporation, 2022).

Statistical data reveals that more than 99% of businesses, 70% of all jobs, and 50%-60% of global value added come from MSMEs (Lamb, Darouichi & Jonczyk Sedes, 2022). In the U.K. and U.S., for instance, MSMEs account for around 51% (UK Business Statistics, 2023) and 43.5% (U.S. Chamber of Commerce, 2023) of their respective GDPs. Hironaka, Zariyawati, and Diana-Rose (2017) compared the performance of Malaysian MSMEs and their Japanese counterparts. The authors emphasized the underperformance of MSMEs in Malaysia, where Japanese MSMEs contributed more than half the country's employment, GDP, and exports, far exceeding the contributions of Malaysian MSMEs. Even when compared to the performance of MSMEs in other developing Asian nations such

as Indonesia and Thailand, the Malaysian MSMEs are lagging (Yoshino & Taghizadeh-Hesary, 2016).

According to the World Bank (2023), formal MSMEs in emerging economies contribute up to 40% of national GDP. When informal SMEs are included, these figures are significantly higher (likely more than 50%).[1] Mohd Thas Thaker and Mohamed (2013) compared the contribution of Malaysian MSMEs to GDP with selected Organization of Islamic Coopertion (OIC) countries such as UAE, Indonesia and Egypt, and several non-OIC countries such as Korea, Singapore, Vietnam and South Africa. They documented that the MSMEs in the OIC countries (non-OIC countries) represent 93-97% (91-99%) of their economies and contribute between 37-60% (40-70%) to their GDP.

The aforementioned data suggests that while the presence of MSMEs in the overall business landscape of Malaysia is substantial, their economic impact is relatively low when compared to MSMEs in other countries. This situation has prompted numerous inquiries on the reasons behind the relatively low contribution of MSMEs in Malaysia to the economy. A potential explanation to this puzzle is that the vast majority (98.57%) of MSMEs in Malaysia are classified as micro enterprises (Mohd Thas Thaker & Mohamed, 2013). These MSMEs often encounter formidable challenges that hinder their growth and sustainability, particularly in suburbs. While the significance of MSMEs cannot be overstated, they frequently face hurdles in areas such as financial management, financial

[1] Ligthelm (2013) defined the informal sector as small unregistered enterprises such as street sellers and in-home businesses set up on private properties. Small formal businesses, on the other hand, are classified as businesses that operate from fixed building structures located on business stands designated as such by local government (municipal) town planning rules. For example, in Japan, Korea, Taiwan, and Germany, MSMEs constitute more than 98% of all establishments and contribute over 65% to employment and more than 50% to GDP (Amrina, 2009).

competency, operational efficiency, and access to relevant resources (Kumar & Saroja, 2017; Selvarajah, et al., 2016). Accordingly, MSMEs were chosen as the community partner for the MAF671 SULAM initiative.

The MAF671 SULAM: Modus Operandi

MAF671, an Integrated Case Study course, extends beyond traditional accounting topics like management accounting, financial reporting, and auditing, to encompass broader business and management issues such as taxation, strategic management, ethics, and corporate governance. Through the MAF671 SULAM project, students engage with real-world integrated case studies, serving as independent advisors to MSMEs. The project provides free advisory support to MSMEs, with students working in teams to analyze the firms, identify business challenges or areas for improvement, and propose practical, effective solutions.

At the start of each MAF671 SULAM project, instructors reached out to participating owner-managers to explain the project's objectives, methodology, and expectations. The roles and responsibilities of students, instructors, and MSMEs were clearly communicated to ensure mutual understanding. Upon completing the project, students submitted business advisory reports to the MSMEs. These reports were evaluated on their quality, clarity, and the practicality and innovativeness of the recommendations. Depending on the MSME owner-managers' availability, students also presented their findings verbally.

Data Collection

After the MAF671 SULAM project concluded, MSMEs were invited to voluntarily complete a survey to provide feedback on its effectiveness. Of the 145 MSMEs that participated in the MAF671 SULAM projects as of July 2024, 63 responded, resulting in a response rate of 43.4%. The

respondents included key figures in the business, such as founders, owner-managers, and managing directors.

The self-constructed survey comprises three main sections. The first section focuses on the impact of the SULAM project on the service beneficiaries, specifically addressing the MSME key person's business management knowledge and behaviour, as well as their innovation capabilities and business performance. The second section pertains to the organization and coordination of the SULAM project as well as the quality of the business advisory report produced. The third section consists of two open-ended questions related to the recommendations proposed by students deemed most beneficial and practical, and areas for improvements of the SULAM project. The first two sections include five statements each. Responses to the five items in the first section were binary (yes or no). For the second section, a five-point Likert scale was employed: 1 = Poor; 2 = Fair; 3 = Good; 4 = Very good; 5 = Excellent.

The data for this study comprises feedback gathered from this survey from October 2020 through July 2024. Responses to the ten statements were analyzed descriptively, while responses to the open-ended questions were manually analyzed to identify recurring themes.

Findings and Discussion

The results of this study are presented and further discussed below.

Section 1

Table 1. Survey feedback of Section 1

No	Statement	No. of responses

		Yes	No
1	This project helps improve my knowledge in business management.	60	3
2	I respond positively to the analysis and recommendations presented.	63	0
3	My business has benefited from this project.	63	0
4	I have become more innovative through this project.	61	2
5	I will make improvements/changes to my business practices as suggested by the students in this project.	63	0

As can be seen in Table 1, most of the owner-managers agreed that the MAF671 SULAM project improves their knowledge in business management and made them more innovative. Additionally, all of them acknowledged that they responded positively to the analysis and recommendations presented by students, their business has benefited from the project, and that they would take up the suggestions to improve their business practices.

Section 2

Table 2. Survey feedback of Section 2

No	**Statement**	**Mean of responses**
1	Achievement of project objectives.	4.54
2	Project management.	4.57
3	Quality of the business advisory report.	4.56
4	Innovativeness of suggestions and recommendations given to improve business performance.	4.40
5	Practicality of suggestions and recommendations given to improve business performance.	4.49

The results in Table 2 indicate that the average scores for all five items range between 4 and 5, reflecting a perception of performance from very good to excellent. Notably, the first three items have a mean score above 4.5, approaching an excellent rating. Although the fourth and fifth items have mean scores slightly below 4.5, they remain above 4.4, indicating a strong positive evaluation. These findings suggest that respondents felt the project objectives were effectively achieved and that the projects were well managed. They also perceived the business advisory reports produced by the students to be of high quality. Furthermore, the innovativeness and practicality of the solutions proposed by the students were also regarded as being of a high standard.

Together, the aforementioned results of sections 1 and 2 imply that the SULAM project has achieved its learning outcomes and objectives, which are for students to act as independent advisors and help identify the issues facing the businesses and propose practical and effective solutions for the identified issues. The results suggest students' analysis and recommendations are well-accepted by the MSMEs.

Section 3

In this final section, we asked the following questions:

Q1: Which recommendations do you find most beneficial and practical, and intend to implement in your business?

Q2: Feedback or suggestions for improving this project (if any).

The responses to Q1 and Q2 above can be categorized into distinct themes as presented in Tables 3 and 4, respectively.

Table 3. Survey feedback of Section 3 (Q1)

No	Theme	Specific recommendations
1	Operational improvements	a. Establishing a queue number system for customer self-pickup. b. Assigning staff to monitor opening and closing times. c. Strengthening inventory management. d. Improving data storage and documentation filing systems. e. Implementing a biological asset tracking system. f. Updating menus and discontinuing low-selling products. g. Enhancing the physical layout and aesthetics of the business premises
2	Marketing and customer engagement	a. Strengthening marketing platforms. b. Creating Telegram accounts and groups for product updates. c. Utilizing social media for customer interaction and engagement. d. Establishing working relationships with local schools and organizations. e. Considering influencer marketing for cost-effective promotion. f. Providing customer feedback platforms. g. Improving digital marketing strategies. h. Updating websites to improve online presence. i. Introducing technology like TikTok for online marketing.
3	Financial management	a. Analyzing company accounts regularly. b. Implementing proper financial management practices. c. Making informed assessments before accepting new projects. d. Creating efficient cash budgets. e. Analyzing company finances every six months. f. Assessing project financials and cash flow.

4	Training and human resources	a. Providing adequate training for staff. b. Collaborating with other entrepreneurs for mutual benefit. c. Increasing workforce to boost production. d. Implementing improvements suggested by the human resource department.
5	Technological integration	a. Implementing online training courses. b. Utilizing gamification for engagement. c. Exploring the use of Zapier system for process automation. d. Using Microsoft Excel for inventory forecasting. e. Moving along with current technology trends.
6	Security compliance	a. Addressing security concerns to protect the company's image. b. Ensuring compliance with regulatory requirements.

The results presented in Table 3 illustrate the breadth of recommendations deemed practical and beneficial by MSMEs, which span not only financial management but also other areas such as operational efficiency, marketing, human resources, technology integration, and security. These areas reflect the diverse challenges that MSMEs face and align with the broader objectives of the Integrated Case Study course, which seeks to provide holistic business solutions through service-learning initiatives.

Table 4. Survey feedback of Section 3 (Q2)

No	**Theme**	**Specific suggestions**
1	Funding and government support	Seeking government funding from MOHE or other agencies to facilitate tasks for educators and students in assisting the community.

2	Operational improvement	a. Increasing the percentage of marks for the implementation of SULAM tasks. b. Adding more images to explanatory videos. c. Encouraging practical application of theories for students to experience real work. d. Adapting academic terminology to local contexts to facilitate understanding and impact agriculture positively.
3	Knowledge transfer and exposure	a. Proposing meetings to be held at the office or on-site post-pandemic for better student exposure. b. Suggesting site visits for better understanding of MSME operations post-pandemic. c. Advocating for more thorough report reviews by supervisors before submission to the companies to minimize errors.
4	Educational enhancement	a. Encouraging more student involvement in company processes through internship programs. b. Emphasizing the importance of preliminary research before project initiation. a. Advocating for practical experience and inventory management exposure through internships or visits.
5	Appreciation and collaboration	b. Expressing gratitude for collaboration and valuable suggestions to the industry. c. Recognizing the program's potential to help MSMEs and young entrepreneurs. d. Acknowledging the contributions and positive attributes of

		participants.

Table 4 offers valuable insights into how MSMEs believe the MAF671 SULAM project could be enhanced. Notably, one key suggestion is the need for sustainable funding, mirroring one of the three critical success factors for SULAM identified by Mohd Naufal et al. (2024). Currently, Malaysian universities often provide financial assistance to support SULAM programs, but MSMEs recommend that more efforts be made to secure long-term funding from government agencies such as MOHE. Furthermore, participants emphasized the importance of increased student engagement through extended time at MSME premises. This time extension would enable students to gain deeper, hands-on experience and build stronger connections with the firms, thereby enhancing the learning experience and the impact on the businesses.

Another important point raised was the disruption caused by the Covid-19 pandemic, which limited the ability of students to visit MSMEs physically. However, with the lifting of lockdowns, this challenge has largely been resolved. MSMEs also expressed a common theme of appreciation for the MAF671 SULAM initiative, highlighting the positive contributions it has made to their businesses and to the development of young entrepreneurs. This feedback underscores the program's success in fostering a mutually beneficial relationship between the university and the community.

The survey responses were further validated by additional unsolicited feedback from some MSMEs via email. These businesses, upon receiving the business advisory report and survey link, voluntarily shared positive comments that reinforced the findings from the survey. This consistency in feedback emphasizes the overall value and impact of the project, suggesting that it effectively meets the needs of both the participating MSMEs and the students involved.

Conclusion and Recommendations

This paper addresses a notable gap in research by investigating service-learning projects from the perspective of community partners. Specifically, it elicited responses from MSMEs to gauge their perception of the relevance of the MAF671 SULAM project. The results suggest that MSMEs found the initiative to be highly relevant to their needs, with particular emphasis on the practical nature of the students' recommendations in areas such as financial management, operational efficiency, marketing, human resources, and technological integration. The feedback indicates that MSMEs believe the MAF671 SULAM project positively contributes to their business expertise and innovativeness. This study builds on prior studies, such as Rinaldo et al. (2022) and Simola (2009), which underscore the value of service-learning for community partners, particularly small businesses. By improving business performance and enhancing operational practices, the SULAM project demonstrates its capacity to offer meaningful, real-world impact beyond the classroom, serving both educational objectives and community development.

However, this study also recognizes certain limitations. One key issue is the potential for response bias among MSME representatives, who may have provided overly positive feedback to maintain favorable relationships with the university, a concern highlighted in previous research (Ferrari & Worrall, 2000). To mitigate this bias, future studies could incorporate anonymous surveys or interviews conducted by third-party researchers to ensure the confidentiality and authenticity of responses. Such methods would likely yield more candid feedback from community partners and provide a more accurate picture of the project's true impact.

Additionally, this paper focuses on the perceived relevance of the MAF671 SULAM project but does not delve deeply into its measurable impact on MSME performance. Future research should consider

conducting more comprehensive analyses to evaluate the tangible effects of service-learning on community partners. For instance, comparing key performance metrics, such as operational efficiency, sales growth, profitability, and market reach, before and after MSME participation in service-learning projects could provide clearer evidence of the project's success. A longitudinal study that tracks these metrics over time would be particularly useful in determining the long-term benefits of service-learning initiatives.

Moreover, expanding the research to include in-depth interviews with MSME owners or managers could provide richer qualitative data. Such interviews would allow for a deeper exploration of the specific challenges MSMEs face and how service-learning projects can be tailored to better meet their needs. This approach could uncover insights that quantitative data alone may not reveal, such as nuanced perspectives on the collaboration between universities and MSMEs, and the sustainability of the changes implemented through service-learning.

In conclusion, while the MAF671 SULAM project appears to be a meaningful and impactful initiative for both students and community partners, there are opportunities for future research to enhance the understanding of its broader implications. By addressing limitations such as potential response bias and focusing on measurable outcomes, future studies can provide more robust evidence of the value that service-learning brings to MSMEs and the community at large. Moreover, extending this research to a wider range of service-learning projects across different sectors and contexts would contribute to a more comprehensive understanding of how such initiatives can be optimized to create mutually beneficial relationships between universities and their communities.

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Quality of Life of Unemployed: Quantitative Assessment in the Context of Entrepreneurial Skills Development

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Abstract

In the article, attention is paid to the specification of the issue of quality of life of the unemployed in terms of development of their entrepreneurial skills. Entrepreneurial skills training often includes metacognitive strategies that increase a sense of control and autonomy, i.e. strong factors in quality of life. In the proposed research, aspects of the quality of life of the unemployed are analyzed from the point of view of the quality of life assessment questionnaire created by the World Health Organization, using this methodology at an international level. Based on the analysis, the differences between the addressed unemployed (N = 139) in the assessment of the quality of life from various points of view and how the unemployed perceive their life situation are characterized. The aim of the research is to verify the quality of life assessment questionnaire and, based on the results of the analysis of differences, to enrich the field of knowledge of the assessment of aspects of the quality of life from the point of view of the selected socio-demographic characteristics of the unemployed, accentuating the need for development of their entrepreneurial skills. Formulating three research hypotheses, existence of statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of gender and in terms of education was assumed and tested. The research sample consisted of the respondents with the completed primary, secondary and higher education, aged between 19 and 61 years. The presented paper also provides an overview of the latest knowledge regarding the complexity of the quality of life in the work environment from the point of view of the unemployed.

Keywords:

unemployed; quality of life; entrepreneurial skills; working life; health

Introduction

Quality of life can be considered as an indicator of overall well-being and satisfaction in life. Self-determination and social relationships define the quality of a person's life, whether from an emotional, physical or material point of view (Hult et al., 2020). According to Lisy et al. (2005), the quality of human life is primarily associated with a sense of the importance of one's own usefulness, with a sense of the need for self-realization, with the need to create positive interpersonal relationships and achieve a high level of cultural maturity, as well as with the need to change how to approach the environment and material wealth. According to Hartl, Hartlova (2000), the quality of life is understood as an expression of the feeling of happiness in life, where mobility and self-sufficiency of one's own person belong to the general characteristics. From a psychological point of view, quality of life is understood as a measure of self-realization and mental harmony. Factors that increase the quality of life include physical and mental activity, as well as an active lifestyle. The quality of life is influenced by the attitudes, experiences and position of a person in the cultural and value-related context. These are subsequently compared in relation to the goals, expectations, requirements and concerns of the individual (Poduzov & Yazykova, 2019). According to Reinders and Schalock (2014), quality of life reflects a person's satisfaction with their achievements in life and can be seen as a process that aims to realize their potential. From the research carried out so far, it is clear that the quality of life is most often investigated on the basis of objective indicators, such as income, working conditions or on the basis of subjective assessments, i.e. based on public opinion research (Cummins, 2005). Mares (2006) emphasizes the fact that the quality of human life is not the same as the state of health, life satisfaction or well-being. It is a more complex category, it includes not only somatic health and psychological state, but also other components such as the level of independence from the environment, social relations, conviction and faith. It emphasizes the complexity and multidimensionality of quality of life concepts and the subjective assessment of quality of life factors. Babincak (2008) claims that the quality of life covers such a wide area of concepts and theories that it would be rather harmful if it were simplified to some well-defined and highly specific concept with good possibilities for measurement, but not covering the entire spectrum of human experience, which refers to a person's evaluation of life.

Based on these ideas, the proposed paper presents research designed to emphasize the comparative-content approach when examining the quality of life. According to the theoretical starting points summarized in the next section of the paper, research objectives were formulated. The main study objective is to find out what differences exist between the unemployed respondents in the assessment of the quality of life from various points of view, and how the unemployed perceive their life situation, accentuating the need for development of their entrepreneurial skills. The first sub-objective is set to verify the QoLAQ (originally DHKŽ) quality of life assessment questionnaire, the second one aims to specify differences in the assessment of aspects of the quality of life in terms of the selected socio-demographic characteristics of the unemployed.

Literature Review

Linking the assessment of the quality of life of unemployed individuals with the development of their entrepreneurial skills is meaningful particularly in the context of supporting their self-realization, employability and overall life satisfaction (Mittal & Raghuvaran, 2021). Low quality of life of the unemployed is often associated with a lack of meaning, self-confidence, social ties and financial stability (Sinha, 2018). Development of entrepreneurial skills (e.g. the ability to solve problems, plan, make decisions, build relationships) can specifically strengthen these areas. The goal is to improve the quality of life by strengthening competencies that lead to self-determination and an active approach to life. Unemployment often leads to a loss of identity and passivity. Entrepreneurial mindset training can restore a sense of purpose, autonomy, and motivation, which may be perceived as key components of quality of life (Williamson et al., 2021).

Job satisfaction is a subjective complex phenomenon that is part of life satisfaction and is based on the evaluation of working conditions. The share of the assessment of working conditions in the overall assessment of work and profession varies depending on the circumstances (Frk, 2002). A better quality of working life is closely connected to the movement towards sustainable development, towards a competitive and knowledge-based economy. It is a multidimensional concept that concerns the labor market, employment, unemployment, intrinsic quality of work, job characteristics, lifelong learning, career development, safety and health at work, work organization, equality and anti-discrimination, work-life balance, culture

work, flexibility and social dialogue. The quality of working life also refers to the active involvement of all participating actors in the process, which on the one hand supports the overall satisfaction and well-being of workers and, on the other hand, increases the quality, performance, and competitiveness of the economy (Svobodova, 2006; Rovnak et al., 2021). Changes in the work sphere and adaptation to them can, due to increasing uncertainty and possible negative impacts on certain work aspects, manifest themselves in an increase in employee dissatisfaction and a deterioration in the quality of their working life (Cervenka, 2007). It is widely known that the environment, health and quality of life are categories that are interconnected and inseparable. As a result of the constantly more significant impact of current development processes and the expansion of science and technology, there are substantial changes in the nature and degree of influence of the determinants of human health, and thus also their relationship to the quality of life (Payne, 2005).

