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Gintarė PAULIUKEVIČIENĖ

SUSTAINABLE DEVELOPMENT OF THE FINTECH INDUSTRY

DOCTORAL DISSERTATION

SOCIAL SCIENCES
ECONOMICS (S 004)

Vilnius, 2025

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Gintarė PAULIUKEVIČIENĖ

FINANSŲ TECHNOLOGIJŲ SEKTORIAUS TVARIOJI PLĖTRA

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Abstract

The development of the FinTech industry plays a crucial role in facilitating financial inclusion and achieving a substantial proportion of the Sustainable Development Goals, thereby making a significant contribution to sustainable economic development. It is essential to acknowledge that sustainable economic growth relies on the sustainable advancement of all economic sectors and industries, including FinTech. To significantly enhance global financial inclusion and sustainable economic development, it is imperative to establish the sustainable growth of the FinTech industry, which is currently undefined. The challenge of evaluating the sustainability of the FinTech industry development at the national level remains unaddressed.

The fundamental issue addressed in the dissertation pertains to the ambiguity surrounding the sustainable development of the FinTech industry, as well as the notable deficiency of evaluations regarding its sustainability in academic literature and practical applications. The dissertation aims to delineate the sustainable development of the FinTech industry at the state level and propose a methodology for assessing its sustainability, thereby identifying areas for enhancement and ensuring the continuous growth of sustainable development within the FinTech sector. By accomplishing these objectives, the dissertation seeks to enhance digital financial inclusion and promote sustainable economic development.

The dissertation comprises an introduction, three chapters, and general conclusions. The First Chapter seeks to elucidate and define sustainable development within the FinTech industry by presenting an overview of the industry and analysing its growth, examining the environmental context of FinTech and the factors propelling its expansion, exploring the connections between the FinTech environment and sustainable development, including the Sustainable Development Goals (SDGs), and reviewing assessment methodologies for sustainable development in the academic literature. The Second Chapter outlines the methodology for evaluating the sustainable development of the FinTech industry, explains the specific methods employed, and presents the data and sources used for the empirical analysis. The Third Chapter presents the findings from the empirical validation of the methodology used to assess the sustainable development of the FinTech industry across 15 selected European nations. The dissertation finishes with a series of general conclusions.

Three publications have been released in peer-reviewed scientific journals, and two publications have been presented in conference proceedings on the subject of the research.

Reziumė

Finansų technologijų sektoriaus plėtra užtikrina finansinę įtrauktį ir įgalina pasiekti didelę dalį darnaus vystymosi tikslų, tokiu būdu reikšmingai prisidėdama prie darnaus (tvariojo) ekonomikos vystymosi, tačiau darnus (tvarusis) ekonomikos vystymasis nėra galimas be darnios (tvariosios) visų ekonomikos sektorių (tarp jų ir finansų technologijų) plėtros. Todėl siekiant reikšmingai prisidėti prie pasaulinio masto finansinės įtraukties didinimo ir darnaus ekonomikos vystymosi, visų pirma reikia užtikrinti finansų technologijų sektoriaus tvariąją plėtrą, kuri iki šiol nėra apibrėžta – nėra aišku nei kaip ją įvertinti, nei kaip pamatuoti.

Disertacijoje nagrinėjama pagrindinė problema – finansų technologijų sektoriaus tvariosios plėtros neapibrėžtumas ir jos vertinimo nebuvimas tiek mokslinėje literatūroje, tiek praktikoje. Disertacijos tikslas – apibrėžti finansų technologijų sektoriaus tvariąją plėtrą valstybės lygmeniu ir pasiūlyti jos vertinimo metodologiją, siekiant įvertinti finansų technologijų sektoriaus plėtros tvarumą, identifikuoti bei sekti tobulintinas sritis ir užtikrinti tvariosios finansų technologijų sektoriaus plėtros augimą, taip prisidedant prie skaitmeninės finansinės įtraukties augimo ir darnaus ekonomikos vystymosi.