Several authors point to the connection between mental well-being and unemployment. Unemployment is a significant stressor that threatens social security and the professional life of individuals. Research shows that unemployment primarily leads to an increased level of stress (Audhoe et al., 2010). Unemployment has enormously detrimental effects on physical and mental quality of life and leads to lower levels of life satisfaction and well-being (Fergusson et al., 2001; McLeod et al,. 2012). In a study by Fergusson et al. (2007), mental health was found to be more impaired than physical health, supporting their claim that unemployment has adverse effects on mental health and may be associated with depressive symptoms and even suicide. Wanberg (2012) highlights the harmful consequences of unemployment in terms of quality of life. These are changes in the social status, changes in work and family roles, and changes regarding the time structure. Loss of identity, reduced social contacts, financial difficulties and uncertainty about the future also play an important role in weakening a person's quality of life. In short, the style of coping with the role of the unemployed and coping with the psychological stress associated with it is to a certain extent connected with the level of physical and mental health of the given person (Waters, 2000).

In her study, Buchtova (2004) deals with the quality of life of the unemployed people. Based on her research, she arrived at the conclusion that the profile of the quality of life of the unemployed and employed does not differ significantly, because the same areas of life are important for both groups – family, health, work, mental well-being and relationships between

people. The author sees the difference between the employed and the unemployed in satisfaction with these important areas of life, where the employed achieve higher satisfaction in the area of work and health, and the unemployed in the area of hobbies. In her studies, the quoted author mentions other effects of unemployment, such as the worsening of health problems and the emergence of negative feelings such as anxiety, inner restlessness, headaches, insomnia and increased fatigue. She further states that the longer the duration of unemployment, the more the importance of the family grows for the unemployed individual, and the job satisfaction decreases. She came to the conclusion that men cope with the loss of their job worse than women, who compensate for the loss of work with their hobbies (Buchtova, 2004). Similarly, the results of research by Hultman et al. (2006) showed that unemployed people perceive a worse quality of life. In their research, the unemployed women scored higher in the areas of existential life than the unemployed men. The unemployed men were the worst off in terms of the overall life situation. Even the unemployed respondents with university education did not benefit in terms of quality of life.

Among the currently employed, the trend is that the less times they were unemployed in the past, the higher their current life satisfaction, while the opposite is true for the unemployed. Unemployed people show lower life satisfaction the less they were unemployed in the past (Clark et al., 2001). Also Winefield and Tiggemann (1990) and Hult et al. (2020) found that the disruption of psychological well-being and the intensity of psychological stress largely depend on the duration of unemployment. Also Yang et al. (2016) state that the long-term unemployed have a worse quality of life compared to the short-term unemployed, i.e. those who have been unemployed for less than a year. Although the number of unemployed is decreasing, the number of long-term unemployed remains high. This is mainly due to the fact that people with health problems are at risk of becoming unemployed and are unlikely to find a new job. Only a small percentage of the long-term unemployed are able to work (Porru et al., 2019). How people cope with job loss relates to how people think and what consequences they attribute to unemployment. Knowing how to minimize the personal, social and economic threat of this situation can be an important predictor of subsequent emotional stress and psychological states (Grossi, 1999). For unemployed persons, motivation in the search for a new job and skill development is important. It is necessary for the unemployed individuals to use the daily time for activities that to a certain extent replace the time spent at the workplace. These are activities

that improve the perception of the unemployed by making efficient use of their time, which ultimately benefits their mental health. However, it is often the other way around, and thus, the unemployed people spend their "free" time passively, which leads to poor health (Goodman et al., 2016).

In the context of unemployment, meaningfulness is an important element of the sense of coherence for several reasons. Meaningfulness means motivation that makes it worthwhile to face life's adversity and actively engage in it. It helps in the implementation of a healthy lifestyle, plays the role of mediator between the positive effects of self-esteem and health behavior (Wiesmann & Hannich 2011). Similarly, Hult et al. (2020) found in their research that the most significant influence on the quality of life is precisely the perception of its meaningfulness. Good health was associated with work engagement, and both elements had a significant impact on quality of life. Meaningfulness and quality of life were better among women compared to men. The unemployed should be encouraged and engaged in activities such as voluntary work that increase their resources, improve their quality of life and contribute to re-employment.

Developing entrepreneurial skills has a positive impact on domains such as psychological well-being (sense of competence, hope), social relationships (networking, collaboration), physical well-being (stress reduction, increased activity), and environmental factors (better access to resources, opportunities). Before and after completing an entrepreneurial skills development program, pre- and post-tests of quality of life (e.g. by means of WHOQOL-BREF methodology) may be conducted.

Methods

In our research, we emphasize the comparative-content approach when examining the quality of life. On the basis of the theoretical starting points, we formulated the following research objectives and hypotheses:

Objective 1: Verify the QoLAQ (originally DHKŽ) quality of life assessment questionnaire.

Objective 2: Specify differences in the assessment of aspects of the quality of life in terms of the selected socio-demographic characteristics of the unemployed.

Hypothesis 1: The QoLAQ quality of life assessment questionnaire has a factor structure.

Hypothesis 2a: There are statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of gender.
Hypothesis 2b: There are statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of the level of education.

The research sample consisted of 139 unemployed respondents, of which 48.2% (N = 67) were men and 51.8% (N = 72) were women aged from 19 to 61 years (M = 32 years, SD = 9.308 years). In terms of education, the sample contained 16.55% (N = 23) of the unemployed respondents with primary, 36.69% (N = 51) with secondary, and 46.76% (N = 65) with university education. According to their family status, 38.85% (N = 54) of the respondents were unmarried, 61.15% (N = 85) were married. Respondents were approached in cooperation with the Labor Offices in Kosice and Presov, Slovakia.

The research was carried out by means of two questionnaires:
1) *The QoLAQ Quality of Life Assessment Questionnaire*
The originally labeled DHKŽ (Dotazník hodnotenia kvality života) questionnaire is inspired by the authors Frankovsky and Istvanikova (2009). Its structure consists of two main factors:

- F1 – Me and Other People (MOP);
- F2 – My Past vs. Current Status (MPCS).

The factors are supplemented by four areas of life: Health, Social Relations, Psyche and Environment. The quality of life assessment questionnaire is based on a comparison of the following indicators:

- MOP – health, me and other people – social relations, me and other people – psyche, me and other people – environment, me and other people;
- MPCS – health, my past vs. current state – social relationships, my past vs. current state – psyche, my past vs. current state – environment, my past vs. current state.

QoLAQ consists of 40 items focused around aspects of the quality of life. Respondents are to express their opinion on a Likert scale from 1 to 6 (1 – completely disagree, 2 – disagree, 3 – rather disagree than agree, 4 – rather agree than disagree, 5 – agree and 6 – completely agree).

Based on the Eigenvalues and the percentage of the total variance explained, two factors were extracted:

Factor F1 – Me and Other People.

This factor is based on a comparison of the respondent's personal view of themselves and the rest of society in four basic contexts of quality of life (Health, Psychology, Social Relations and Environment). Example items:

"Compared to other people, I am satisfied with my health."

"I feel disadvantaged by other people because of my appearance."

"I get the help I need from other people."

"I think other people live in a safer environment than I do."

"I am convinced that other people have better conditions in their environment to find meaningful work."

Factor F2 – My Past vs. Current Status.

This factor compares the quality of life of the given person in the past with their quality of life in the present in four basic contexts (Health, Psychology, Social Relations and Environment). Example items:

"I felt that I was healthier in the past than I am today."

"I had more time to rest in the past than now."

"I felt mentally better in the past than now."

"I feel that currently my personal relationships are worse than before."

"I feel that in the past there were fewer crimes committed in my environment than now."

2) *World Health Organization's WHOQOL-BREF Quality of Life Questionnaire*

In 1991, the Division of Mental Health of the WHO initiated a project to develop a methodology at the international level that would deal with the measurement of quality of life. The WHOQOL-BREF questionnaire consists of 24 items that are grouped into four main domains – Physical Health, Psychology, Social Relationships, Environment, and 2 separate items that assess overall quality of life and health status. It is therefore a 26-item measure issued by the World Health Organization to determine the level of quality of life in four

domains, each of which focuses on a different area of life. Individual items were selected so that this questionnaire covers a wide spectrum of aspects of quality of life (WHOQOL, 1997). This questionnaire evaluates the degree of conviction on a 5-point scale, where 1 means "very low", or "very dissatisfied" and 5 means "very high", or "very satisfied". Scores range from +25 (lowest quality of life) to +125 (highest quality of life) (WHOQOL, 1997). According to WHOQOL (1997), the methodology covers four dimensions of quality of life:

1. ***Physical Health domain*** – this dimension measures the frequency and amount of medical assistance that is necessary for everyday life, the quality of sleep, the strength of pain felt, satisfaction or dissatisfaction with movement skills, and the level of vital energy. Scores range from +7 (low rate) to +35 (high rate).
2. ***Psychological domain*** – measures satisfaction or dissatisfaction with the appearance of the individual, the meaning of life, and the intensity of experiencing negative states, such as moodiness, anxiety and depression. Scores range from +6 (low rate) to +30 (high rate).
3. ***Social Relationships domain*** – measures satisfaction or dissatisfaction of the individual in social relations, personal and partnership life. Scores range from +2 (low rate) to +10 (high rate).
4. ***Environment domain*** – it measures, for example, the availability of health services, the quality of transport and the feeling of safety in everyday life. Scores range from +8 (low rate) to +40 (high rate).

Results

Hypothesis 1: "The QoLAQ quality of life assessment questionnaire has a factor structure." was verified by means of a factor analysis in the statistical program IBM SPSS Statistics 26. Using the Principal Component Analysis method with Varimax rotation, two factors assessing the respondents' quality of life were extracted and labeled as: F1 – Me and Other People, and F2 – My Past vs. Current State (Table 1).

Table 1.

Factor Structure of the Quality of Life Assessment Questionnaire – QoLAQ

	F1	F2

	Me and Other People (MOP)	My Past vs. Current State (MPCS)
Compared to other people, I am satisfied with my health.	-0.772	
I think other people are healthier than me.	0.853	
I feel that physical pain prevents me, unlike others, from doing what I need to do.	0.802	
I feel that, unlike other people, I need some kind of treatment to function in my normal life.	0.743	
I think the people around me have more energy than I do.	0.716	
I feel very lonely or distant from other people lately.	0.699	
I can concentrate enough on what I'm doing, just like the people around me.	-0.697	
I can accept my physical appearance compared to other people.	-0.791	
I feel disadvantaged by other people because of my appearance.	0.712	
I think other people are mentally better than me.	0.696	
I get the help I need from other people.	-0.644	
I am satisfied with the support provided by my friends.	-0.720	
Compared to others, I feel lonely in my life.	0.649	
I am popular among my friends.	-0.752	
I feel that society does not allow me to increase the quality of my life.	0.843	
I think other people live in a safer environment than I do.	0.792	
I feel that other people around me have better housing conditions.	0.842	
I am convinced that other people in my environment have better conditions to find a meaningful job.	0.726	
I live in a noisier environment than other people.	0.794	
Despite all the adverse and life-threatening circumstances, I am as satisfied with my life as anyone else.	-0.647	
I felt that I was healthier in the past than I am today.		0.854
I feel that in the past I was able to perform daily activities better.		0.876
I had more time to rest in the past.		0.878
In the past, I was able to do without some of the medications I currently take.		0.730
I worry more about my health now than I did in the past.		0.894
I felt mentally better in the past than now.		0.718
I currently have more negative feelings (depression, anxiety) than in the past.		0.693
I currently feel a greater lack than in the past.		0.825

I think that in the past I was less disadvantaged because of my appearance than I am now.	0.674
In the past, I enjoyed life regardless of what was happening. Nowadays it is different.	0.726
I am currently more satisfied with my social relationships than in the past.	-0.655
I feel that currently my personal relationships are worse than before.	0.756
I had more friends in the past than now.	0.796
In the past, I had more opportunities and time to devote myself to my hobbies.	0.828
If I think about my life and personal circumstances, it can be said that I am currently less satisfied with my life than in the past.	0.737
My environment was safer in the past than it is now.	0.794
In the past, I had worse housing conditions than at present.	-0.718
In the past, it was easier for me to find a job in my environment than it is today.	0.913
I feel that in the past there were fewer crimes committed in my environment than now.	0.818
Nowadays, it is easier for me to get to where I need to be.	-0.683

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
MOP	8.730	51.353	51.353
MPCS	1.940	11.412	62.765
Rotation Sums of Squared Loadings			
Total	% of Variance	Cumulative %	
5.377	31.629	31.629	
5.293	31.136	62.765	

Source: own processing

The extracted factors explain 62.765% of the variance. The appropriateness of using factor analysis is confirmed by the Kaiser-Mayer-Olkin measure of Sampling Adequacy (.971), Bartlett's sphericity test (sig. .000) and the KMO assessment measure calculated as intercorrelations of variables through Anti-Image Matrices.

The internal consistency of the individual factors, as an indicator of the reliability of the individual factors of the QoLAQ questionnaire, was determined by calculating the Cronbach's alpha coefficient (Table 2).

Table 2.

Reliability Values for Factor F1 and F2 in Four Aspects of Quality of Life

	Cronbach´s Alpha	N of Items
F1 - Health	0.753	5
F1 - Psyche	0.659	5
F1 - Social Relations	0.768	5
F1 - Environment	0.600	5
F2 - Health	0.773	5
F2 - Psyche	0.771	5
F2 - Social Relations	0.769	5
F2 - Environment	0.756	5

Source: own processing

Table 2 illustrates clearly that in the case of the factor F1 (MOP) in the aspects of *Health* and *Social Relations* and in the case of the factor F2 (MPCS) in each aspect of the quality of life, the level of internal consistency is satisfactory as Cronbach's alpha approaches the value of 0.8. The determined values of the Cronbach's alpha coefficients indicate that the internal consistency of the items saturating the specified aspects of both factors is within the acceptable range.

The proposed structure of the defined factors of the QoLAQ questionnaire is also supported by the values of the calculated intercorrelation coefficients of the eight aspects of quality of life and the total quality of life score (Table 3).

Table 3.

Intercorrelations of Quality of Life Aspects and Total Quality of Life Scores

	Health F1	Psyche F1	Social Relations F1	Envi-ronment F1	Health F2	Psyche F2	Social Relations F2	Envi-ronment F2
Psyche F1 Sig.(2tailed)	0.418** 0.000							
Social Relations F1 Sig.(2tailed)	0.291** 0.003	0.467** 0.000						

Environment F1 Sig.(2tailed)	0.374** 0.000	0.405** 0.000	0.430** 0.000					
Health F2 Sig.(2tailed)	0.465** 0.000	0.212* 0.034	0.281** 0.005	0.297** 0.003				
Psyche F2 Sig.(2tailed)	0.298** 0.003	0.474** 0.000	0.542** 0.000	0.433** 0.000	0.340** 0.001			
Social Relations F2 Sig.(2tailed)	0.200* 0.046	0.420** 0.000	0.425** 0.000	0.425** 0.000	0.350** 0.000	0.655** 0.000		
Environment F2 Sig.(2tailed)	0.096 0.340	0.007 0.944	0.001 0.993	0.388** 0.000	0.257** 0.010	0.356** 0.000	0.272** 0.006	
total QoL Sig.(2tailed)	0.617** 0.000	0.634** 0.000	0.655** 0.000	0.692** 0.000	0.647** 0.000	0.798** 0.000	0.728** 0.000	0.432** 0.000

Source: own processing

Based on Table 3, it can be concluded that the intercorrelations of the aspects of quality of life in the factor F1 (MOP) and the factor F2 (MPCS) are statistically significant, although not too high. It documents the fact that individual aspects of quality of life are related to each other but not identical. Table 4 describes the correlations between the individual factors of the QoLAQ questionnaire and the WHOQOL-BREF questionnaire.

Table 4.

Correlations of Aspects of Quality of Life between QoLAQ and WHOQOL BREF

	WHO Physical Health	**WHO Psychological**	**WHO Social Relationships**	**WHO Environment**
Health F1 Sig. (2tailed)	0.604** 0.000	0.350** 0.000	0.297** 0.003	0.125 0.215
Psyche F1 Sig. (2tailed)	0.558** 0.000	0.688** 0.000	0.458** 0.000	0.194 0.053
Social Relations F1 Sig. (2tailed)	0.459** 0.000	0.616** 0.000	0.541** 0.000	0.403** 0.000
Environment F1 Sig. (2tailed)	0.425** 0.000	0.459** 0.000	0.398** 0.000	0.431** 0.000
Health F2 Sig. (2tailed)	0.516** 0.000	0.242* 0.015	0.179 0.074	0.381** 0.000

Psyche F2	0.460**	0.681**	0.552**	0.358**
Sig. (2tailed)	0.000	0.000	0.000	0.000
Social Relations F2	0.527**	0.573**	0.585**	0.294**
Sig. (2tailed)	0.000	0.000	0.000	0.003
Environment F2	0.138	0.160	0.111	0.205*
Sig. (2tailed)	0.171	0.111	0.272	0.041

Source: own processing

Table 4 shows that the aspects of quality of life in the factors F1 and F2 of the QoLAQ questionnaire and the quality of life according to WHO are related to each other in several ways. We recorded the highest correlation between the factor *F1 Psyche* and the *WHO Psychological domain* (0.688**), factor *F2 Psyche* and *WHO Psychological domain* (0.681**), factor *F1 Social Relations* and *WHO Social Relationships domain* (0.616**), and factor *F1 Health* and *WHO Physical Health domain* (0.604**). We did not observe any connections between *F2 Environment* in relation to other aspects of quality of life.

Based on the aforementioned analyses, it can be concluded that ***Hypothesis 1:*** "The QoLAQ quality of life assessment questionnaire has a factor structure." has been ***supported***.

We verified **Hypothesis 2a**: "There are statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of gender." using the t-test for two independent samples in the statistical program IBM SPSS Statistics 26. Both men and women have fundamentally different priorities in their lives, which results from psychological differences in terms of gender. In Table 5, gender differences found between the unemployed men and the unemployed women in the assessment of aspects of their quality of life are presented.

Table 5.

Gender Differences in the Aspects of the Quality of Life of the Unemployed Assessment

	M unemployed men	**M unemployed women**	**t**	**p**
Health F1	4.2917	4.1538	0.524	0.602
Psyche F1	4.2250	4.2154	0.061	0.952
Soc. Relations F1	4.1417	4.2769	-0.745	0.460
Environment F1	4.3333	4.3462	-0.073	0.942
Health F2	**3.6250**	3.1769	2.218	**0.021**

Psyche F2	3.6667	3.7846	-0.446	0.658
Soc. Relations F2	4.0500	4.0538	-0.018	0.986
Environment F2	3.4583	3.3308	0.800	0.428
WHO Physical Health	3.9464	4.0440	-0.668	0.507
WHO Psychological	3.5972	3.7372	-1.101	0.276
WHO Social Relationships	3.3306	**3.9231**	2.912	**0.012**
WHO Environment	**3.7031**	3.3712	2.200	**0.041**

Source: own processing

Based on the results presented in Table 5, it can be concluded that there are statistically significant differences between the unemployed men and the unemployed women in the assessment of the selected aspects of the quality of life. They were confirmed in the aspect of *Health* in factor *F2* (MPCS) and in two aspects of quality of life according to the World Health Organization – *Social Relationships domain* and *Environment domain*. Unemployed men perceived their health more positively in the past compared to the present than the unemployed women. According to WHO, the unemployed women perceive the quality of their working life in the context of social relations better than the unemployed men. They have a more optimistic view of their working and non-working lives. For greater satisfaction, they maintain their social relationships and perceive social support from others. In the WHO domain of *Environment*, they perceive the quality of their life in a place where the unemployed men live more positively.

Based on the aforementioned analyses, it can be concluded that ***Hypothesis 2a***: "There are statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of gender." has been ***supported***.

Hypothesis 2b: "There are statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of the level of education." was verified using One-way ANOVA in the statistical program IBM SPSS Statistics 26.

Another factor that can influence the quality of life of the unemployed people is the degree of their education. The level of education also has an impact on the quality, well-paid work and thus also on the quality of life. Table 6 describes the obtained results of differences in the assessment of the aspects of the quality of life from the point of view of education.

Table 6.

Differences in the Aspects of the Quality of Life of the Unemployed Assessment in Terms of Education

	M primary education	M secondary education	M higher education	M total	F	p
Health F1	4.7333	4.0359	4.3448	4.2360	0.915	0.407
Psyche F1	**4.7667**	4.3077	4.0100	4.1980	3.318	**0.041**
Soc. Relations F1	4.2000	4.1897	4.3724	4.2960	0.336	0.716
Environment F1	4.6667	4.2615	4.4241	4.3680	0.339	0.714
Health F2	4.0667	3.3487	3.4759	3.4440	0.593	0.557
Psyche F2	4.6000	3.7692	3.8172	3.8220	1.381	0.261
Soc. Relations F2	**4.7333**	4.0615	3.8931	3.9840	3.854	**0.028**
Environment F2	3.6667	3.4154	3.6069	3.5340	0.128	0.880
WHO Physical Health	4.3810	3.9597	4.0099	4.0014	0.341	0.713
WHO Psychological	4.0000	3.6154	3.6264	3.6333	0.395	0.676
WHO Soc. Relationships	3.8889	3.4786	3.7069	3.6233	0.522	0.597
WHO Environment	3.5833	3.6122	3.4978	3.5450	1.069	0.351

Source: own processing

Table 6 provides an overview of the significance of individual aspects of the assessment of the quality of life by the unemployed with regard to their educational attainment. We noted statistically significant differences in the aspect of the *Psyche* in the *F1* factor, which is based on the comparison of the unemployed person's personal view of themself and other people. Statistically significant differences were also recorded in the aspect of *Social Relations* in the *F2* factor, based on the comparison of the quality of life of the unemployed in the past and in the present. We did not observe statistically significant differences in other aspects of quality of life. Unemployed respondents with primary education in the *F1* factor evaluate the *Psyche* of other people more positively compared to their own quality of life in the aspect of the *Psyche*. They are followed by the unemployed with a secondary education. The unemployed respondents with a higher or university education responded on the neutral part of the assessment scale in the aspect of their *Psyche* compared to the *Psyche* of others. All the

unemployed respondents, in terms of their educational attainment, assessed the quality of life aspect of *Psyche* more in favor of other people, but the difference is in the degree of their agreement. A statistically significant difference was also recorded in the aspect of *Social Relations* in factor *F2*, which compares the quality of life of the given person in the past with the quality of their life in the present. Similarly, as in the aspect of *Psyche*, also in the aspect of *Social Relations*, the unemployed with primary education were evaluated more intensively on the scale of agreement. It means that, compared to both secondary-school-educated and university-educated unemployed, they feel that their personal relationships are worse now than before and that they had more friends in the past than they do now.

On the basis of the aforementioned analyses, it can be concluded that ***Hypothesis 2b***: "There are statistically significant differences in the assessment of the selected aspects of the quality of life of the unemployed in terms of the level of education." has been ***supported***.

Discussion

The paper was aimed at the research of the unemployed respondents in the assessment of their quality of life from various viewpoints, and at how the unemployed perceive their life situation. The obtained results enabled verification of the factor structure of the original QoLAQ questionnaire, which evaluates the quality of life, on a research sample of the unemployed respondents. Subsequently, this methodology was verified in the conducted research on a specific research sample. From this point of view, as expected, the methodology appears as a tool registering the differences between the groups we have studied. The results of the research by Kentos (2006) also show the complexity of the impact of unemployment on individual areas of a person's life in the research conducted using the WHOQOL-BREF methodology. In addition to the expected economic impacts, the differences in the areas of health status, work potential and social relations to the disadvantage of the unemployed are becoming more and more apparent. The psychometric indicators of the methodology testify to the fact that we can consider it as a suitable starting point for the construction of a diagnostic tool for determining the structure of the unemployed. We consider the structural approach in relation to the investigation of questions to be an important starting point in their theoretical definition, but also in relation to the methodology of the construction of tools for detecting mutual differences in the unemployment situation and possible interventions.

In the context of the presented issue, we investigated the existence of statistically significant differences in the assessment of the selected aspects of the quality of life from the point of view of the gender of the unemployed. Based on the research results, we can confirm the suitability of using the verified QoLAQ methodology for quality of life assessment. The research confirmed that there are statistically significant differences between the unemployed men and the unemployed women in the assessment of the selected aspects of quality of life. They were confirmed in the aspect of *Health* in factor *F2* (MPCS) and in two aspects of quality of life according to the World Health Organization – *Social Relationships* and *Environment*.

However, the analysis of gender differences in connection with unemployment did not yield clear results. On the contrary, it is not uncommon for individual findings to contradict each other. In the research by Kentos (2004) on a sample of unemployed respondents, no significant differences between men and women were recorded. In other words, the unemployed men and women perceived the quality of life equally. Walsh and Jackson (1995) in a study devoted to the "gender" issue state that no differences were confirmed between the unemployed men and women in the assessment of behavioral strategies. However, according to some authors (Fielden & Davidson 2001), men and women manage unemployment differently. This may be due to the fact that men mostly prefer problem-focused strategies – in this case unemployment, and spend more effort on, for example, actively looking for work, thereby eliminating unwanted sources of stress. Contrarily, women are more likely to apply emotion-focused coping strategies. Bartell and Bartell (1985) argue in this regard, despite the general belief in the past, that the effect of unemployment is as complex for women as for men. It can have an even worse impact caused by the effects of marital status. Married women are often in the position of a secondary earner and therefore cannot express themselves as negatively about job loss as men or single women who can be even more negative in this sense than men. According to some authors, the differences between men and women are caused by role configurations rather than gender differences (Ensminger & Celento, 1990).

As part of the investigation of the statistical significance of differences in terms of educational attainment in the assessment of the selected aspects of the quality of life of the unemployed, we noted a statistically significant difference in the aspect of the *Psyche* in the *F1* factor, which is based on a comparison of the unemployed's personal view of themself and other people. Statistically significant differences were also recorded in the aspect of *Social Relations* in the *F2*

factor, based on the comparison of the quality of life of the unemployed in the past and in the present. In both factors, the unemployed with primary education responded more intensively on the agreement scale. We did not observe statistically significant differences in other aspects of quality of life.

Even the comparison according to the level of education by Kentos (2005) showed significant differences in all dimensions of the methodology. The differences in the assessment of the quality of life turned out to be significant, to the disadvantage of the long-term unemployed as well as the unemployed with a lower education. A study by González-Chica et al. (2017) showed significant differences in the respondents' quality of life. Differences in the health status were twice as high among those who had less education and did not work. These authors are of the opinion that the lower levels of education and unemployment increase adverse health effects. Huang et al. (2017) in their research on a Chinese population showed that a lower quality of life index was associated with older age, low level of education and unemployment. A study of the links between gender differences and educational attainment by Chinweub et al. (2018) showed that the unemployed women with a higher level of education rated their quality of life better than the unemployed women with a lower level of education. In their study of the Serbian unemployed population, Jankovic et al. (2012) concluded that individuals with low education were four times more likely to rate their health as poor than those with higher education. The probability of a poor self-perception of health among the unemployed was about 1.5 times higher than among the employed.

Our results prove that it is important to pay attention to increasing the professional qualifications of the unemployed, their adaptation to the current labor market, and supporting the unemployed in the process of moving to cities with a high demand for labor. This is important not only in the context of unemployed individuals, but also of national economies.

Conclusion

Entrepreneurial skills training often includes metacognitive strategies (e.g. planning, reflection, self-regulation) that increase a sense of control and autonomy, i.e. strong factors in quality of life. Developing these skills does not necessarily lead to entrepreneurship, but it does increase viability, resilience and the ability to respond to change.

Our findings indicate that the differences in the perception of the unemployment situation between men and women are not clear and significant. This perception is probably influenced by the convergence of the positions of men and women on the labor market. After all, men perceive the unemployment situation more as temporary with a good prospect of its solution than women. Our findings, as well as several presented findings of other authors, testify to the fact that the interpretation of mutual differences in relation to unemployment carries a certain contradiction. Studies in which no differences were found are presented, as well as studies describing differences, but sometimes in the opposite direction. The results of the study may be significant for public health policies in Slovakia and other countries at a similar level of economic development. The current study has its strengths and weaknesses. A strength of the study is the nature of the research group, as the unemployed are not often the subject of research. Little research is devoted to the issue of quality of life relating to health, psychology, social relations and the environment of the unemployed. The results of the study confirmed that these determinants are important. Such an analytical approach may allow the identification of further differences and correlations between specific components of quality of life and socio-economic factors. The weakness of this study is the limitation of the investigated area to one region. Future research should therefore try to cover the entire territory of Slovakia, or examine the same issue within different countries.

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Finance-led tourism growth hypothesis and sustainable tourism in the R&D-based location model

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Abstract

Due to the increasing severity of tourism pollution worldwide, the realization of sustainable tourism is being sought. It is hoped that the development of financial markets indirectly enhances the development and sustainability of the tourism industry. If there is a positive relationship between financial markets and the tourism industry, then there is the potential for monetary policy to promote sustainable tourism. In order to clarify this relationship and its effects, we analyze the impact of emission quotas and interest rates on growth, location, pollution, and tourism in an R&D-based location model with tourism and finance. In the case of loans to both manufacturing and R&D firms, reducing the total quota of emissions leads to improve global welfare by reducing pollution emissions worldwide and increasing tourism consumption, without causing pollution havens from the North to the South. In addition, in the case of loans to manufacturing firms, environmental policies also promote the development of financial markets. On the other hand, in both types of lending, reducing the nominal interest rate causes pollution havens from the North to the South and tourism migration, in addition to economic growth. In lending to R&D firms, a small interest rate cut leads to financial-led tourism growth through the expansion of tourism and finance, and leads to sustainable tourism only in the North. Environmental policies are more likely to bring about sustainable tourism through financial development than monetary policies. Policy makers should aim for sustainable tourism development through a policy mix of environmental and monetary policies.

Keywords: Permits, Monetary policy, Interest rate, Pollution haven hypothesis, Monetary-led tourism growth hypothesis, Sustainable tourism

JEL codes : E52, F18, O30, Q56, Z32

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1 Introduction

Due to the expansion of international tourism accompanying globalization, economic and financial crises are having a serious adverse effect on the tourism industry (Hall, 2010). The stagnation of the tourism industry is a factor that hinders economic development. In 2023, export revenue from international tourism balloons to USD 1.8 trillion, and the tourism industry generates USD 3.4 trillion, or 3% of global GDP (UNWTO, 2024). The reason for the expanding share of the tourism sector in the economy is that tourism development has a side effect of promoting economic growth. The tourism-led growth hypothesis proposed by Balaguer and Cantavella-Jorda (2002) has been widely recognized for its empirical existence (Alcalá-Ordóñez et al., 2023). Tourism development promotes financial development (Cannonier and Burke, 2017; Nishkar Kumar et al., 2023; Musakwa and Odhiambo. 2022). Therefore, the link between tourism and finance is becoming stronger and stronger.

Under the close relationship between tourism and finance, Munir et al. (2021) began to call the effect of promoting the growth of the tourism industry through financial development the finance-led tourism growth hypothesis. Financial development leads to an increase in tourism demand (Ahamad and Chowdhury, 2024; Li et al., 2024) and an increase in tourism expenditure (Khanna and Sharma, 2023). The expansion of tourism demand and tourism expenditure due to financial development promotes tourism development (Al-Mulali et al., 2021; Churchill et al., 2023; Ma and Ouyang, 2023; Musakwa and Odhiambo, 2021). According to Chiu and Wang (2023), inbound tourism reduces income inequality, but the effect of reducing the income gap is weakened through the development of the banking sector. Tourism and finance mutually stimulate each other's development. Tourism growth and development promote financial development, while financial development also leads to tourism growth and development (Fauzel and Seetanah, 2023; Shahbaz et al., 2019). Menegaki and Tiwari (2022) and Opuala-Charles et al. (2023) have empirically confirmed that the tourism-led growth hypothesis and the finance-led growth hypothesis are compatible. While empirical verification of this hypothesis is progressing, the theoretical mechanisms behind it have not been elucidated. This is because financial markets and monetary policy are not taken into account in the analysis of the tourism-led growth hypothesis using economic growth models (Hamaguchi, 2024d). Bridging this gap is the first issue addressed in this study.

On the other hand, there are concerns that the tourism industry continues to grow. Because the carbon footprint of international tourism is high, there are concerns that tourism development will lead to the carbon intensification of the tourism industry if environmental taxes and emissions trading are not introduced into the tourism industry (Lenzen et al., 2018). Gössling et (2023) concluded that if the tourism industry does not introduce sufficient mitigation measures, 40% of the remaining carbon budget for a temperature increase of 1.5°C will be consumed by carbon dioxide emissions from tourism. There are many issues that need to be resolved in order to achieve sustainable tourism development (Streimikiene et al., 2021). According to Acheampong et al. (2020), the impact of financial development on carbon dioxide emissions depends on the stage of economic development. Financial development induces the agglomeration of carbon-intensive industries due to the ease of obtaining loans, thereby increasing greenhouse gas emissions (Feng et al., 2020; Hao et al., 2022; Maji et al., 2017; Sethi et al., 2020). Therefore, the expansion of the tourism sector through finance may increase the environmental impact of the tourism industry. Mehmood and Kaewsaeng-on (2024) found that the carbon footprint increased due to tourism development and decreased due to financial development. In China, there is an inverse U-shaped relationship between green finance and tourism development, and air pollution hinders tourism (Cong et al., 2024). It is hoped that monetary policy will contribute to sustainable tourism through sustainable finance, but this hope may be

betrayed.

However, it is becoming clear that the development of financial markets contributes to the reduction of greenhouse gases through the accumulation of carbon-non-intensive industries (Qian et al., 2022; Tao et al., 2023; Zhang et al., 2024). A key element of this empirical mechanism is the location behavior of polluting firms. Under the global economy, the pollution haven hypothesis states that regional differences in environmental regulatory standards lead to the transfer of pollution from regions with strict regulations to regions with lax regulations through the location of polluting firms (Bashir, 2022). The tourism industry is also closely related to economic globalization. According to Song et al. (2018), globalization stimulates the growth of the tourism industry, and the development of the industry is under the influence of various interdependencies in the world. In addition, international trade and foreign direct investment (FDI) promote tourism (Cong et al., 2024). The warming effect of the tourism industry is dominated by air travel in international tourism (Lenzen et al., 2018). In the global economy, as the location behavior of polluting firms is active, if financial development promotes the accumulation of carbon-non-intensive industries, it is possible to reduce greenhouse gases in tourism destination countries and contribute to sustainable tourism.In China, digital inclusive finance is bringing about sustainable tourism development (Wang et al., 2024). In African countries, trade liberalization, renewable energy, and international tourism are promoting the development of financial markets (Aboagye and Kwakwa, 2023). Hailiang et al. (2023) confirmed the positive correlation between green finance and the tourism industry in China, and also clarified the stimulation of tourism activities by green finance and the reduction of tourism due to carbon dioxide emissions. If the development of financial markets promotes the accumulation of carbon-non-intensive companies, the reduction of the carbon load of the tourism sector through the development and dissemination of decarbonization technology may promote sustainable tourism.

According to Hamaguchi (2024d), although there are several theoretical analyses of sustainable tourism that can balance tourism development and environmental conservation, the analyses that take into account innovation and are related to the pollution haven hypothesis are limited to Hamaguchi (2020b) and Hamaguchi and Thakur (2024). Hamaguchi (2020b) shows that tourism-led growth through environmental policies contributes to sustainable tourism. Hamaguchi and Thakur (2024) reveal that under the blue economy, emission quota reductions lead to pollution haven from the North to the South. On the other hand, Hamaguchi (2021d) points out that emissions trading between the manufacturing and aviation sectors hinders the compatibility of tourism-led growth and sustainable tourism. Munir et al. (2021) empirically demonstrate finance-led sustainable tourism based on positive feedback relationships in renewable energy, tourism, and finance. Therefore, there is potential for the finance-led tourism growth hypothesis and sustainable tourism development to be compatible. However, while the debate on sustainable tourism development continues, the ripple effects of tourism and the environment due to monetary policy and financial markets have not been theoretically examined. The second research question is to present a mechanism by how monetary policy promotes sustainable tourism through the development of financial markets.

In order to clarify the theoretical relationship between the financial-led tourism growth hypothesis and sustainable tourism development, this study applies the analytical framework of Hamaguchi (2020b) and Hamaguchi and Thakur (2024), which incorporates the R&D-based location model of Martin and Ottaviano (1999) with the international tourism mobility of Albaladejo and Martínez-García (2015) and the international emissions trading of Hamaguchi (2021a). The monetary economy framework of Chu (2022) and Hamaguchi (2024c) is introduced into this framework, and in addition to the R&D sector, lending to the manufacturing sector is also considered. The main results are as follows. In the

case of loans to manufacturing firms, the reduction in emission quotas does not cause pollution haven and economic growth, and in addition to global pollution reduction and expansion of tourism consumption. The environmental policy results improving welfare in the North and South and promoting the development of financial markets through expansion of the money supply and loan volume. Therefore, sustainable tourism and financial-led tourism growth are confirmed by environmental policy, but tourism-led growth is not confirmed. On the other hand, a reduction in the nominal interest rate on loans to R&D firms stimulates economic growth. Furthermore, this monetary policy causes pollution haven from the North to the South and tourism migration, and in addition to the expansion of FDI and tourism consumption, it stimulates the development of financial markets through an increase in the money supply. Sustainable tourism development through monetary policy is only observed in the North, while monetary policy-led tourism-led growth and financial-led tourism growth are observed in the North and South. Therefore, these results partially support the empirical results for the hypotheses of sustainable tourism development and financial-led tourism growth.

Alcalá-Ordóñez et al. (2023) argue for the need to construct a theoretical model of the relationship between the tourism sector and economic growth, based on a survey of empirical analyses of the tourism-led growth hypothesis. In terms of research direction, the theorization of the finance-led tourism growth hypothesis by Munir et al. (2021) is important. Furthermore, according to Hamaguchi (2024d), the interrelationship between tourism, the environment, and finance was not clear because tourism and finance were not linked in economic growth models. The reason for this is that the impact of monetary policy on economic growth and pollution emissions in R&D-based growth models has only recently begun to be analyzed (Afonso, 2023; Hamaguchi, 2024c). In this research trend, this study makes a major contribution in that it theoretically demonstrates the financial-led tourism growth hypothesis and sustainable tourism development. This modeling leads to providing theoretical support for related empirical research.

The structure of the paper is as follows. In section 2, a dynamic general equilibrium model is constructed. In section 3, the equilibrium is characterized. In section 4, a comparative static analysis of environmental and monetary policies is performed. In section 5, the case of lending to R&D firms rather than manufacturing firms is analyzed. In section 6, the conclusions are presented.

2 The model

There are two countries in this economy, the North and the South, which trade with each other. With the exception of initial capital, the two countries are almost identical, and the households in the North have more initial assets than those in the South, with $Y(0) > Y^*(0)$. In this context, $Y(0)$ and $Y^*(0)$ are the initial capital of the North and South, respectively. Therefore, we describe only the variables for the North unless necessary, with an asterisk attached to the variables for the South.