Disertaciją sudaro įvadas, trys skyriai ir bendrosios išvados. Pirmame skyriuje siekiama išgryninti ir pasiūlyti tvariosios finansų technologijų sektoriaus plėtros apibrėžimą, atliekant finansų technologijų sektoriaus apžvalgą bei jo augimo analizę, finansų technologijų sektoriaus aplinkos apžvalgą ir augimo veiksnių analizę, išanalizuojant sąsajas tarp finansų technologijų sektoriaus aplinkos ir darnaus vystymosi bei darnaus vystymosi tikslų, atliekant tvariosios plėtros vertinimo metodų analizę mokslinėje literatūroje ir tokiu būdu teoriškai pagrindžiant tvariosios finansų technologijų sektoriaus plėtros vertinimo koncepcijos kūrimą. Antrame skyriuje pristatoma tvariosios finansų technologijų sektoriaus plėtros vertinimo metodologija ir aprašomi pavieniai jos metodai. Taip pat pristatomi empiriniam tyrimui naudotini duomenys ir šaltiniai. Trečiame skyriuje pateikiami finansų technologijų sektoriaus tvariosios plėtros metodologijos pritaikomumo empirinio patvirtinimo pasirinktų 15 Europos valstybių lygmeniu rezultatai. Disertacija užbaigiama bendrosiomis išvadomis.

Aptariamo tyrimo tema paskelbtos publikacijos: 3 – recenzuojamuose mokslo žurnaluose, 2 – konferencijų straipsnių rinkiniuose.

Notations

Abbreviations

AI – artificial intelligence (liet. *dirbtinis intelektas*);

BCBS – the Basel Committee on Banking Supervision (liet. *Bazelio bankų priežiūros komitetas*);

EU – European Union (liet. *Europos Sąjunga*);

EUR – euro (liet. *euras*);

fDi – foreign direct investment (liet. *tiesioginės užsienio investicijos*);

FinTech – financial technology (liet. *finansų technologijos*);

FSB – Financial Stability Board (liet. *Finansinio stabilumo taryba*);

FT4SD – FinTech for Sustainable Development (liet. *finansų technologijos darniam vystymuisi*);

GDP – gross domestic product (liet. *bendrasis vidaus produktas*);

G7 – the Group of Seven (liet. *Didysis septynetas*);

IMF – International Monetary Fund (liet. *Tarptautinis valiutos fondas*);

IoT – the Internet of Things (liet. *daiktų internetas*);

Kendall's W – Kendall's Coefficient of Concordance (liet. *Kendalio konkordacijos koeficientas*);

MMQR – Method of Moments Quantile Regression (liet. *kvantilių regresija pagal momentų metodą*);

OECD – the Organization for Economic Cooperation and Development (liet. *Ekonominio bendradarbiavimo ir plėtros organizacija*);

PCA Index – Principal Component Analysis Index (liet. *Pagrindinių komponenčių analizės indeksas*);

PEST analysis – analysis of external political, economic, social and technological factors (liet. *išorinių politinių, ekonominių, socialinių ir technologinių veiksnių analizė*);

PISA – Programme for International Student Assessment (liet. *Tarptautinė mokinių vertinimo programa*);

R&D – research and development (liet. *moksliniai tyrimai ir eksperimentinė veikla (plėtra)*);

SAW method – Simple Additive Weighting Method (liet. *paprastasis adityvus svorių metodas*);

SDG 1 – Sustainable Development Goal 1 "No Poverty" (liet. *darnaus vystymosi tikslas Nr. 1 „Sumažinti skurdą"*);

SDG 2 – Sustainable Development Goal 2 "Zero Hunger" (liet. *darnaus vystymosi tikslas Nr. 2 „Sumažinti badą"*);

SDG 3 – Sustainable Development Goal 3 "Good Health and Well-Being" (liet. *darnaus vystymosi tikslas Nr. 3 „Gera sveikata ir gerovė"*);