The economy of the North consists of households, the manufactured goods sector, the R&D sector, the tourism goods sector, the government, and the monetary authority. Households earn wage income from supplying labor to each sector and dividend income from stocks purchased from entrepreneurs. The tourism goods produced by the tourism goods sector are consumed by households in the North and South. The households in the North and South supply labor only to their own country's sector and not to the other country's sector. However, it is possible for households in the North to temporarily move to the other country in order to consume the tourism goods produced by the tourism goods sector in the South. This movement is interpreted as the number of tourists moving between the two countries.

In a manufacturing sector under monopolistic competition, entrepreneurs who observe positive profits by existing firms attempt to enter this market. To purchase blueprints for new varieties of manufactured goods developed by firms in the R&D sector, entrepreneurs raise funds by selling shares to households. The entrepreneur applies for a patent based on the blueprint and enters the market, and then distributes the positive profit as dividends to the household. The household in the North perceives positive utility from the consumption of manufactured and tourism goods, but perceives negative utility from the pollution emitted during the production process of the manufactured goods sector.

In order to internalize the pollution emissions of the manufacutred goods sector, the governments of the North and South are establishing a single international emissions trading market. The amount of emissions quotas allocated is also decided in a coordinated manner by the governments of the North and South. The monetary authority in the North supplies money to households as helicopter money, based on the k% rule, and then distributes the seigniorage revenue as a lump-sum subsidy to households. In this economy, it is assumed that the monetary authorities of the North and South choose the same nominal interest rate under international policy coordination.

Households in the North use the money they hold to purchase manufactured goods or to lend to the manufactured goods sector. This is because firms in the manufactured goods sector need fixed costs for their production activities, and they cover these costs by borrowing from households. After analyzing this case, the case of lending to firms in the R&D sector is analyzed. This firm needs to borrow money from households in order to finance the labor costs of its workers. Both firms are subject to the Cash-In-Advanced (CIA) constraint. Households use their money to purchase manufactured goods and to lend to firms, and like firms, they are subject to the CIA constraint. This monetary economy setting follows Chu (2022) and Hamaguchi (2024c).

2.1 Household

Households in this economy survive for an infinite period of time. The logarithmic utility function of a representative household in the North between different time periods is expressed as follows:

$$U_t = \int_0^{\infty} \log\left[Q_t^{\gamma} C_t^{\chi} C_t^{*1-\gamma-\chi} (D_t + D_t^*)^{-\eta}\right] e^{-\rho t}\, dt, \tag{1}$$

where Q_t, $C_{t,}$, C_t^*, D_t, and D_t^* are the consumption of manufactured goods, the consumption of tourism goods in the North, the consumption of tourism goods in the South, the total pollution emissions in the North, and the total pollution emissions in the South. Moreover, $\gamma \in (0,1)$, $\chi \in (0,1)$, $\eta > 0$, and $\rho > 0$ are, respectively, the weight of consumption of manufactured goods in utility, the weight of consumption of tourism goods in the North in utility, the weight of total pollution emissions in utility, and the subjective discount rate. Here, the pollution emissions of the North and South take into account transboundary pollution that crosses borders into the other country. Following Hamaguchi (2020b) and Hamaguchi and Thakur (2024), we assume that households in the North need to temporarily move to the South in order to consume the tourism goods produced in the South.

As Dixit and Stiglitz (1977) state, the structure of differentiated goods is defined as follows:

$$Q_t = \left[\int_0^{A_t} q_{j,t}^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $q_{j,t}$ is an manufactured good with variety $j \in [0, A_t]$, and A_t is the total number of varieties in the world. The substitutability between any two varieties is constant, as $\sigma > 1$. The total amount of pollution emitted in the North is

expressed as follows:

$$D_t = \int_0^{A_t} d_{j,t} dj\,, \tag{3}$$

where $d_{j,t}$ is the pollution emitted in the production process of manufactured goods with variety j.

There are four sources of income for the household. The first, wage income from a wage rate normalized to 1. The second, $\Pi_t A_t/L$, is dividend income from stocks held, where Π_t is the profit of manufacturing firms. The third, $i_t b_t A_t$, is interest income from lending to manufactuirng firms, where i_t is the nominal interest rate and b_t is the amount of the loan. The fourth, h_t is a lump-sum subsidy from the monetary authority. These revenues are used to purchase stocks ($v_t \dot{A}_t/L$), to spend on goods (E_t), and to hold money ($\dot{M}_t/P_t$), where v_t is the stock price, $\dot{A}_t$ is the increase in variety, $\dot{M}_t$ is the increase in the nominal money supply, and P_t is the price index for manufacturing goods. Therefore, the budget constraint for households is expressed as follows:

$$\frac{v_t \dot{A}_t}{L} + E_t + \frac{\dot{M}_t}{P_t} = 1 + \frac{\Pi_t A_t}{L} + i_t b_t A_t + h_t.$$

Here, $m_t = M_t/P_t$ is the real money supply. By taking the time derivative of this money supply, we obtain $\dot{m}_t = \dot{M}_t/P_t - \left(\dot{P}_t/P_t\right)(M_t/P_t) = \left(\dot{M}_t/M_t\right)m_t - \pi_t m_t$, where $\pi_t \equiv \dot{P}_t/P_t$ is the inflation rate measured by the price of manufactured goods. Since the monetary authority's money supply rule is based on the k% rule, the rate of increase in the money supply is $\dot{M}_t/M_t = \mu$. Therefore, the rate of increase in the real money supply is expressed as follows:

$$\frac{\dot{m}_t}{m_t} = \mu - \pi_t, \tag{4}$$

where the rate of increase in the real money supply decreases due to the rise in the inflation rate.

Converting the household budget constraint equation per capita, we get the following:

$$\dot{w}_t + \dot{m}_t = r_t w_t + i_t b_t A_t - \pi_t m_t + 1 - E_t + h_t$$

where w_t is household assets, and $\dot{w}_t$ is the increase in household assets. Here, the household is subject to the CIA constraint, which means that it must hold money in advance when purchasing goods. This constraint is expressed as $B_t + \alpha L E_t \leq m_t$, where $\alpha \in [0,1]$ implies the proportion of the CIA constraint in expenditure.

When the Hamiltonian conjugate variable is λ_t, the household chooses expenditures and assets that maximize the level of utility in (1) under the budget constraint. The first-order condition for the dynamic utility maximization problem is as follows:

$$-\frac{\dot{\lambda}_t}{\lambda_t} = r_t - \rho = \frac{\dot{E}_t}{E_t}, \tag{5}$$

$$\frac{1}{\lambda_t} = (1 + \alpha i_t) E_t, \tag{6}$$

$$\lim_{t \to \infty} w_t\, e^{-rt} \leq 0,$$

where the Fisher equation of $i_t = \pi_t + r_t$ is used to derive (5). Using (5) and (6) yields $\dot{E}_t/E_t = \dot{E}_t^*/E_t^* = r_t - \rho$, where $r_t = \rho$ holds in steady state. Therefore, from now on, unless necessary, the subscript t is omitted. Here, the monetary authority's monetary policy is considered as an operation on the nominal interest rate, with $i_t = i$.

Expenditure on household goods is expressed as follows:

$$E = \int_0^a p_j q_j dj + \int_0^{a^*} \tau p_k^* q_k dk + P_T C + P_T^* C^*, \tag{7}$$

where p_j, p_k^*, P_T, and P_T^* are the price of manufacturing goods with variety j in the North, the price of manufacturing goods with variety k in the South, the price of tourism goods in the North, and the price of tourism goods in the South. As in Samuelson (1954), $\tau > 1$ is the transportation cost of the iceberg type, which is the additional cost required when a household in the home country purchases manufactured goods from the partner country. On the other hand, we assume that the cost of transportation is included in the price of tourism goods when purchasing tourism goods. Here, a and a^* are the total number of varieties in the North and South, respectively.

By solving the static utility maximization problem of selecting the consumption level that maximizes the level of utility in (1) under the constraints in (7), we obtain the following between the demands for each good:

$$q_j = \gamma p_j^{-\sigma} P^{\sigma-1} E, \qquad q_k = \gamma \tau^{-\sigma} p_j^{*-\sigma} P^{\sigma-1} E, \qquad P_T C = \chi E, \qquad P_T^* C^* = (1-\gamma-\chi)E, \tag{8}$$

where the price index for manufactured goods is defined as follows:

$$P = \left(\int_0^a p_j^{1-\sigma} dj + \int_0^{a^*} \tau^{1-\sigma} p_k^{*1-\sigma} dk \right)^{\frac{1}{1-\sigma}}, \tag{9}$$

where this price is selected as an inflation indicator.

2.2 Manufacturing sector

The pollution emission function in Gradus and Smulders (1993), which includes endogenous pollution abatement goods, is simplified by Hamaguchi (2020a, 2020b, 2021a, 2021b, 2022, 2024a, 2024b, 2024c) as a pollution emission function that includes exogenous pollution abatement productivity. The pollution emitted by the manufactured goods firm in the North is based on the following simplified pollution emission function:

$$d_j = \frac{q_j}{\psi_j}, \tag{10}$$

where ψ_j is an exogenous pollution abatement parameter. While pollution emissions increase due to production expansion, pollution emissions decrease due to improvements in exogenous pollution abatement technology.

In order to deal with global warming and environmental pollution, an international emissions trading market has been established. The governments of the North and South allocate emission quotas for their own manufacturing firms, s_j and s_j^*, respectively, in accordance with the grandfathering method. When $d_j - s_j > 0$, firms that emit more than their quota can purchase the missing quota from other firms at the emission quota price of $p^e(d_j - s_j) > 0$. On the other hand, for firms with more emission quotas than emissions, when $s_j - d_j > 0$, they sell their surplus emission quotas to other firms at the emission quota price of $p^e(s_j - d_j) > 0$. Therefore, the emissions trading market is cleared. Here, we assume that, according to Hamaguchi (2020b, 2021a, 2022, 2024a, 2024c), the emissions quota allocated per firm by the governments of the North and South is equal, as a result of international policy coordination, to $s = s^*$, where s^*, the average emissions quota, is equal to S. This quota is the average quota for the total quota of S. Thus, $s = S/A$ holds. The total cost of a firm with variety j is $TC_j = q_j + p^e(d_j - s_j)$ is the cost of purchasing emission quotas, and $-p^e(s_j - d_j)$ is the profit from selling emission quotas.

In accordance with Dixit and Stiglitz (1977), in a monopolistic competitive market, manufacturing firms produce horizontally differentiated goods. In addition to labor, fixed costs are required when industrial firms produce manufactured goods. Manufacturing firms cover these fixed costs by obtaining loans from households in the North and South, but they are subject to the CIA constraint. In this case, $\beta \in (0,1)$ implies the proportion of the CIA constraint in the loan. Given

the demand function in (8) and the pollution function in (10), the Northern manufacturing firm with variety j chooses the manufactured good price that maximizes its profit in the following profit function:

$$\max_{p_j} \Pi_j = p_j q_j - q_j - p^e(d_j - s_j) - \beta i(b_j + b_k^*), \tag{11}$$

and the first-order condition for profit maximization yields

$$p = \frac{\sigma}{\sigma - 1}\left(1 + \frac{p^e}{\psi}\right), \quad p^* = \tau p, \tag{12}$$

where $\sigma/(\sigma - 1)$ is a markup and p^e/ψ is the price pass-through of environmental regulation costs. As in Hamaguchi (2020b, 2021a, 2022, 2024a, 2024c), $\psi = \psi^*$ is assumed for the sake of analytical simplicity. Since symmetry between firms holds at equilibrium, we drop the subscript j from now on.

Substituting (10) and (12) into (11) yields

$$\Pi = \frac{q}{\sigma - 1}\left(1 + \frac{p^e}{\psi}\right) + p^e s - \beta i(b + b^*), \tag{13}$$

where $p^e s$ implies the allocation rent and creates the distribution effect in Hamaguchi (2020a). The supply of manufactured goods in the North and South is balanced by the demand for manufactured goods in the North and South. From this equilibrium condition, the following is derived:

$$q = \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\gamma L}{1 + p^e/\psi}\right)\left(\frac{E}{a + \varphi a^*} + \frac{\varphi E^*}{\varphi a + a^*}\right), \qquad q^* = \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\gamma L}{1 + p^e/\psi}\right)\left(\frac{\varphi E}{a + \varphi a^*} + \frac{E^*}{\varphi a + a^*}\right), \tag{14}$$

where $\varphi \equiv \tau^{1-\sigma}$ represents the degree of trade liberalization expressed in terms of transportation costs, and an increase in φ implies trade liberalization. In accordance with Martin and Rogers (1995), manufactured firms can freely change their production bases because there is no need to incur the cost of relocating. Since the arbitrage opportunity disappears through relocation, $\Pi = \Pi^*$ holds through $q = q^*$. In the stock market, the number of shares held by households in the North and South is fixed by the number of patents worldwide, so $a + a^* = Y + Y^* = A$ holds.

Using these equations, we can rewrite (14) to obtain the following as the equilibrium production volume of manufactured goods:

$$q = \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\gamma L}{1 + p^e/\psi}\right)\frac{E + E^*}{A}, \tag{15}$$

which is substituted for (13) to derive the following profit in equilibrium:

$$\Pi = \left(\frac{\gamma L}{\sigma}\right)\frac{E + E^*}{A} + p^e s - \beta i(b + b^*), \tag{16}$$

where profits increase due to the rent allocated while they decrease due to interest payments to households.

The number of companies located in the North is defined as Ψ as follows:

$$\Psi \equiv \frac{a}{A} = \frac{E - \varphi E^*}{(1 - \varphi)(E + E^*)}, \tag{17}$$

which includes the home market effect in Krugman (1980). This effect expresses the fact that the relative market size of the North and South determines the distribution of the location of firms. Using (14) and (15), when we aggregate the production of manufactured goods, the global production of manufactured goods is as follows:

$$aq + a^* q^* = \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\gamma L}{1 + p^e/\psi}\right)(E + E^*). \tag{18}$$

2.3 R&D sector

In accordance with Romer (1990) and Grossman and Helpman (1991), new varieties are developed through the innovation process $\dot{A} = (\iota/\varepsilon)A$, where ι is labor in the R&D sector and $\varepsilon > 0$ is the productivity parameter of the R&D sector. Under perfect competition, the free entry condition is $v = \varepsilon/A$, given the zero profit condition. The value of a firm in the stock market is the sum of the discounted present value of profits over the entire future period. Thus, $v = \int_t^{\infty} \Pi_\zeta \, d\zeta$ holds. By taking the time derivative of this stock price, we obtain the non-arbitrage condition for risky assets (stock holdings) and safe assets as follows:

$$\Pi + \dot{v} = rv. \tag{19}$$

2.4 Tourism sector

In a perfectly competitive market, the tourism goods sector produces tourism goods using only labor. The production function is $R = L_T$, where R is the amount of tourism goods produced and L_T is the labor in the tourism goods sector. Since the wage rate is numeraire, we obtain $P_T = 1$ from the zero profit condition.

In this economy, when a household in the home country consumes tourism goods from the partner country, it is necessary to temporarily move to the partner country. The number of tourists moving from the South to the North is represented as T, and the number of tourists moving from the north to the south is represented as T^*. Following Albaladejo and Martínez-García (2015), Hamaguchi (2020b), and Hamaguchi and Thakur (2024), the mechanism of tourist movement is defined as a logistic curve as follows:

$$\dot{T} = T\left(1 - \frac{T}{CC}\right), \qquad \dot{T}^* = T^*\left(1 - \frac{T^*}{CC^*}\right), \tag{20}$$

where T is the number of tourists who moved from South to North for sightseeing, and T^* is the number of tourists who moved from North to South for sightseeing.

Here, CC and CC^* are the tourist accommodation capacities in the North and South, respectively. Following Gössling (1999), Albaladejo and Martínez-García (2015), Hamaguchi (2020b), and Hamaguchi and Thakur (2024), we assume the following tourist accommodation capacities:

$$CC \equiv \frac{1}{P_T C D}, \qquad CC^* \equiv \frac{1}{P_T^* C^* D^*}, \tag{21}$$

where the carrying capacity of a tourist destination to accommodate visitors is reduced by the rising prices of tourist goods and increased pollution emissions (Gössling, 1999) and the crowding effect (Albaladejo and Martínez-García, 2015).

2.5 Market

Through international trading of emission quotas, the pollution emitted by manufacturing firms in the North and South is balanced and equal to the total emission quotas issued by the governments of the North and South. The market clearing condition for emission quotas is $a^* p^e (s - d^*) - a p^e (d - s) = 0$. By rewriting this market clearing condition using (3), (10), and $s = s^* = S/A$, we obtain $D + D^* = S$. Then, using (3), (10), (17), $a + a^* = A$, and $D + D^* = S$, (18) can be rewritten as follows:

$$S = \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\gamma L}{\psi + p^e}\right)(E + E^*), \tag{22}$$

where the total emission quota caps the production of manufactured goods. The labor supply of the world population is equal to the labor demand in each sector. This market clearing condition is expressed as follows:

$$\varepsilon\frac{\dot{A}}{A}+\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\gamma L}{1+p^e/\psi}\right)(E+E^*)+L(1-\gamma)(E+E^*)=2L, \tag{23}$$

where the first term on the left is the R&D sector, the second term is the manufacturing sector, and the third term is the tourism sector.

3 Equilibrium

3.1 Symmetric equilibrium

In accordance with a certain growth rate in $g\equiv\dot{A}/A$, all variables in the balanced growth path equilibrium grow. By differentiating $v=\varepsilon/A$ with respect to time, we obtain $\dot{v}/v=-g$. When we substitute (13), (22), $ab+a^*b^*=B+B^*$, $v=\varepsilon/A$, and $\dot{v}/v=-g$ into (19) and rearrange, we get the following:

$$g=\frac{S(\sigma p^e+\psi)}{\varepsilon(\sigma-1)}-\rho-\frac{\beta i}{\varepsilon}(B+B^*), \tag{24}$$

where unlike Martin and Ottaviano (1999) and Hamaguchi (2020b, 2021a, 2022, 2024a, 2024b, 2024c), the inflation rate determines the economic growth rate in the present model. By taking the time derivative of (9), we obtain the following endogenous inflation rate:

$$\pi=\frac{\dot{P}}{P}=-\frac{g}{\sigma-1}, \tag{25}$$

which is rewritten by using $\pi=i-\rho$ as follows:

$$g=(\sigma-1)(\rho-i), \tag{26}$$

where $\rho>i$ is assumed. In a deflationary economy with $\rho-i=-\pi$, the Fisher effect means that an increase in the nominal interest rate reduces the economic growth rate in (26) and increases the inflation rate in (25).

Using (26), (23) can be rewritten as follows in terms of per capita expenditure in the world:

$$E+E^*=\frac{2-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)}{1-\gamma+\frac{\gamma(\sigma-1)}{\sigma(1+p^e/\psi)}}, \tag{27}$$

where the income sources for the household are the sum of labor income in the north and south $(1+1=2)$ and the sum of capital income $(-(\varepsilon/L)(\sigma-1)(\rho-i))$. This capital income can be rewritten as $(vA/L)(\dot{v}/v)$ by using (26) and $v=\varepsilon/A$, and it implies capital gains from stock holdings. From (27), per capita expenditure in the North and South can be expressed as follows:

$$E=\frac{2-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)y}{1-\gamma+\frac{\gamma(\sigma-1)}{\sigma(1+p^e/\psi)}},\qquad E^*=\frac{2-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)(1-y)}{1-\gamma+\frac{\gamma(\sigma-1)}{\sigma(1+p^e/\psi)}}, \tag{28}$$

where $y>1/2$ holds because the initial assets held by households in the North are greater than those in the South.

Substituting (27) for (22) and rearrange, we obtain the following equilibrium emissions price:

$$p^e=\frac{1}{S}\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\gamma}{1-\gamma}\right)\left[2-\left(\frac{\psi S}{L}\right)-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)\right]-\psi, \tag{29}$$

where raising the nominal interest rate raises the price of emission quotas, encouraging manufacturing firms to reduce their pollution.

3.2 Geographic distribution of innovation activity and finance

By substituting (27) and (28) into (21), we get the following ratio of the number of firms in the world and the number of firms located in the North:

$$\Psi = \frac{1-\varphi-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)[y-\varphi(1-y)]}{2(1-\varphi)\left[1-\frac{\varepsilon}{2L}(\sigma-1)(\rho-i)\right]}, \tag{30}$$

where unlike Hamaguchi (2020b, 2021a, 2022, 2024a, 2024b, 2024c), the total emission quota does not affect the location behavior of firms. This is because the Fisher equation uses the economic growth rate in (26) rather than (24), and the price of emission quotas is not included in the household income source in (27). At this time, the monetary authority can influence the location behavior of firms through the nominal interest rate, because its monetary policy acts on the home market effect through the capital income of households.

Rewriting $a + a^* = Y + Y^*$ as $a - Y = Y^* - a^*$ and taking the time derivative, we obtain $\dot{a} - \dot{Y} = \dot{Y}^* - \dot{a}^*$. The implication of $\dot{a} - \dot{Y}$ is that the purchase of shares in manufactured firms in the North exceeds the initial assets held by households in the North over time. The implication of $\dot{a} - \dot{Y}$ is that the purchase of shares in manufacturing firms in the South is less than the initial assets held by households in the South over time. Therefore, $\dot{a} - \dot{Y} > 0$ indicates that households in the South are purchasing shares in manufactuirng firms in the North, and implies FDI from the South to the North. On the other hand, $-(\dot{Y} - \dot{a}) < 0$ represents the purchase of shares in manufacturing firms in the South by households in the North, and implies FDI from the North to the South. By incorporating (30) and $a + a^* = Y + Y^*$ into $\dot{a} - \dot{Y}$, net offshoring is derived as follows:

$$\dot{a} - \dot{Y} = g(a - Y) = \frac{g\left(y-\frac{1}{2}\right)\left[(\sigma-1)(\rho-i)\left(\frac{\varepsilon}{L}\right)\varphi - L(1-\varphi)\right]}{(1-\varphi)\left[1-\frac{\varepsilon}{2L}(\sigma-1)(\rho-i)\right]} \gtrless 0,$$

for

$$\bar{\iota} \equiv \frac{\varphi L}{\varepsilon\varphi(\sigma-1)}\left[\frac{\rho\varepsilon(\sigma-1)+L}{L} - \frac{1}{\varphi}\right] \gtrless i,$$

where $\varphi > L/[\rho\varepsilon(\sigma-1)+L]$ is assumed for $\bar{\iota} > 0$ and $\bar{\iota}$ is the threshold for the direction of FDI related to transportation costs. The nominal interest rate affects the location behavior of firms and therefore affects long-term FDI. However, because the total emissions quota does not affect this location behavior, unlike Hamaguchi (2020b, 2021a, 2022, 2024a, 2024c), this environmental policy does not affect long-term FDI.

By substituting (26) and (29) into (24), we obtain the following as the global loan amount at equilibrium:

$$B + B^* = \frac{1}{\beta i}\left[\frac{\gamma}{1-\gamma}\left\{2 - S - \frac{\varepsilon}{L}(\sigma-1)(\rho-i)\right\} - (\varepsilon + \psi S)\right], \tag{31}$$

where the total emission quota affects corporate profits and production, and therefore influences the amount of this loan. By substituting (22) and (31) into $(B + B^*) + \alpha L(E + E^*) = m + m^*$, we obtain the following as the real money supply in the world at equilibrium:

$$m + m^* = \frac{1}{1-\gamma}\left(\frac{\gamma L}{\beta i} + \frac{\alpha}{S}\right)\left[2 - \left(\frac{\psi S}{L}\right) - \frac{\varepsilon}{L}(\sigma - 1)(\rho - i)\right] - \frac{\varepsilon + \psi SL}{\beta i}, \tag{32}$$

where the total emission quota also affects the actual money supply through the amount of loans.

3.3 Environment and tourism

Substituting (10) and (15) into (3) and use (22), the total amount of pollution emitted in the North, the total amount of pollution emitted in the South, and the relative amount of pollution emitted in the North and South can be expressed as follows:

$$D = \Psi S, \qquad D^* = (1 - \Psi)S, \qquad \frac{D}{D^*} = \frac{1}{(1/\Psi) - 1}, \tag{33}$$

where since the total amount of pollution emissions depends on the total emission quota and the number of firms located in the country, the relative amount of pollution emissions depends only on the number of firms located in the country. Here, the nominal interest rate affects the total amount of pollution emissions through the number of firms located in the country.

By substituting $P_T = P_T^* = 1$ and (22) into C and C^* in (8), we obtain the following as the world consumption of tourism goods in equilibrium:

$$C + C^* = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{1-\gamma}{\gamma}\right)\left(\frac{S}{L}\right)(\psi + p^e),$$
$$C = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{\chi}{\gamma}\right)\left(\frac{S}{L}\right)(\psi + p^e), \qquad C^* = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{1-\gamma-\chi}{\gamma}\right)\left(\frac{S}{L}\right)(\psi + p^e) \tag{34}$$

where since the nominal interest rate affects household spending through the price of emission credits, it is possible that it will affect tourism spending. In the steady state, from $\dot{T} = \dot{T}^* = 0$ in (20), $T = CC$ and $T^* = CC^*$. Substituting $P_T = P_T^* = 1$, (21), (33) and (34) into these equations, we obtain the number of tourists moving between the North and South in equilibrium and the relative number of tourists moving between the North and South, respectively, as follows:

$$T = \left(\frac{\sigma - 1}{2\sigma}\right)\left(\frac{\gamma}{\chi}\right)\left(\frac{L}{\psi + p^e}\right)\left(\frac{1}{S^2}\right)\frac{1}{1-\Psi}, \qquad T^* = \left(\frac{\sigma - 1}{2\sigma}\right)\left(\frac{\gamma}{1-\gamma-\chi}\right)\left(\frac{L}{\psi + p^e}\right)\left(\frac{1}{S^2\Psi}\right), \tag{35}$$

and

$$\frac{T}{T^*} = \frac{\gamma}{1-\gamma-\chi}\left[\frac{1}{(1/\Psi) - 1}\right], \tag{36}$$

where environmental and financial policies affect the number of tourists through their capacity to accommodate tourists. In addition, the relative number of tourists depends only on the preference parameter and the number of firms in the location.

3.4 Stability

By rewriting (23), we obtain the following:

$$g_L = \frac{2L}{\varepsilon} - \frac{L}{\varepsilon}\left[\left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\gamma}{1 + p^e/\psi}\right) + (1 - \gamma)\right](E + E^*),$$

which is used with $g = (\sigma - 1)(\rho - i)$ to derive $E + E^*$ in steady state. In the phase diagram, when the economy is not in a steady state at the initial point, it moves away from the steady state along g_L. The economy then jumps to the steady state at an arbitrary point. Therefore, the steady state of this economy is unstable and deterministic.

4 Comparative statics

In this section, we analyze the impact of environmental and financial policies on the economy in the case where households provide loans to manufacturing firms.

4.1 Firm's location and pollution emissions

The impact of environmental and financial policies on the location of firms and the emission of pollution is summarized in the following proposition:

Proposition 1 [Effect of environmental and finance policies on location and pollution]

i) Reducing the total emissions quota has no effect on economic growth rates or the location of firms, but raises the price of emissions quotas and leads to pollution reduction in the North and South.

ii) Reducing the nominal interest rate raises economic growth rates and the amount of FDI, while lowering the price of emissions quotas, and leads to pollution reduction in the North and pollution increase in the South through the location of firms from the North to the South.

Proof 1

See Appendix A. ■

The economic growth rate is determined by the Fishr equation. Therefore, the total emissions quota does not affect household capital income. As a result, the total emissions quota cannot affect the location behavior of firms through the home market effect. The reduction of the total emissions quota increases the demand for emission quotas, and therefore increases the price of emission quotas. It reduces the total pollution emissions of the North and South through the total emissions quota, not through the location behavior of firms. Since the location of manufacturing firms does not change, the relative pollution emissions of the North and South also do not change. This is a different result from Hamaguchi (2020b, 2021a, 2022, 2024a, 2024b, 2024c), in which the total emissions quota affects the location behavior of firms.

A reduction in the nominal interest rate increases the economic growth rate through the Fisher effect. At this time, household capital income decreases, and so expenditure in the North and South falls. Due to a decrease in demand for manufactured goods, manufacturing firms reduce their production volume. As a result, the price of emission quotas also falls due to a decrease in demand for them. Due to this decrease in expenditure, the market size of the North compared to the world shrinks, and manufacturing fimrs in the North begin to locate from the North to the South. Through this location behavior, the total amount of pollution emissions in the North decreases, while the total amount of pollution emissions in the South increases. Therefore, the relative total pollution emissions of the North and South also decrease. Due to this industrial concentration from the North to the South, the amount of FDI increases, because households in the North have more initial assets and use these assets to purchase stocks.

4.2 Monetary policy and tourism

The impact of environmental and financial policies on tourism consumption and the number of tourists is summarized in the following proposition:

Proposition 2 [Effect of environmental and finance policies on tourism consumption and a number of tourists]

i) A reduction in the total quota increases consumption of tourism goods in the North and South, but does not affect the ratio of the number of tourists from the North to the South.

ii) A reduction in the nominal interest rate reduces consumption of tourism goods in the North and South, and reduces the ratio of the number of tourists from the North to the South.

Proof 2

See Appendix B. ■

In (22), the increase in the price of emission quotas due to the reduction in the total emission quota increases household expenditure. This increase in expenditure also expands consumption of tourism goods in the North and South. However, because the total emission quota does not affect the location behavior of firms, it does not affect tourism capacity through pollution emissions. Therefore, it does not have an effect on the relative number of tourists moving between the North and South.

A reduction in the nominal interest rate decreases household expenditure because it reduces household capital income. This reduction in expenditure also decreases consumption of tourism goods in the North and South. In addition, as manufacturing firms are located in the South from the North, the number of polluting firms decrease, improving the tourism capacity in the North, while the number of polluting firms increases, worsening the tourism capacity in the South. Therefore, the relative number of tourists in the North and South also decreases.

4.3 Borrowing and money supply

We analyze the impact of environmental and monetary policies on the amount of loans and the real money supply. By differentiating (31) with respect to the nominal interest rate, we obtain the following:

$$\frac{dB+B^*}{di}=-\frac{1}{\beta i^2}\left[\left(\frac{\gamma}{1-\gamma}\right)\left\{2-S-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)\right\}-(\varepsilon+\psi S)\right]+\frac{\sigma-1}{\beta i}\left(\frac{\gamma}{1-\gamma}\right)\left(\frac{\varepsilon}{L}\right)\gtrless 0,$$

where the left side of this inequality can be rewritten as follows:

$$S\gtrless\frac{\gamma}{\gamma-\psi(1-\gamma)}\left[2+\frac{\varepsilon}{\gamma}\left\{(1-\gamma)-\frac{\gamma\rho}{L}(\sigma-1)\right\}\right]\equiv\hat{S},$$

with the monotonic effect of an increase in the nominal interest rate on the global amount of lending is affected by the total emission quota. Therefore, while an increase in the nominal interest rate has a positive effect on this amount of lending when $S\geq\hat{S}$, this monetary policy has a negative effect on this amount of lending when $S<\hat{S}$. Differentiating (31) with respect to the total emissions quota, we obtain $d(B+B^*)/dS<0$. In this case, a reduction in the total emissions quota increases the global loan amount.

Differentiating (32) with respect to the nominal interest rate, we obtain the following:

$$\frac{dm+m^*}{di}=-\frac{\gamma L}{\beta i^2(1-\gamma)}\left[2-\frac{S\psi}{L}-\frac{\varepsilon}{L}(\sigma-1)(\rho-i)\right]+\frac{\sigma-1}{1-\gamma}\left(\frac{\varepsilon}{L}\right)\left(\frac{\gamma L}{\beta i}+\frac{\alpha}{S}\right)+\frac{\varepsilon+\psi SL}{\beta i^2}\gtrless 0,$$

where the left side of this inequality can be rewritten as follows:

$$i\gtrless\sqrt{\left(\frac{SL}{\alpha\varepsilon}\right)\left(\frac{1-\gamma}{\sigma-1}\right)\left[\frac{\gamma L}{\beta(1-\gamma)}\left\{2-\frac{\varepsilon}{L}(\sigma-1)\right\}-\left(\frac{\varepsilon}{\beta}\right)+\frac{S\psi}{\beta}\left(\frac{\gamma}{1-\gamma}-L\right)\right]}\equiv\tilde{\imath},$$

which represents the threshold for the inverted U-shaped effect of an increase in the nominal interest rate on the real money supply. Therefore, when $i\geq\tilde{\imath}$, an increase in the nominal interest rate has a positive effect on this money supply, while when $i<\tilde{\imath}$, this monetary policy has a negative effect on this money supply. Differentiating (32) with respect to the total emission quota, we obtain $d(m+m^*)/dS<0$. In this case, a reduction in the total emission quota increases the real

money supply. These results can be summarized as follows:

Proposition 3 [Effect of environmental and finance policies on tourism consumption and a number of tourists]

i) A reduction in the total emission quota increases the amount of global lending and the global real money supply.

ii) A reduction in the nominal interest rate increases or decreases the amount of global lending, depending on the total emission quota. In addition, the nominal interest rate has an inverse U-shaped relationship with the global real money supply.

Proof 3

See text. ■

As stated in Proposition 2, a reduction in the total emissions quota increases household expenditure. As demand for manufactured goods increases, manufacturing firms need to borrow more money from households in order to expand production. Therefore, the reduction in the total emissions quota increases the amount of lending worldwide. As households face increased expenditure and borrowing, the demand for money increases, so the monetary authority expands the real money supply.

There are two effects of a reduction in the nominal interest rate on the amount of lending worldwide. First, as a result of the reduction in the nominal interest rate, capital income decreases, and as expenditure decreases, households reduce the amount of lending to manufactured goods. Second, as a result of the reduction in the nominal interest rate, the borrowing costs of manufacturing firms decrease, and they try to increase the amount of borrowing. The total emission quota determines whether the positive effect of the nominal interest rate on the amount of lending is dominated by its negative effect. As the total emission quota decreases, the positive effect of the nominal interest rate changes to a negative effect.

A reduction in the nominal interest rate has a positive and negative effect on the real money supply. The first is the effect through the amount of lending in the world. A reduction in the nominal interest rate decreases the money supply by reducing household lending, but increases the money supply by increasing corporate borrowing. The second effect is through household expenditure. A reduction in the nominal interest rate decreases the price of emission quotas, which increases household expenditure and therefore increase the money supply. Depending on which of these positive and negative effects dominate, an inverse U-shaped relationship is created between the nominal interest rate and the real money supply. When the total emissions quota is reduced, this threshold decreases, so there is a greater chance that a reduction in the nominal interest rate reduces the real money supply.

5 Finance for R&D sector

In this section, we analyze the impact of environmental and financial policies on the economy in the case where households provide loans to the R&D sector. We derive the equilibrium in this case by modifying the model in Section 2 and the equilibrium in Section 3. In doing so, we only describe the equations that have beenchanged.

5.1 Permit price and money supply

In this case, since the manufacturing firm is not receiving a loan from a household, the profit in (16) is rewritten as follows:

$$\Pi = \left(\frac{\gamma L}{\sigma}\right)\frac{E + E^*}{A} + p^e s. \tag{37}$$

Instead, the R&D firm receives a loan from the household. As in Chu (2022) and Hamaguchi (2024c), this firm receives a loan from the household to cover the labor costs of its workers. From the zero profit condition, we obtain

$$v = \frac{\varepsilon}{A}(1 + \beta i), \tag{38}$$

where an increase in the nominal interest rate raises stock prices with other factors held constant.

Substituting (37) and (38) into (19), we get the following economic growth rate:

$$g = \frac{S(\psi + \sigma p^e)}{\varepsilon(\sigma - 1)(1 + \beta i)} - \rho, \tag{39}$$

which is used with (26) to derive the following emissions permit price in equilibrium:

$$p^e = \frac{\varepsilon(\sigma - 1)^2(1 + \beta i)}{\sigma S}\left[\left(\frac{\sigma}{\sigma - 1}\right)\rho - i\right] - \frac{\psi}{\sigma}, \tag{40}$$

where the nominal interest rate has a positive effect on the price of emission credits, but also a negative effect. Differentiating the price of emission quotas with respect to the nominal interest rate, we get $\frac{dp^e}{di} \gtrless 0$ for

$$\hat{\imath} \equiv \frac{1}{2}\left(\frac{\sigma\rho}{\sigma - 1} - \frac{1}{\beta}\right) \gtrless i, \tag{41}$$

where $\sigma\rho/(\sigma - 1) > 1/\beta$ is assumed for $\hat{\imath} > 0$. Therefore, the nominal interest rate has an inverted U-shaped effect on the price of emission quotas.

Following Hamaguchi (2024c), solving (4) as a first-order linear differential equation, we obtain the following:

$$m_t = m_0 \exp\left[t\left(\mu + \frac{g}{\sigma - 1}\right)\right] = m_0 \exp[\mu + (\rho - i)]t, \tag{42}$$

where m_0 is the initial real money supply. The real money supply at equilibrium increases with the rate of increase in the money supply and decreases with an increase in the inflation rate. Substituting (28) and (41) into $(B + B^*) + \alpha L(E + E^*) = m + m^*$, we obtain the following as the world's loan amount at equilibrium:

$$B + B^* = m_0 \exp[\mu - (\sigma - 1)(\rho - i)]t - \alpha L\left[\frac{2 - \frac{\varepsilon}{L}(\sigma - 1)(\rho - i)}{1 - \gamma + \frac{\gamma(\sigma - 1)}{\sigma(1 + p^e/\psi)}}\right]. \tag{43}$$

5.2 Monetary policy driven pollution haven hypothesis

In the case of households financing R&D sector, the impact of environmental and financial policies on the economy can be summarized by the following proposition:

Proposition 4 [Effect of environmental and finance policies on environment and tourism]

i) *Reducing the total emission quota brings about pollution reduction in the North and South without affecting the economic growth rate, the industrial location, the real money supply, or the ratio of the number of tourists moving from the North to the South. In addition, that environmental policy increases the price of emission quotas, increase consumption of tourism goods in the North and South, and reduce the amount of lending worldwide.*

ii) *Lowering the nominal interest rate increases economic growth and FDI, and through the firms' location from the North to the South, it leads to a decrease in pollution in the North and an increase in pollution in the South.*

Furthermore, that monetary policy increases the real money supply and reduce the ratio of the number of tourists from the North to the South. Furthermore, the inverse U-shaped relationship between the nominal interest rate and the price of emission quotas leads to an inverse U-shaped relationship between the nominal interest rate and the consumption of tourism goods in the North and South.

Proof 4

See Appendix C. ■

As described in propositions 1 to 3, in the case of lending to R&D firms, as in the case of lending to manufacturing firms, a reduction in the total emissions quota leads to a reduction in total pollution emissions in the North and South due to an increase in the price of emissions quotas, and to an increase in tourism consumption in the North and South. In the case of lending to manufacturing firms, a reduction in the total emissions quota increases the amount of lending and the money supply, but in the case of lending to R&D firms, that environmental policy has no effect on the money supply and leads to a decrease in the amount of lending. The reason for this is that in this case, the equilibrium money supply is determined by the Fisher equation in (26). At this time, the equilibrium loan amount is derived from the household's CIA constraint. The increase in household expenditure due to the reduction in the total emissions quota leads to a decrease in the loan amount by increasing the money demand for trading motives. Even if the loan destination is changed from manufacturing firms to R&D firms, the impact of environmental policies on the environment and tourism will not change.