SDG 4 – Sustainable Development Goal 4 "Quality Education" (liet. *darnaus vystymosi tikslas Nr. 4 „Kokybiškas išsilavinimas"*); "SDG 5 – Sustainable Development Goal 5 "Gender Equality" (liet. *darnaus vystymosi tikslas Nr. 5 „Lyčių lygybė"*);

SDG 6 – Sustainable Development Goal 6 "Clean Water and Sanitation" (liet. *darnaus vystymosi tikslas Nr. 6 „Švarus vanduo ir higiena"*);

SDG 7 – Sustainable Development Goal 7 "Affordable and Clean Energy" (liet. *darnaus vystymosi tikslas Nr. 7 „Prieinama ir švari energija"*);

SDG 8 – Sustainable Development Goal 8 "Decent Work and Economic Growth" (liet. *darnaus vystymosi tikslas Nr. 8 „Deramas darbas ir ekonominis augimas"*);

SDG 9 – Sustainable Development Goal 9 "Industry, Innovation and Infrastructure" (liet. *darnaus vystymosi tikslas Nr. 9 „Pramonė, inovacijos ir infrastruktūra"*);

SDG 10 – Sustainable Development Goal 10 "Reduced Inequalities" (liet. *darnaus vystymosi tikslas Nr. 10 „Sumažinti nelygybę"*);

SDG 11 – Sustainable Development Goal 11 "Sustainable Cities and Communities" (liet. *darnaus vystymosi tikslas Nr. 11 „Darnūs miestai ir bendruomenės"*);

SDG 12 – Sustainable Development Goal 12 "Responsible Consumption and Production" (liet. *darnaus vystymosi tikslas Nr. 12 „Atsakingas vartojimas ir gamyba"*);

SDG 13 – Sustainable Development Goal 13 "Climate Action" (liet. *darnaus vystymosi tikslas Nr. 13 „Sušvelninti klimato kaitos poveikį"*);

SDG 14 – Sustainable Development Goal 14 "Life below Water" (liet. *darnaus vystymosi tikslas Nr. 14 „Gyvybė vandenyse"*);

SDG 15 – Sustainable Development Goal 15 "Life on Land" (liet. *darnaus vystymosi tikslas Nr. 15 „Gyvybė žemėje"*);

SDG 16 – Sustainable Development Goal 16 "Peace, Justice and Strong Institutions" (liet. *darnaus vystymosi tikslas Nr. 16 „Taika ir teisingumas, stiprios institucijos"*);

SDG 17 – Sustainable Development Goal 17 "Partnerships for the Goals" (liet. *darnaus vystymosi tikslas Nr. 17 „Partnerystė įgyvendinant tikslus"*);

SDGs – Sustainable Development Goals (liet. *darnaus vystymosi tikslai*);

SE – standard error (liet. *standartinė paklaida*);

UN – United Nations (liet. *Jungtinių Tautų Organizacija*);

UNDP – the United Nations Development Programme (liet. *Jungtinių Tautų vystymo programa*);

UNCDF – United Nations Capital Development Fund (liet. *Jungtinių Tautų kapitalo plėtros fondas*);

USD – United States dollar (liet. *Jungtinių Amerikos Valstijų doleris*);

WCED – World Commission on Environment and Development (liet. *Pasaulinė aplinkos ir vystymosi komisija*);

WoS – Web of Science.

Definitions

Digital financial inclusion – the use of digital financial services to advance financial inclusion (World Bank, 2025) (liet. *Skaitmeninė finansinė įtrauktis – finansinei įtraukčiai didinti skirtų skaitmeninių finansinių paslaugų teikimas)*.

External environment – the conditions and events outside the business industry that affect the way it operates (Combley, 2011) (liet. *Išorinė aplinka – už verslo sektoriaus ribų esančios sąlygos ir įvykiai, darantys įtaką jo veiklai*).