In the case of lending to R&D firms, as in the case of lending to manufacturing firms, a reduction in the nominal interest rate leads to pollution haven from the North to the South and tourism moving from the North to the South, along with economic growth and an expansion of FDI. In the case of lending to manufacturing firms, a reduction in the nominal interest rate has an inverted U-shaped effect on the money supply and a monotonous effect on the amount of lending, reducing tourism consumption in the North and South. However, in the case of lending to R&D firms, that monetary policy has a more complex effect on the amount of lending, in addition to increasing the money supply, and has an inverted U-shaped effect on tourism consumption in the North and South. The reason for this is that in this case, the equilibrium money supply is determined by the Fisher equation (26). In (26), the reduction in the nominal interest rate increases the economic growth rate. The expansion of the number of varieties decreases the price index of manufactured goods through an increase in the supply of manufactured goods. This fall in inflation leads to an increase in the real money supply. This effect, combined with the effect on money demand of the motive for transactions, makes the effect of that monetary policy on the amount of lending complex.

In this case, in addition to the effect of lowering the nominal interest rate causing the price of emission quotas to fall, there is also an effect of raising it, so there is an increase in tourism consumption due to the rise in expenditure in (22) and a decrease in tourism consumption due to the fall in expenditure. In (38), the decline in the nominal interest rate lowers the marginal cost of R&D firms, encouraging new entrants in this sector and promoting the development of new varieties. As a result, in (39), the economic growth rate rises and new entries into the manufacturing sector are also encouraged. At this time, in a monopolistic competitive market, the production volume per manufacturing firm decreases with the new entries, and so the price of emission quotas falls due to the decrease in demand for emission quotas. On the other hand, the reduction in the nominal interest rate leads to a decrease in the inflation rate under the deflationary economy in (26). At this time, deflation is occurring due to the increase in the total production of manufactured goods in (25) as the

number of varieties increases. As demand for emission quotas increases due to the expansion of production in the manufacturing sector, the price of emission quotas rises. The positive and negative effects of monetary policy on the price of emission quotas result in an inverted U-shaped relationship between the policy and price.

5.3 Welfare effect of both lending destinations

We analyze the welfare effects of environmental and financial policies at both lending destinations. Using (12), we rewrite (9) as follows:

$$P = \frac{\sigma}{\sigma - 1}\left(\frac{1}{a + \psi a^*}\right)^{\frac{1}{\sigma-1}}, \qquad P^* = \frac{\sigma}{\sigma - 1}\left(\frac{1}{\psi a + a^*}\right)^{\frac{1}{\sigma-1}}, \tag{44}$$

where the expansion of the variety of manufacturing goods increases the total supply, causing the price index to fall in both the North and the South. The measure of welfare is the utility level of households in (1). After substituting (2), (8), (12), (44), and (28) into (1), and rewriting using $D + D^* = S, a + a^* = A$, and $a_t = A_0 e^{gt}$, we obtain the following welfare in the North and South:

$$U = \frac{1}{\rho}\log\left[U_1 U_2 \left(\frac{1}{S}\right)^{\eta}\left\{\frac{(1 + p^e/\psi)^{1-\gamma}}{(1-\gamma)(1 + p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}}\right\}\right]\left[\{(1-\psi)\Psi + \psi\}^{\frac{\gamma}{\sigma-1}}\right] + \frac{1}{\rho^2}\left(\frac{\gamma g}{\sigma - 1}\right), \tag{45}$$

and

$$U^* = \frac{1}{\rho}\log\left[U_1 U_3 \left(\frac{1}{S}\right)^{\eta}\left\{\frac{(1 + p^e/\psi)^{1-\gamma}}{(1-\gamma)(1 + p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}}\right\}\right]\left[\{(1-\psi)\Psi + \psi\}^{\frac{\gamma}{\sigma-1}}\right] + \frac{1}{\rho^2}\left(\frac{\gamma g}{\sigma - 1}\right), \tag{46}$$

where $U_1 \equiv \gamma^{\gamma}\chi^{\chi}(1-\gamma-\chi)^{1-\gamma-\chi}(\sigma - 1/\sigma)^{\gamma}(\sigma/L)A_0^{\gamma}$, $U_2 \equiv 2 - (\varepsilon/L)(\sigma - 1)(\rho - i)y$, and $U_3 \equiv 2 - (\varepsilon/L)(\sigma - 1)(\rho - i)(1 - y)$.

In (45) and (46), welfare improves due to an increase in consumption of manufactured and tourism goods, but worsens due to an increase in total pollution emissions. Consumption of manufactured goods depends on expenditure through the growth rate of manufactured goods prices and the number of varieties. In (44), the price index falls due to an increase in the number of varieties and the number of firms located in the area. Households can improve their welfare by increasing consumption of manufactured and tourism goods due to the increase in expenditure caused by this price decline. The welfare effect of environmental policy can be summarized in the following proposition:

Proposition 5 [Welfare effect of environmental policy]

Reducing the total emissions quota monotonically improves welfare, whether it is lent to manufacturing or R&D firms.

Proof 5

See Appendix D. ■

Environmental policy does not affect the industrial location or economic growth, so it affects welfare through household expenditure on the price of emission quotas in addition to total pollution emissions. In (45) and (46), a reduction in the total emission quota improves welfare through the direct effect of pollution reduction $[(1/S)^{\eta}]$. Furthermore, through the indirect effect of an increase in the price of emission quotas, it causes a deterioration in welfare due to an increase in

the price of manufactured goods $[(1+p^e/\psi)^{-\gamma}]$ and an improvement in welfare due to an increase in household expenditure $[(1+p^e/\psi)]$. In the case of lending to R&D firms, a reduction in the total emissions quota has a positive welfare effect, but in the case of lending to manufacturing fimrs, it has the same welfare effect under the following parameter conditions:

$$S < \frac{\left[2 - -\frac{\varepsilon}{L}(\sigma-1)(\rho-i)\right]}{\frac{1-\gamma}{\gamma}+\frac{\psi}{L}} \equiv \bar{S},$$

where a reduction in the total emissions quota may have a non-monotonic welfare effect in $S \geq \bar{S}$. Monetary policy may also have a non-monotonic welfare effect due to the additional indirect effects of firms' location and economic growth. However, due to the complexity of the issue, it is difficult to provide an analytical proof.

5.4 Impact of changing lending destination

Which would be more conducive to the realization of sustainable tourism through environmental and financial policies: lending more heavily to manufacturing or R&D firms? Reducing the total emission quota for both manufacturing and R&D firms would reduce pollution emissions worldwide and increase tourism consumption without causing pollution haven from the North to the South. Thus, the environmental policy results improving welfare in the North and the South. In addition, when lending to manufacturing firms, the environmental policy also promotes the development of financial markets through the expansion of the money supply and the amount of loans. On the other hand, when lending to both manufacturing and R&D firms, a reduction in the nominal interest rate causes pollution haven from the North to the South and tourism to move, in addition to economic growth and an increase in FDI. In the case of lending to manufacturing firms, the lower the level of the total emissions quota, the more the interest rate reduction policy promotes the development of financial markets through the expansion of the money supply and the amount of lending, but it also reduces global tourism consumption. When lending to R&D firms, the interest rate reduction policy leads to the development of financial markets due to an increase in the money supply, but the initial expansion of tourism consumption eventually leads to a contraction in tourism consumption.

Based on these results, even if the lending institution is changed, the expansion of tourism and financial development due to environmental policies not change. Therefore, this environmental policy is highly likely to bring about sustainable tourism through financial development. On the other hand, while financial policies promote economic growth and tourism migration, they also cause pollution haven. Furthermore, the nominal interest rate within the range of $\bar{\imath} < \hat{\imath} < i$ brings about FDI from the North to the South, and also promotes pollution haven in the long term. Here, when the level of the total emissions quota is high in lending to manufacturing firms, a policy of lowering interest rates reduces both tourism and finance. Even if the lending is changed to R&D firms, a small-scale policy of lowering interest rates brings about a win-win relationship between tourism and finance, but a large-scale policy of lowering interest rates brings about a trade-off relationship between tourism and finance. However, when the level of the total emissions quota is sufficiently reduced and the policy is limited to a small interest rate cut, the financial policy is able to suppress the contraction of tourism and the relationship between tourism and finance changes to a win-win relationship.

Therefore, it can be said that a policy mix of environmental and financial policies, which involves a small interest rate cut accompanied by a reduction in the total emissions quota, rather than a change in the borrower, lead to sustainable

tourism. When lending to R&D firms, financial policy leads to financial-led tourism growth, because a small interest rate cut encourages the expansion of tourism and finance. When the nominal interest rate is set within the range $\hat{\imath} < i < \bar{\imath}$, it is possible to bring about FDI from the South to the North and to deter long-term pollution haven. Even if short-term pollution haven from the North to the South is created through the firms' locations, pollution reduction in the North brings about sustainable tourism in the North.

6 Conclusion

The development of tourism due to globalization has led to the carbon intensification of the tourism industry, and the realization of sustainable tourism is being called for. As the relationship between tourism and finance deepens, financial globalization may further increase the carbon footprint of the tourism industry. Clarifying the theoretical mechanisms by which the mutual relationship between tourism and finance affects the environment suggests useful policy measures for sustainable tourism development through financial development. By introducing a monetary economy into a R&D-based location model that includes emissions trading and international tourism migration, we analyze the impact of total emissions quotas and nominal interest rates on pollution emissions, firms' location, FDI, economic growth, tourism goods consumption, tourist numbers, money supply, and loan volume. As a result, sustainable tourism and financial-led tourism growth due to environmental policies are confirmed in loans to manufacturing firms, but tourism-led growth is not confirmed. On the other hand, in terms of loans to R&D firms, sustainable tourism development through monetary policy is only confirmed in the North, while monetary policy-driven tourism-led growth and monetary policy-driven tourism growth are confirmed in both the North and South. Therefore, the empirical results of the sustainable tourism development and monetary policy-driven tourism growth hypotheses are theoretically supported.

This study proposes that a policy mix of environmental and financial policies would be beneficial for policy makers to achieve sustainable tourism development. When lending to R&D firms, a small interest rate cut would promote tourism and financial expansion, resulting in financial-led tourism growth. A small interest rate cut can also deter long-term pollution haven through FDI from the South to the North. At this time, a reduction in the total emission quota will achieve sustainable tourism development through global pollution reduction and tourism expansion. However, because this is a qualitative analysis, this study cannot tell us what level of nominal interest rate should be set. Quantitative policy effects need to be shown through numerical analysis. In addition, it is necessary to verify whether the main results of this study are also statistically supported by empirical analysis. Further research is needed to determine whether it is possible to reconcile the financial-led tourism growth hypothesis and sustainable tourism development.

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Declarations

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Appendix

This appendix describes the derivation of formulae and proofs of propositions used in the paper.

A) Proof of Proposition 1

Since g in (26) and Ψ in (30) are not dependent on S, the total emission quota does not affect g and Ψ. By differentiating (29) with respect to S, we obtain the following:

$$\frac{dp^e}{dS} = -\frac{p^e}{S} - \frac{\psi}{SL}\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\gamma}{1-\gamma}\right) < 0.$$

By differentiating D, D^*, and D/D^* in (33) with respect to S, we obtain $dD/dS = \Psi > 0$, $dD^*/dS = 1-\Psi > 0$, and $d(D/D^*)/dS = 0$.

Differentiating g in (26) with respect to the nominal interest rate i, we get $dg\ /\ di = -(\sigma-1) < 0$. By differentiating p^e in (29) with respect to i, we get the following:

$$\frac{dp^e}{di} = \frac{(\sigma-1)^2}{\sigma SL}\left(\frac{\varepsilon\gamma}{1-\gamma}\right) > 0.$$

By differentiating Ψ in (30) with respect to the nominal interest rate i, we get the following:

$$\frac{d\Psi}{di} = \frac{\varepsilon(\sigma-1)(1+\varphi)}{2L(1-\varphi)}\left[1 - \frac{\varepsilon(\sigma-1)(\rho-i)}{2L}\right]^{-2}\left(y - \frac{1}{2}\right) > 0,$$

which is used to derive $dD/di = S(\partial\Psi/\partial i) > 0$, $dD^*/di = -S(\partial\Psi/\partial i) < 0$, and $d(D/D^*)/di = [1/(1-\Psi)^2](\partial\Psi/\partial i) > 0$, which are obtained by differentiating D, D^*, and D/D^* in (33) with respect to i.

B) Proof of Proposition 2

Since Ψ in (30) is independent of S, the total emission quota does not affect T/T^* in (36). Differentiating C, C^*, and $C + C^*$ in (34) with respect to S, we can obtain the following:

$$\frac{dC}{dS} = -\frac{2\psi}{L^2}\left(\frac{\chi}{1-\gamma}\right) < 0, \qquad \frac{dC^*}{dS} = -\frac{2\psi}{L^2}\left(\frac{1-\gamma-\chi}{1-\gamma}\right) < 0, \qquad \frac{dC+C^*}{dS} = -\frac{2\psi}{L^2} < 0.$$

By differentiating C, C^*, and $C + C^*$ in (34) with respect to i, we can obtain the following:

$$\frac{dC}{di} = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{\chi}{\gamma}\right)\left(\frac{S}{L}\right)\frac{\partial p^e}{\partial i} > 0, \qquad \frac{dC^*}{di} = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{1 - \gamma - \chi}{\gamma}\right)\left(\frac{S}{L}\right)\frac{\partial p^e}{\partial i} > 0,$$

$$\frac{dC + C^*}{dS} = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{1 - \gamma}{\gamma}\right)\left(\frac{S}{L}\right)\frac{\partial p^e}{\partial i} > 0.$$

Differentiating T/T^* in (36) with respect to i, we can obtain the following:

$$\frac{d}{di}\left(\frac{T}{T^*}\right) = \frac{\gamma}{1 - \gamma - \chi} \cdot \frac{1}{(1 - \Psi)^2} \cdot \frac{\partial \Psi}{\partial i} > 0.$$

C) Proof of Proposition 4

In addition to g in (26) and Ψ in (30), m_t in (41) is independent of S, the total emission quota, so the total emission quota does not affect m_t in (41) or T/T^* in (36). By differentiating D, D^*, and D/D^* in (33) with respect to S, we obtain $dD\ /\ dS = \Psi > 0$, $dD^*/dS = 1 - \Psi > 0$, and $d(D/D^*)/dS = 0$.

By differentiating p^e in (29) with respect to S, we obtain

$$\frac{dp^e}{dS} = -\frac{\varepsilon(\sigma - 1)^2(1 + \beta i)}{\sigma S^2}\left[\left(\frac{\sigma}{\sigma - 1}\right)\rho - i\right] < 0,$$

which is used to derive $dC/dS = [C/(\psi + p^e)](\partial\Psi/\partial S) < 0$, $dC^*/dS = [C/(\psi + p^e)](\partial\Psi/\partial S) < 0$ and $d(C + C^*)/dS = [(C + C^*)/(\psi + p^e)](\partial\Psi/\partial S) < 0$, which are obtained by differentiating C, C^*, and $C + C^*$ in (34) with respect to S. By differentiating $B + B^*$ in (42) with respect to S, we obtain the following:

$$\frac{dB + B^*}{dS} = -\frac{\left[2 - \frac{\varepsilon}{L}(\sigma - 1)(\rho - i)\right]}{\left[1 - \gamma + \frac{\gamma(\sigma - 1)}{\sigma(1 + p^e/\psi)}\right]^2} \cdot \frac{\gamma\alpha L(\sigma - 1)}{\sigma(1 + p^e/\psi)^2}\left(\frac{1}{\psi}\right)\frac{\partial p^e}{\partial S} > 0.$$

By differentiating g in (26) with respect to the nominal interest rate i, we get $dg\ /\ di = -(\sigma - 1) < 0$. Differentiating Ψ in (30) with the nominal interest rate i, we get $d\Psi/di > 0$, which is used to derive $dD/di = S(\partial\Psi/\partial i) > 0$, $dD^*/di = -S(\partial\Psi/\partial i) < 0$, and $d(D/D^*)/di = [1/(1 - \Psi)^2](\partial\Psi/\partial i) > 0$, which are obtained by differentiating D, D^*, and D/D^* in (33) with respect to i. Differentiating T/T^* in (36) with respect to i yields $d(T/T^*)/di > 0$.

Differentiating p^e in (40) with respect to i yields $\frac{dp^e}{di} \gtrless 0$ for $\hat{\imath} \gtrless i$ in (41). Therefore, differentiating C, C^*, and $C + C^*$ in (34) with respect to i yields the following:

$$\frac{dC}{di} = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{\chi}{\gamma}\right)\left(\frac{S}{L}\right)\frac{\partial p^e}{\partial i} \gtrless 0, \qquad \frac{dC^*}{di} = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{1 - \gamma - \chi}{\gamma}\right)\left(\frac{S}{L}\right)\frac{\partial p^e}{\partial i} \gtrless 0,$$

$$\frac{dC + C^*}{dS} = \left(\frac{2\sigma}{\sigma - 1}\right)\left(\frac{1 - \gamma}{\gamma}\right)\left(\frac{S}{L}\right)\frac{\partial p^e}{\partial i} \gtrless 0,$$

for $\hat{\imath} \gtrless i$.

D) Proof of Proposition 5

By differentiating (45) with respect to S, we obtain the following:

$$\frac{dU}{dS} = -\frac{\eta}{\rho S} + \frac{1}{\rho}\left[\frac{(1-\gamma)(1+p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}}{(1+p^e/\psi)^{1-\gamma}}\right]\frac{\partial}{\partial S}\left\{\frac{(1+p^e/\psi)^{1-\gamma}}{(1-\gamma)(1+p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}}\right\} < 0,$$

which holds when the second term on the right-hand side of this inequality is negative. The derivative of this second term can be rewritten as follows:

$$\frac{\partial}{\partial S}\left\{\frac{(1+p^e/\psi)^{1-\gamma}}{(1-\gamma)(1+p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}}\right\} = \frac{(1-\gamma)(1+p^e/\psi)^{-\gamma}}{(1-\gamma)(1+p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}} - \frac{(1-\gamma)(1+p^e/\psi)^{1-\gamma}}{\left[(1-\gamma)(1+p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}\right]^2} < 0,$$

which is further rewritten as follows:

$$\frac{(\gamma/\psi)(1-\gamma)(1+p^e/\psi)^{1-\gamma}}{\left[(1-\gamma)(1+p^e/\psi) + \frac{\gamma(\sigma-1)}{\sigma}\right]^2}\left[\frac{(\sigma-1)}{\sigma(1+p^e/\psi)} - 1\right] < 0,$$

where the second term on the left-hand side of this inequality can be rewritten by using (29) and (40) as follows:

$$S < \frac{\left[2 - \frac{\varepsilon}{L}(\sigma-1)(\rho-i)\right]}{\frac{1-\gamma}{\gamma} + \frac{\psi}{L}} \equiv \bar{S},$$

and

$$0 < \frac{\varepsilon(\sigma-1)^2(1+\beta i)}{\sigma S}\left[\left(\frac{\sigma}{\sigma-1}\right)\rho - i\right].$$

Thus, $dU/dS < 0$ holds for $\bar{S} > S$. Differentiating (46) with respect to S and go through the same calculation process, we obtain $dU^*/dS < 0$.

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IFRS S1 AND S2: A NEW ERA FOR ESG DISCLOSURE IN KAZAKHSTAN'S BUSINESS LANDSCAPE

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Abstract
The adoption of IFRS S1 and S2 by the International Sustainability Standards Board (ISSB) is an important step towards global harmonization of ESG disclosure standards. This study examines the transition of Kazakhstan to these standards, focusing on regulatory changes, corporate readiness, and specific cases from various sectors. As ESG disclosure will become mandatory for financial institutions from January 2024, the research assesses the readiness of large corporations and SMEs and analyzes the financial impact of compliance with these standards. Based on data from PwC, KPMG, and company reports, the study identified issues such as uncertainty surrounding regulatory requirements and a lack of ESG experience among SMEs. The most successful companies in this regard are those that were the first to start this work, such as KazMunayGas, KPO, and KAZ Minerals. T The findings of the study are accompanied by recommendations for policy reform, capacity building, and financial incentives to ensure broad and equitable compliance with ESG requirements. Successfully bringing Kazakhstan into compliance with IFRS S1 and S2 could make it a regional leader in sustainable finance.
Keywords: IFRS S1, IFRS S2, ESG Reporting, Kazakhstan, sustainability disclosure, corporate governance.

1. Introduction

1.1 Global importance of ESG reporting

Sustainability reporting has become an important componenet of corporate governance over the past several years. Investors, regulators and other interested in 3rd parties are demanding greater transparency according to the social and environmental impact to the business. According to the PwC research in 2023, more than 90% of investors are considering ESG metrics as an important factor in financial decision making process. Responding to this demand, global regulators are developing standardized frameworks for ESG disclosure to insure transparency principles in reporting. ISSB established two new sustainability standards in June 2023 under the International Financial Reporting Standards (IFRS) Foundation.

1 – IFRS S1 (General requirements for sustainability – related financial disclosures)
2 – IFRS S2 (Climate – related disclosures)

This framework represents clear guidelines on reporting about sustainability risks and future opportunities. It makes sure, that presented ESG disclosures are consistent, reliable and comparable across all industries.

1.2 ESG standards -Kazakhstan's growing commitment

Kazakhstan is paying more attention to ESG reporting, showing how important it is in bringing foreign investments into transparent corporate activities. In 2023, the Agency for Regulation and Development of the Financial Markets (ARFMD) introduced mandatory ESG disclosure requirements for financial institutions, effective date is 1st of January 2024.

In addition, Astana International Financial Center (AIFC) and Kazakhstan's Sovereign Wealth Fund Samruk-Kazyna have integrated ESG principles into their corporate strategy. This implications shows, that the government is seeking to bring its sustainability reporting policy into line with IFRS S1/S2 standards. It will strengthen investor confidence and enhance economic stability of the country.

2. Literature review

Recent researches highlights the increasingly active integration of ESG factors into global capital markets. A study presented by PwC in 2023 shows that more than 90% of worldwide investment organizations incorporate ESG metrics into the decision making process. According to the McKinsey research (2023), company's ability to achieve sustainable development goals is determined by its ability to manage risks related to environmental, social and corporate governance aspects. Companies that actively disclose ESG information, demonstrate more effective risk management practices, resilience during the crisis conditions and long-term profitability. Last 5 years, research works are rising in Kazakhstan and Central Asia.

3. Methodology

This research employs a mixed-methods design. Quantitative data were sourced from publicly available ESG surveys (PwC, KPMG, 2023) and official corporate reports. Qualitative insights were drawn from case study analysis of leading Kazakhstani corporations (KazMunayGas, KAZ Minerals, KPO, and EDB). A comparative assessment framework was developed to measure ESG readiness, cost impact, and alignment with IFRS S1 and S2 indicators. Secondary data were validated through triangulation, and findings were categorized by sector and company size.

4. Results and discussion

4.1 ESG compliance rates by company size and its financial impact

Companies adopting IFRS S1 and S2 standards experience both short-term costs and long-term financial benefits.

Short-term challenges

– Compliance costs: Initial implementation may require investments in ESG reporting systems (estimated at $1M - $5M per large corporation).
– Training costs: Firms must educate employees on sustainability reporting standards.
– Long-term financial benefits
– Lower capital costs: Companies with ESG-aligned strategies secure cheaper financing.
– Higher stock valuations: Public companies with transparent ESG disclosures outperform those without.
– Operational efficiency: Companies adopting climate-conscious strategies reduce energy costs by 10%-15% annually.

As Table 1 shows, ESG compliance levels vary significantly by company size. Large corporations demonstrate the highest level of preparedness due to greater access to financial and human capital. SMEs face severe limitations in both reporting infrastructure and financial capacity.

Table 1- ESG compliance levels

Company size	*Fully prepared (%)*	*Partially prepared (%)*	*Not prepared (%)*
Large Corporations	35	50	15
Medium Enterprises	22	48	30
Small Businesses	10	25	65

Kazakhstani large enterprises are benefiting from early integration of ESG frameworks. The financial sector, in particular, has made substantial progress due to regulatory mandates and investor pressure.

Table 2 illustrates the financial advantages of ESG compliance. Firms that aligned with IFRS S1 and S2 experienced a significant increase in investor confidence and stock performance. Moreover, green financing became more accessible, with reduced capital costs and favorable credit ratings.

Table 2- Financial advantages of ESG compliance

Indicator	*ESG-Compliant*	*Non-Compliant*	*Difference*
Stock Performance (YoY)	+12%	-4%	+16%
Investor Confidence	+20%	-8%	+28%
Access to Green Finance	High	Low	—

These findings confirm that ESG integration not only meets regulatory requirements but also strengthens financial resilience and investor trust.

4.2 Understanding IFRS S1: General sustainability-related disclosures

The International Financial Reporting Standard (IFRS) S1, issued by the International Sustainability Standards Board (ISSB) in June 2023, establishes general requirements for disclosing sustainability-related financial information. Its primary objective is to provide investors and stakeholders with consistent, comparable, and verifiable sustainability information that can influence financial decision-making (IFRS Foundation, 2023).

Unlike traditional financial reporting, which focuses primarily on historical financial performance, IFRS S1 integrates forward-looking sustainability risks and opportunities that may impact an organization's financial health over time.

Key objectives of IFRS S1:

1. Ensure comparability: Companies across different jurisdictions and industries should disclose sustainability information in a consistent format.
2. Improve decision-making: Investors require clear, high-quality sustainability data to assess long-term risks and opportunities.
3. Increase accountability: Organizations are expected to disclose material ESG factors, ensuring greater corporate transparency.

IFRS S1 requires companies to align their fundamental principles presented in Table 3. sustainability-related disclosures

Table 3 - IFRS S1 sustainability-related disclosures fundamental principles

Principle	*Description*
Relevance	Sustainability information should affect investor decision-making.
Faithful representation	Disclosures must be accurate, unbiased, and complete.
Comparability	Companies should use standardized reporting metrics.
Verifiability	ESG disclosures should be supported by auditable evidence.
Timeliness	Sustainability-related financial information must be reported on time.

These principles align with IFRS Accounting Standards and ensure that ESG information is as reliable as traditional financial statements.

To comply with IFRS S1, companies must provide sustainability-related financial disclosures at the same time as their general financial reports. These disclosures should cover:

1. Governance: How sustainability-related risks are managed by a company's board and leadership team.
2. Strategy: The company's approach to handling ESG risks and opportunities.
3. Risk management: How ESG risks are identified, assessed, and mitigated.
4. Metrics and targets: Clear sustainability-related KPIs and performance indicators (e.g., carbon footprint, gender diversity, supply chain transparency).

For example, Kazakhstani banks and financial institutions, starting from 2024, are required to publish ESG reports in accordance with IFRS S1 (AIFC, 2023).

Examples of global trends in IFRS S1 implementation:

– Europe: The European Union has incorporated IFRS S1 into its Corporate Sustainability Reporting Directive (CSRD), ensuring that all large companies report sustainability-related financial risks.

– United States: The U.S. Securities and Exchange Commission (SEC) is evaluating IFRS S1 to align it with its climate-related financial disclosure rules.

– Asia-Pacific: Japan and Australia have voluntarily adopted IFRS S1, encouraging businesses to integrate ESG factors into financial reporting.

4.3 Understanding IFRS S2: Climate-related disclosures

IFRS S2, issued alongside IFRS S1, is a climate-specific sustainability disclosure standard. It focuses on how climate change risks and opportunities affect a company's financial position and strategy (ISSB, 2023).

Key objectives of IFRS S2:

1. Enhance transparency in corporate climate risk management.
2. Provide investors with reliable climate-related financial data.
3. Standardize climate disclosures across industries and jurisdictions.

IFRS S2 is closely aligned with the Task Force on Climate-related Financial Disclosures (TCFD) framework, making it one of the most globally recognized climate reporting standards.

To comply with IFRS S2, companies must disclose four key areas of climate-related financial information:

1. Governance: How boards and management oversee climate-related risks and opportunities.
2. Strategy: The company's long-term approach to handling climate change risks.
3. Risk management: The process of identifying, assessing, and mitigating climate-related risks.
4. Metrics & targets: Quantitative and qualitative climate performance indicators (e.g., GHG emissions, net-zero targets, climate adaptation investments).

Greenhouse Gas (GHG) Emissions reporting

Companies reporting under IFRS S2 must disclose their GHG emissions in the following categories presented in Table 4.

Table 4 – GHG emissions categories

Emission category	*Description*
Scope 1	Direct emissions from owned operations
Scope 2	Indirect emissions from energy use
Scope 3	Indirect emissions from supply chain activities

For example, KazMunayGas, Kazakhstan's national oil company, reported a 12% reduction in Scope 1 and 2 emissions in 2023, aligning with IFRS S2 requirements.

Global implementation of IFRS S2:

– EU & UK: IFRS S2 has been integrated into corporate climate reporting directives.

– Japan: Listed companies must disclose climate-related financial risks under IFRS S2.

– China: Regulators are working on mandatory carbon disclosure frameworks, aligning with IFRS S2.

Case study (Kazakhstan): Samruk-Energy's climate reporting

Samruk-Energy, one of Kazakhstan's largest power generation companies, has integrated IFRS S2 principles into its ESG reporting.

– Reduced carbon intensity by 8% in 2023.

– Invested $150 million in renewable energy projects (solar and wind power).

– Issued its first Green Bond under the Kazakhstan Stock Exchange (KASE) in 2022.

These efforts demonstrate how Kazakhstani companies are proactively aligning with IFRS S2 standards.

Table 5 - Differences and interconnections between IFRS S1 and S2

Aspect	*IFRS S1*	*IFRS S2*
Scope	General sustainability-related disclosures	Climate-specific financial disclosures
Focus areas	Broad ESG risks and opportunities	Greenhouse gas emissions, climate risk
Reporting framework	Aligns with IFRS Accounting Standards	Aligns with Task Force on Climate-Related Financial Disclosures (TCFD)

4.4 The importance of ESG reporting in Kazakhstan

Kazakhstan's economy relies heavily on natural resources, making ESG a critical factor in long-term economic sustainability. With global investors prioritizing sustainability-linked investments, non-compliance with ESG standards could limit capital access for Kazakhstani firms.

Table 6 - Investor ESG priorities

Investor ESG priorities (2023)	*% of investors*
Companies with strong ESG disclosure	78%
Companies with weak ESG disclosure	22%

The AIFC Green Finance Centre has launched several initiatives to promote green bonds, sustainable finance, and ESG reporting. In 2023, the AIFC issued over $500 million in green bonds, signaling a strong commitment to sustainable investment.

Industry-specific ESG challenges and opportunities

– Energy sector: Oil and gas companies face high pressure to reduce carbon emissions.
– Banking sector: Financial institutions are required to implement mandatory ESG reporting by 2024.
– Mining industry: Companies are expected to adopt responsible sourcing and environmental risk mitigation strategies.

4.5 Kazakhstan's adoption of IFRS S1, S2

Kazakhstan has taken major steps toward aligning its corporate reporting frameworks with IFRS S1. The Astana International Financial Centre (AIFC) has developed a regulatory roadmap for Kazakhstani companies to gradually transition to IFRS S1 standards.

According to PwC Kazakhstan's 2023 ESG Survey, 62% of large Kazakhstani companies have already started implementing IFRS-aligned sustainability disclosures.

Table 7 - IFRS S1 Adoption rate according to the company's size

Company size	*IFRS S1 Adoption rate (2023)*
Large corporations	62%
Medium enterprises	23%
Small businesses	15%

Despite progress, many small and medium-sized enterprises (SMEs) still struggle with data collection, reporting infrastructure, and compliance costs.

Kazakhstan's position:
Kazakhstan is still in the early stages of IFRS S2 implementation. However, companies with international operations (such as KazMunayGas and Samruk-Kazyna) have already begun climate-risk disclosures under IFRS S2.

Table 8 - Kazakhstan companies reporting climate data

Kazakhstan companies reporting climate data (2023)	*% of companies*
Large corporations	55%
Medium enterprises	25%
Small businesses	10%

While large corporations have adopted IFRS S2 faster, smaller businesses need more support in understanding climate-related financial risks.

Table 9 – ESG readiness in Kazakhstan companies

ESG readiness in Kazakhstan firms (2023)	*% of Companies*
Fully prepared for ESG disclosure	35%
Partially prepared	45%
Not yet prepared	20%

Kazakhstan's adoption of IFRS S1 and S2 involves:
– Legislative frameworks mandating ESG disclosures.
– Collaboration with global organizations such as the ISSB and IFRS Foundation.
– Training programs for corporate leaders on ESG reporting compliance.

4.6. The impact of IFRS S1 and S2 on businesses in Kazakhstan
The implementation of IFRS S1 and S2 in Kazakhstan has a direct impact on corporate transparency, making companies more attractive to investors. Global financial institutions, such as the World Bank and International Finance Corporation (IFC), have stated that companies with strong ESG disclosures have 20% higher valuation multiples than those without clear sustainability reporting (IFC, 2023).

Case study 1: KAZ Minerals
Overview: KAZ Minerals, a prominent copper producer in Kazakhstan, has integrated Environmental, Social, and Governance (ESG) principles into its operations.
Key Initiatives:
- Installation of an automated quarry drainage system: The company has implemented an automated quarry drainage control system, which improves efficiency in water use and reduces environmental impact.
- Safety program – Living Goal Zero: KAZ Minerals has launched the Living Goal Zero program with the aim of creating a culture based on the principle of "safety first" and strives to completely eliminate injuries in its operations.
- High vigilance of heavy equipment operators: Measurements were taken at the enterprise to increase operator vigilance, which reduced the risk of accidents involving heavy equipment.
Impact: These initiatives have led to improved operating efficiency, enhanced safety performance, and reduced environmental impact in line with global ESG standards.

Case study 2: Karachaganak Petroleum Operating B.V. (KPO)
Overview: KPO explores one of the largest oil and gas condensate fields in Kazakhstan and has been acknowledged for its ESG disclosure practices.

Achievements:
– Top 10 leaders in ESG disclosure: Since 2019, KPO has been ranked among the top 10 non-financial companies in terms of ESG disclosure in a rating presented by PwC Kazakhstan. In December 2023, KPO was recognized as one of the leaders in nominations as: “50 Best Companies in Kazakhstan” rating for ESG disclosure, compiled by PwC Kazakhstan based on performance reports for 2022.
– Best practice awards: Company wins awards for “Best practices in ESG disclosure” and “Best practices in environmental disclosure.”
Impact: This commitment to transparent ESG reporting has strengthened KPO's reputation and demonstrated its commitment to sustainable development in Kazakhstan.

Case study 3: Eurasian Development Bank (EDB)
Overview: The Eurasian Development Bank has integrated ESG principles into its activities, emphasizing environmental and social responsibility.
Key Initiatives:
– Environmental and social responsibility framework: In 2012, EDB adopted a framework aimed at reducing the negative environmental impact of its financed projects.
– Renewable energy investments: Between 2017 and 2020, the bank financed renewable energy projects with a total installed capacity of approximately 500 MW, worth more than US$540 million.
– Emission of green bonds: In September 2021, EDB emitted green bonds on the Kazakhstan Stock Exchange to provide financing for environmentally friendly projects.
Impact: EDB's initiatives have supported the development of sustainable infrastructure in Kazakhstan and the broader Eurasian region, promoting environmental stewardship and social well-being.

Case Study 4: KazMunayGas and ESG integration
Overview: Kazakhstan’s largest oil and gas company, KazMunayGas (KMG), has strengthened its ESG reporting by integrating IFRS S1 and S2 into its sustainability strategy.
Key Initiatives:
– Reduced Scope 1 and Scope 2 greenhouse gas emissions by 12%.
– Increased renewable energy investment by $100 million.
– Improved ESG disclosure ratings from "B" to "A-" according to MSCI ESG Ratings.
These improvements resulted in greater investor confidence, with KMG’s bond yield decreasing by 1.5%, lowering financing costs.

4.7. Challenges and barriers to IFRS S1 and S2 implementation

While Kazakhstan has made ESG disclosure mandatory for financial institutions, enforcement mechanisms remain unclear. Many companies are still awaiting specific legal guidelines for IFRS S1 and S2 compliance.

Table 10 – Challenges in implementation of IFRS S1 and S2 standards in Kazakhstan

Challenge	*Impact on ESG reporting*	*% of Kazakhstan firms affected*
Lack of ESG reporting expertise	Inconsistent sustainability reports	45%
Data collection issues	Poor quality of ESG metrics	60%
High compliance costs	Difficulty for SMEs to comply	50%

The main barriers is the lack of qualified specialists with experience in sustainability reporting and climate risk assessment.

In addition, there is the problem of limited access to reliable ESG data, which is particularly relevant for small and medium-sized enterprises, which often lack the infrastructure to properly collect and analyze relevant data. The financial costs related to implementation also pose a serious problem—many companies need to invest in staff training, software, and external consulting services. In addition, uncertainty in the regulatory framework creates risks in the interpretation and application of standards. In the absence of clear guidance from the authorities, it is difficult for companies to prioritize the steps involved in transitioning to the new standards. These obstacles collectively slow down the implementation of IFRS S1 and S2 and require a systematic approach from the government and active support from the professional community.

4.8. Future prospects and recommendations

Despite initial difficulties, IFRS S1 and S2 have long-term benefits for Kazakhstan:

- Improve corporate accountability through standardized ESG reporting.
- Enhance Kazakhstan's position as a leader in green finance and responsible investment.
- Attract global investors seeking sustainability-focused companies.

Policy recommendations for Kazakhstan - to ensure a smooth transition to IFRS S1 and S2, policymakers should:

1. Develop clear ESG regulations: Establish mandatory compliance frameworks for all listed companies.
2. Offer financial incentives: Provide tax benefits to companies investing in ESG compliance.
3. Enhance ESG education programs: Train corporate leaders on IFRS S1 and S2 standards.
4. Strengthen data collection infrastructure: Create government-supported ESG data centers for businesses.
5. Encourage SME participation: Develop cost-effective ESG compliance models for small businesses.

With the adoption of IFRS S1/S2 in Kazakhstan, sustainability reporting become not only a regulatory requirement, but also a strategic necessity for long-term profit seeking companies. The transformations are fraught with certain difficulties, but with implementation of proactive planning, government support systems and corporate commitment, Kazakhstan can achieve a leading position at a regianal level in sustainable business practices.

5. Conclusion

Kazakhstan;s adoption of IFRS S1/S2 marks a new era in corporate sustainability reporting. Sespite initial implemintation challenges, these standards can:

- Improve corporate transparency and investors confidence.
- Help businesses mitigate ESG risks and to optimize financial performance.
- Position Kazakhstan as a leading country in sustainable business practices.

As ESG reporting becomes a Global requirement, companies in Kazakhstan must proactively adopt these standards to remain competititve policy measures in international markets. Despite ongoing challenges, strategic policy measures and corporate commitment can ensure a smooth transition to the future business sustainable development.

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Redefining ERP with AI in organizations: Toward a Greener and Smarter Future

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ABSTRACT

The relatively rapid technological progress of the last period, as well as the concerns of organizations to develop as sustainable as possible, have led to the evolution of ERP systems towards artificial intelligence and sustainability. Even though traditional ERP systems offered efficiency in terms of integrating all organizational processes, they were considered by practitioners as underdeveloped from the perspective of sustainability and data-driven sustainable decision-making. The article aims to explore how the integration of artificial intelligence (AI) in ERP systems can redefine organizational management practices and contribute to building greener and smarter organizational ecosystems.