Financial inclusion – the uptake and usage of a range of appropriate financial products and services by individuals and MSMEs (micro, small, and medium enterprises), provided in a manner that is accessible and safe to the consumer and sustainable to the provider (World Bank, 2025) (liet. *Finansinė įtrauktis – įvairių tinkamų finansinių produktų ir paslaugų, teikiamų vartotojui prieinamu ir saugiu, o paslaugų teikėjų – tvariu būdu, įsisavinimas ir naudojimas tarp fizinių asmenų ir MVĮ (labai mažų, mažų ir vidutinių įmonių)*).

FinTech (financial technology) – a broad term that encompasses the use of technology to innovate and transform various aspects of the financial industry; the advances in technology that have the potential to transform the provision of financial services, spurring the development of new business models, applications, processes, and products (World Bank, 2025) (liet. *Finansų technologijos – plati sąvoka, apimanti technologijų naudojimą naujovėms diegti ir įvairiems finansų pramonės aspektams keisti; technologijų pažanga, galinti pakeisti finansinių paslaugų teikimą, skatinanti naujų verslo modelių, taikomųjų programų, procesų ir produktų kūrimą*).

Sustainable development – the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Keeble, 1988) (liet. *Darnus vystymasis – vystymasis, kuris tenkina dabarties poreikius ir nepakenkia ateities kartų galimybėms patenkinti savo poreikius. Pasak Valstybinės lietuvių kalbos komisijos, skirtinguose kontekstuose šiuo anglų kalbos terminu įvardijamos nelygiavertės sąvokos, todėl siūlomi lietuviški šio termino atitikmenys:* ***darnus vystymas(is)***, ***tvarusis vystymas(is)***. *Rūšinis pažyminys* ***darnus*** *tinkamas tada, kai siekiama pabrėžti, kad vystymasis yra suderintas,* ***tvarusis*** *– kai kalbama apie patvarų, nenutrūkstamą vyksmą. Atsižvelgiant į kontekstą, angl. „sustainable development“ lietuviškai gali būti verčiama ir* ***darni plėtra***, ***tvarioji plėtra***. ***Plėtra*** *labiau tinka tais atvejais, kai kalbama apie kiekybinius pokyčius, plėtimą(si),* ***vystymasis*** *– kai norima įvardyti kokybinius pokyčius (Valstybinė lietuvių kalbos komisija, n. d.*). *Todėl disertacijos*

kontekste turima omenyje lietuvių kalbos sąvoka ***tvarioji plėtra****, kadangi siekiama nenutrūkstamo finansų technologijų sektoriaus plėtimosi*).

Sustainable Development Goals – 17 global goals set by the UN General Assembly in 2015 to be achieved by 2030; each SDG comprises a list of targets and indicators (UNDP, 2024) (*Darnaus vystymosi tikslai – 17 visuotinių tikslų, kuriuos 2015 m. Jungtinių Tautų Generalinė Asamblėja numatė pasiekti iki 2030 m.; kiekvieną tikslą sudaro uždavinių ir rodiklių sąrašas*).

Contents

Introduction

Problem Formulation

Over the past 150 years, finance has become one of the most globalised, digitalised, and regulated sectors (Arner et al., 2022), with digitalisation driving the rise of the financial technology (FinTech) industry. Since 2010, and especially after 2018, FinTech has experienced rapid growth, with global investment increasing from USD 51–74 billion (2014–2017) to USD 238.9 billion in 2021, marked by a record 7,321 deals (KPMG & CB Insights, 2016; KPMG, 2017–2023). Though FinTech reached 2% of global financial services revenue and was projected to reach 7% by 2030 (BCG & QED Investors, 2023), recent economic turbulence caused investment to drop to USD 95.6 billion and 4,639 deals in 2024 (KPMG, 2025), raising concerns about the industry's consistency and sustainability. FinTech's growth and its potential to advance the UN Sustainable Development Goals (SDGs) have drawn increasing scholarly interest (Hasan et al., 2024; Jie et al., 2024; Kishor et al., 2024; Noreen, 2024; Tidjani & Madouri, 2024; Choudhary et al., 2025; Guermazi, 2025). Despite its benefits, challenges such as regulatory gaps (Ozili, 2018) and inherent risks (Arner et al., 2022) remain. Ensuring FinTech's sustainable growth is therefore critical to advancing broader environmental, social, and economic goals (Purvis et al., 2019); a clear definition and methodology for assessing its sustainable development are still lacking. The

dissertation, therefore, seeks to address the issue of what theoretical and/or methodological approaches, considering the incoherence of the definition of the sustainable development of the FinTech industry, can be used to clarify the appropriateness of the methods of assessing the sustainable development of the FinTech industry, the assessment indicators, and the development of the methodology of assessment.

Relevance of the Dissertation

The relevance of this dissertation is grounded in the global push for financial and digital financial inclusion, and sustainable economic development – trends increasingly shaped by the rapid growth of the financial technology industry (Fratiloiu, 2022; Honecker & Chalmers, 2022; Young & Young, 2022; Yu et al., 2022; Ozili, 2022; Popescu, 2022; Senyo et al., 2022; Adjasi et al., 2023; Asif et al., 2023; Ediagbonya & Tioluwani, 2023; Esmaeilpour Moghadam & Karami, 2023; Faust et al., 2023). However, recent data show that FinTech's growth has been inconsistent and highly sensitive to external factors, revealing a lack of coherence in its development (KPMG, 2025). This underlines the urgent need for a clearly defined and sustainable FinTech development framework, especially in the context of ongoing global challenges. According to the World Bank (2025), as of 2021, only 76% of the worldwide population held a bank account, and just 10% of individuals aged 15 and above used mobile money, underscoring the continued importance of inclusive digital financial services. These services play a crucial role in reaching underserved populations affordably and sustainably. With the global effort toward achieving the SDGs now at a midpoint, yet increasingly off track, the FinTech sector's projected 7% growth by 2030, reaching an estimated USD 1.5 trillion or 25% of total global bank valuations (BCG & QED Investors, 2023), underscores the importance of assessing the sustainability of its expansion. This dissertation addresses this research gap through empirical research conducted in 2012–2023 across 15 European countries, using 45 indicators related to FinTech development, the external FinTech environment, and sustainable development.

Research Object

The object of the dissertation research is the sustainable development of the FinTech industry.

Aim of the Dissertation

The dissertation aims to define the sustainable development of the FinTech industry at the state level and to propose a methodology for its assessment.

Tasks of the Dissertation

To accomplish the aim of the dissertation, the subsequent tasks are delineated:

1. To examine the scientific literature regarding the sustainable development of the FinTech industry, ascertain the scientific problem within this context, and establish the theoretical foundation of the dissertation.
2. To propose a methodology and set of indicators for the quantitative assessment of the sustainable development of the FinTech industry at the national level.
3. To evaluate the relevance of the proposed methodology for the sustainable development of the FinTech industry via an empirical investigation in specific nations.

Research Methodology

The research methods utilised to execute the dissertation tasks included logical analysis, systematic analysis, comparative analysis, complex analysis, and modelling. The compiled data included scientific databases, official databases from international organisations, and the latest scientific literature. The empirical research employed the expert evaluation method, specifically a questionnaire survey, and the simple additive weighting (SAW) method for multi-criteria decision-making, alongside Spearman's and Kendall's correlation coefficients for statistical data analysis and the Method of Moments Quantile Regression. The research findings were analysed utilising VOSviewer, Microsoft Excel and R software.

Scientific Novelty of the Dissertation

During the development of this doctoral dissertation, the following notable findings for the field of economics were achieved:

1. The definition of the sustainable development of the FinTech industry was clarified. It was proposed that sustainable development of the FinTech industry be defined as *the coherent development of the industry*

in a favourable external environment, responding to today's society's digital financial inclusion needs without compromising the prospects for future prosperity.