The research in this paper focuses on a quantitative study based on a semi-structured questionnaire distributed to participants from various industries that use ERP systems within their organization, focusing mainly on assessing the impact of ERP systems on the processes within the organization and what is the perception of the respondents regarding the integration of AI within ERP systems to facilitate their efficiency in reporting performance and ensuring an eco-friendly environment.

The case study proposed in this paper highlights the importance of redefining the functions of ERP systems by integrating artificial intelligence so that organizations can become green and smart businesses and can subsequently gain a number of benefits. Thus, this study provides vital information about ERP and AI systems to both academia and business by presenting the essential aspects that any organization should consider with regard to adapting to the continuous evolution of technology.

KEYWORDS: ERP systems, artificial intelligence, sustainability, technological progress, digital transformation, redefinition

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INTRODUCTION

The profound digital transformations of recent decades have caused organizations to witness numerous changes in terms of resource management, operational processes, and strategies for adapting to the ever-changing business environment. These changes have also been made by ERP systems, which have evolved from simple accounting tools used to record accounting documents and visualize inventories, thus reaching integrated platforms that have the role of supporting complex multidimensional processes as a result of the numerous modules integrated by these systems.

Recent pressures from business and government regarding digitalization and sustainability, as well as the need to make decisions quickly, have led to the redefinition of the functions of traditional ERP systems through the use of artificial intelligence (AI), so that organizations become intelligent and sustainable businesses.

The functions that traditional ERP systems had were quite static in the past, so the analytical capacity was limited. New functions introduced into ERP systems through AI integration allow for dynamic adaptive functionalities, capable of learning from historical data, predicting behaviors and optimizing processes automatically, allowing organizations to make the right decisions much faster.

Sustainability is defined in the specialized literature as *"the ability of an organization to carry out its economic activity without compromising the needs of future generations"* (Dobhan and Zitzmann, 2022). Thus, regulatory organizations and the government have required organizations to reduce their carbon footprint, reduce inefficient consumption of resources, adopt practices that are as environmentally and socially responsible as possible, and reduce as much as possible the negative effects of the organization's activities.

Redefining traditional ERP systems using AI can directly contribute to achieving ESG (Environmental, Social, Governance) objectives by providing advanced tools for measuring, reporting and improving non-financial performance.

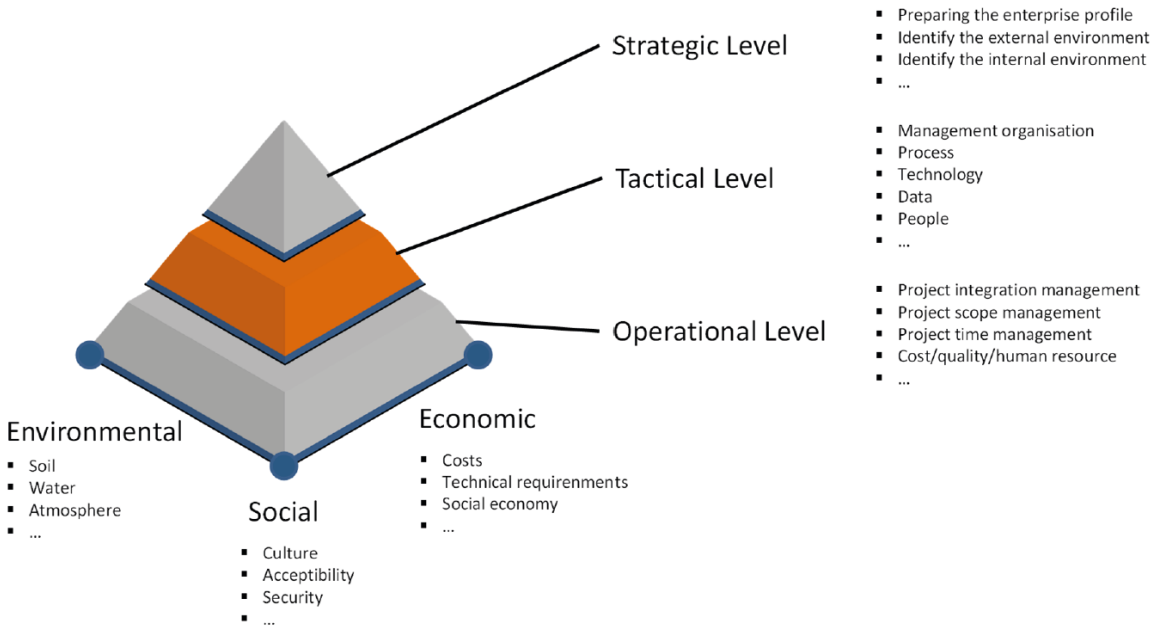
Analyzing the specialized literature, we can state that very few works explore the intersection of the 3 topics AI, ERP systems and sustainability, this article proposing to develop this topic much more through the quantitative research carried out at the level of this article, as well as how AI can support the transition to sustainable business models. The statistical analysis addressed in this article provides a clear picture of the impact of AI on ERP systems, tracking how simple ERP systems can become true strategic partners for a green and digital future.

This article is structured as follows: the review of the specialized literature that defines the key concepts of the paper, a section that defines the research methodology used at the article level, a section that analyzes the results obtained through the proposed research and the article concluding with the presentation of the main conclusions and limitations of the article as a result of the research conducted.

LITERATURE REVIEW

Integrated ERP systems have evolved a lot compared to the previous period, integrating a series of functions necessary for organizations. Dobhan and Zitzmann (2022) define sustainable ERP systems as *"as a holistic solution to support sustainability initiatives"*. These systems improve production efficiency, minimize energy consumption and reduce carbon emissions (figure 1).

Figure 1. *S-ERP systems implementation framework*



Source: Dobhan and Zitzmann (2022)

Integrating AI into ERP systems optimizes resource utilization by mitigating the risks associated with data manipulation and fragmented workflows (Egbuhuzor et al., 2022). Thus, artificial intelligence (AI) has opened up opportunities for process automation, predictive analytics, and informed decision-making (Forbes, 2024). Faster data analysis using AI has led to optimized resource allocation, anticipating market demand.

In addition to the opportunities offered by ERP systems to improve operational efficiency, these functionalities allow achieving sustainability goals. According to Dumitru et al. (2023), ERP systems that incorporate AI allow organizations to monitor and report sustainability performance indicators, facilitating regulatory compliance and promoting transparency, while also tracking energy consumption, carbon emissions and waste management, providing relevant data for strategic sustainability decision-making.

Laulita et al. (2022), states that ERP systems *"integrate and automate business activities, eliminating traditional work barriers and promoting data exchange between users in various departments"*. AI introduces *"advanced features such as predictive analytics, process automation and real-time insights that can revolutionize business operations"* (Egbuhuzor et al., 2022).

The impact of AI in ERP systems on organizational sustainability allows them to more easily monitor and report sustainability performance indicators (example: tracking energy consumption, carbon emissions, and waste management that could be harmful to the environment), thus facilitating regulatory compliance and promoting transparency.

The integration of modules such as SIRAI (Sustainable Integration of RPA and AI) could also improve operational efficiency, ensuring responsible and sustainable decision-making. This SIRAI model allows for *"assessing technological need, assessing organizational readiness, customizing evaluation metrics, and providing practical recommendations for optimizing technology use"* (Patricio et al, 2024).

Table 1 presents decision-making analytics in ERP systems:

Report Type	Data Source	Key Insights Generated	IT integration
Sales performance	CRM, Order data	Trends in sales, customer behaviour	ERP (Sales and CRM modules)
Inventory levels	Inventory data	Stocks levels, demand forecasting	ERP (Inventory module)
Financial health	Financial data	Profit margins, cash flow trends	ERP (Finance module)

Table 1. *Decision-making analytics in ERP systems*

Source: Kambala, 2024, p. 431

The types of analytics applied by organizations are presented in Table 2:

Analytics Type	Application	Business Outcome
Real-time analytics	Operational monitoring	Faster decision-making
Predictive analytics	Demand forecasting	Optimized resource allocation
Prescriptive analytics	Strategic planning	Enhanced long-term planning

Table 2. *Type of analytics applied by organizations*

Source: Kambala, 2024, p. 431

AI allows for the responsible use of the organization's resources and the adoption of more sustainable decisions (Nikitas et al., 2020; Omar et al., 2024).

According to Shaik (2023), using ERP systems together with AI allows:

- reducing energy consumption and costs
- improving energy efficiency and sustainability
- real-time insights into energy usage patterns
- data-driven decision-making for energy optimization

Even though digital transformation brings numerous benefits to the organization, special attention should be paid to the technical and procedural vulnerabilities to which data could be subjected, ensuring advanced cybersecurity (Kunduru, 2023).

METHODOLOGY

The research in this article aims to analyze the perception of employees, managers, and students regarding the use of AI in ERP systems to redefine management practices so that organizations become sustainable and make the best and smartest decisions. This was possible by conducting a quantitative study based on a semi-structured questionnaire distributed between April 28, 2025 – May 25, 2025 on various social networking platforms (Facebook, LinkedIn, etc.) to participants from various industries that use ERP systems within the organization, focusing mainly on assessing the impact of ERP systems on the processes within the organization and what is the perception of the respondents regarding the integration of AI within ERP systems to facilitate their efficiency in reporting performance and ensuring an eco-friendly environment.

The final sample size was 90 respondents distributed as follows according to Table 3 and 4:

Age & Gender	Inside Romania	Inside Europe	Outside Europe	TOTAL
20 - 30	65	1	0	**66**
Male	17	0	0	17
Female	48	1	0	49
31 - 40	7	2	0	**9**
Male	4	1	0	5
Female	3	1	0	4
41 - 50	6	4	1	**11**
Male	2	0	1	3
Female	4	4	0	8
51 - 60	1	1	2	**4**
Male	0	1	1	2
Female	1	0	1	2
TOTAL	**79**	**8**	**3**	**90**

Table 3. *Respondents distributed by age, gender and residence*

Source: Author's contribution, 2025

Work area	Role in organization												TOTAL
	Employee	COO	CFO	CTO	CEO	CMO	Deputy Director	Research Engineer	Entrepreneur	Manager	Auditor	Students	
Financial Banking	1	0	0	0	0	0	0	0	0	0	0	0	1
Human resources	1	0	0	0	0	0	0	0	0	0	0	1	2
Audit intern	1	0	0	0	0	0	0	0	0	0	0	0	1
Transport	0	1	0	0	0	0	0	0	0	0	0	0	1
Consultancy	1	0	0	0	0	0	0	1	0	0	0	2	4
Financial - accounting	21	0	0	0	1	0	0	0	0	0	1	20	43
Certified auditor.	1	0	0	0	0	0	0	0	0	0	0	0	1
IT	3	0	2	1	1	0	0	0	0	0	0	1	8
Marketing	2	0	0	0	0	1	0	0	0	0	0	3	6
Master	0	0	0	0	0	0	0	0	0	0	0	1	1
Services	0	0	1	0	1	0	0	0	0	0	0	0	2
Education	6	0	0	0	0	0	1	0	0	0	0	6	13
Financiar - IT	1	0	0	0	0	0	0	0	0	0	0	0	1
Psychology	0	0	0	0	0	0	0	0	1	0	0	1	2
Financial Audit	0	0	0	0	0	0	0	0	0	1	0	0	1
Production	1	0	0	1	0	0	0	0	0	0	0	0	2
Retail / Retail	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	40	1	3	2	3	1	1	1	1	1	1	35	90

Table 4. *Respondents distributed by work area and role in organization*

Source: Author's contribution, 2025

According to the 2 tables, most respondents are between 20 and 30 years old, 44% of them being employed and 39% of them being students in the financial accounting field.

The data collected using the questionnaire were processed with Excel and SPSS, going through a series of preliminary stages:

- data completeness check;
- coding variables and converting text responses into numerical values;
- calculating descriptive statistics (means, standard deviations) for each variable;
- verifying the correlations between the variables of the multiple linear regression model proposed by the author and testing the proposed hypotheses.

The hypothesis proposed for analysis was: *"The use of AI in ERP systems is positively associated with the perception of an increased impact on sustainability"*, and the data used came from the following questions:

Q_1: Have you implemented AI functionalities in the ERP you use? (0 - No, 1 - Partially, 2 - Yes)

Q_2: Do you think AI has improved decision-making in the company? (1 - Not at all, 5 - Very much)

Q_3: Do you think AI can help achieve ESG (Environmental, Social, Governance) goals? (1 - Not at all, 5 - Very much)

Q_4: Are you interested in expanding AI functionalities in ERP systems? (0 – No, 1 – Yes)

The proposed hypothesis was tested on the following regression model:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

where:

y = perception on ERP sustainability with AI (SUSTAIN)
X_1 = the degree of integration of AI into ERP systems (GRAD)
X_2 = perception regarding the improvement of the decision-making process (PROC)
X_3 = intention to expand the use of AI in the future (EXTEND)

In the next section, the proposed regression model will be analyzed by testing the hypothesis.

ANALYSIS/RESULTS INTERPRETATION

The model proposed in the previous section tests the influence of three key variables (GRAD, PROC and EXTEND) on the dependent variable (SUSTAIN) in order to observe how sustainability is perceived and as a result of the use of ERP systems with AI.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,445[a]	,198	,170	,451	,198	7,065	3	86	,000

a. Predictors: (Constant), EXTEND, GRAD, PROC

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4,308	3	1,436	7,065	,000[a]
	Residual	17,481	86	,203		
	Total	21,789	89			

a. Predictors: (Constant), EXTEND, GRAD, PROC

b. Dependent Variable: SUSTAIN

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-,043	,179		-,238	,812	-,399	,314					
	GRAD	,093	,053	,179	1,759	,082	-,012	,199	,290	,186	,170	,899	1,112
	PROC	,075	,052	,158	1,431	,156	-,029	,179	,316	,153	,138	,763	1,310
	EXTEND	,175	,080	,250	2,201	,030	,017	,334	,383	,231	,213	,720	1,389

a. Dependent Variable: SUSTAIN

Table 5. *ANOVA analysis*

Source: Author's contribution, 2025

According to table 5 from the ANOVA analysis, we can interpret the results obtained as follows:

Model Summary

- R = 0,445 => there is a moderate relationship between the predictor and the dependent variable
- R^2 = 0,198 => the proposed model explains only 19.80% of the total variation of the dependent variable
- Adjusted R Square = 0,170 => 17% of the variation can be explained by the model, indicating a moderate effect
- Std. Error of the Estimate = 0,451 => relatively small value indicating that the model's predictions are accurate.
- F change = 7,065 => the proposed model is significant
- Sig. F Change = 0,000 => because p<0.001 the proposed model is statistically significant

ANOVA

- Sum of Squares (Regression) = 4,308 => variability explained by the model
- Sum of Squares (Residuals) = 17,481 => unexplained variability

Coefficients

- The term EXTEND has the strongest influence because the intention to extend AI into ERP systems clearly increases the perception of sustainability
- The term GRAD has a positive effect, but not significant due to p<0.05, being considered only marginal (p=0.082)
- The term PROC has a positive, but insignificant, contribution (p=0.156)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
GRAD	90	0	2	,92	,951
PROC	90	1	5	3,74	1,045
SUSTAIN	90	0	1	,59	,495
EXTEND	90	0	2	1,51	,707
Valid N (listwise)	90				

Table 6. *Descriptive Statistics*

Source: Author's contribution, 2025

According to Table 6, the degree of sustainability is perceived relatively low (mean wave 0.59). The degree of AI integration in ERP systems is quite low (mean = 0.92). The perception of improving the decision-making process is significantly high on a scale from 1-5 (mean = 3.74), and the intention to expand AI in ERP systems is considered moderate on a scale from 1-5 (mean = 1.51).

Correlations

		SUSTAIN	GRAD	PROC	EXTEND
SUSTAIN	Pearson Correlation	1	,290**	,316**	,383**
	Sig. (2-tailed)		,006	,002	,000
	N	90	90	90	90
GRAD	Pearson Correlation	,290**	1	,206	,311**
	Sig. (2-tailed)	,006		,051	,003
	N	90	90	90	90
PROC	Pearson Correlation	,316**	,206	1	,483**
	Sig. (2-tailed)	,002	,051		,000
	N	90	90	90	90
EXTEND	Pearson Correlation	,383**	,311**	,483**	1
	Sig. (2-tailed)	,000	,003	,000	
	N	90	90	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7. *Pearson correlations between dependent variable and independent variables*

Source: Author's contribution, 2025

According to Table 7, we can interpret the correlations as follows:

- *SUSTAIN variable*

Variable	Correlation with SUSTAIN	Meaning	Interpretation
GRAD	0.290	p = 0.003	Positive correlation, weak to moderately significant. As the degree of AI integration increases, so does the perception of sustainability.

Variable	Correlation with SUSTAIN	Meaning	Interpretation
PROC	0.316	p = 0.001	Moderate positive correlation. The use of AI in processes is associated with the perception of better sustainability.
EXTEND	0.383	p < 0.001	Strongest correlation with SUSTAIN. AI expansion intention has a clear link to perceived sustainability.

Table 8. *Interpreting the correlation between the SUSTAIN variable and the predictor variables*
Source: Author's contribution, 2025

- *Between predictor variables*

Variables in correlation	Correlation	Meaning	Interpretation
GRAD - PROC	0.206	p = 0.026	**Type of correlation:** *Weak but significant connection* The level of AI and the use of AI in processes are connected.
GRAD - EXTEND	0.311	p = 0.001	**Type of correlation:** *Moderate connection* The higher the degree of integration an organization has, the more likely it is to plan to expand AI.
PROC - EXTEND	0.483	p = 0.000	**Type of correlation:** *The strongest connection* Organizations that use AI in processes are also those that want to expand it.

Table 9. *Interpreting the correlation between the predictor variables*
Source: Author's contribution, 2025

Since none of the correlations exceeds the threshold of 0.8 to suggest collinearity, the regression model can be considered robust. The term EXTEND having the strongest correlation thus confirms the essential role in redefining ERP systems in a greener and smarter direction.

The regression model proposed by the authors confirmed the hypothesis of the case study, that AI-related elements directly influence the perception of sustainability in an ERP system. The intention to extend AI (EXTEND) being the strongest predictor, reinforces an organization's proactive

orientation towards AI, thus becoming the key to a greener and smarter future for organizations and the environment.

CONCLUSIONS

Integrating the concept of AI into ERP systems represents a vital step for the organization's digital transformation, allowing them to more easily perform analyses and make decisions. In the case study proposed by the authors, three key concepts were used, namely the degree of integration of AI in ERP systems, the perception of improving the decision-making process, the intention to expand the use of AI in the future in order to track the perception of the sustainability of ERP using AI. The results obtained by the authors confirm that redefining ERP systems with the help of AI can significantly contribute to achieving the organization's sustainability goals.

The most relevant component in the regression model showed that the intention to expand the use of AI (EXTEND) had a significant impact, indicating that the integration or use of AI in certain processes is not significant, and the existence of a long-term vision, including concrete plans for expansion and continuous development, is essential. Organizations that include AI in their business strategy show an inclination to develop sustainable practices, both ecologically and economically.

The case study proposed by the authors has multiple implications, providing managers and strategic decision-makers with a much clearer understanding of how ERP and AI systems can contribute to achieving sustainability goals, improving operational efficiency, reducing resource consumption, optimizing the supply chain, and reducing waste. The current case study can be developed by including new analysis variables such as: organizational culture, level of digitalization or degree of employee preparation for digital transformation.

At the same time, the research highlights the fact that integrating AI into ERP systems should not be viewed as a technological opportunity, but as a responsibility of modern organizations.

The main limitations of the article could be the small sample size (only 90 respondents) and the fact that the study focused on perceptions without correlating the results with quantitative performance or sustainability indicators.

Redefining ERP systems by integrating AI represents not only an opportunity for innovation, but also a strategic path towards a more sustainable and intelligent future, and organizations that understand their potential have a great chance of becoming leaders in the digital age, contributing to social well-being and environmental protection.

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