2. A methodology is proposed for quantifying the sustainable development of the FinTech industry at a national level, incorporating FinTech, the external environment (PEST), the Sustainable Development Goals (SDGs), and energy consumption.
3. A set of indicators has been developed for the integrated assessment of the sustainable development of the FinTech industry, encompassing the following categories: FinTech indicators, indicators of the FinTech's political, economic, social, and technological environment, economic, social, and environmental sustainability indicators, and energy consumption indicators.

Practical Value of the Research Findings

The dissertation has practical value across three levels: government, business, and society. The proposed methodology and set of indicators for assessing the sustainable development of the FinTech industry at a national level:

1. Can be easily adapted by *national regulators* to assess the sustainable development of the FinTech industry in any country worldwide, as well as its strengths and weaknesses.
2. Can be of use to FinTech *companies*, as it provides a rational and objective assessment of the sustainability of FinTech development in a selected country when planning business development.
3. Can benefit the *public*, including FinTech customers and users, as the development of the FinTech industry promotes the digital financial inclusion of society.

The dissertation contributes to sustainable FinTech growth, digital financial inclusion, SDG progress, and global economic sustainability.

Defended Statements

The following statements, based on the results, may serve as the official hypotheses to be defended:

1. Sustainable development of the FinTech industry is defined by two key drivers: a favourable external environment and digital financial inclusion.
2. The sustainable development of the FinTech industry should be assessed at the country level by developing and adapting a set of indicators that

integrate the political, economic, social, and technological environments of the FinTech industry.

3. FinTech development, the external FinTech environment, and Sustainable Development indicators should be integrated into a methodology suitable for assessing the sustainable development of the FinTech industry at the country level.
4. Energy consumption is an essential factor in the context of the sustainable development of the FinTech industry.

Approval of the Research Findings

This dissertation topic has been the subject of three scientific articles by the author, *one of which* is indexed in the *Web of Science* database, and *all of which* are indexed in the *Scopus* database (Pauliukevičienė et al., 2025; Pauliukevičienė & Stankevičienė, 2024; Pauliukevičienė & Stankevičienė, 2021).

The research findings were disseminated during two presentations at international scientific conferences, one of which took place overseas:

- Emerging trends in economics, culture and humanities (etECH2024), 2024, Riga, Latvia;
- 12th International scientific conference "Business and management 2022", 2022, Vilnius, Lithuania.

The results of the research were also presented at four doctoral seminars at Vilnius Gediminas Technical University (9 September 2024, 23 October 2023, 15 May 2023, and 30 May 2022) and two seminars of other universities abroad (science centre, institute) researching a topic close to the dissertation:

- The University of Malta, Faculty of Economics, Management and Accountancy, 2024, Msida, Malta;
- International Colloquium New Scientific-Didactic Challenges in Time of Turbulence, 2022, Bialystok, Poland.

Structure of the Dissertation

The dissertation is structured as follows: an introduction, three chapters, general conclusions and recommendations for future research, references, a list of the author's publications, and a summary of the dissertation in Lithuanian.

The dissertation comprises 150 pages, 27 figures, 47 tables, 17 numbered formulas, and 220 references.

1

Theoretical Aspects of the Assessment of the Sustainable Development of the Financial Technology Industry

The First Chapter provides a comprehensive analysis of the dissertation topic's elements, including an analysis of the definition of financial technology and its industry's expansion, an analysis of the external environment factors in the financial technology industry and identification of growth drivers, a discussion on sustainable development and its assessment methodologies, an exploration of the interconnections between the FinTech industry's environment and sustainable development, and an analysis of its relationship with the UN Sustainable Development Goals (SDGs). Consequently, this chapter delineates two primary conclusions, highlighting the absence of a unified definition for the sustainable development of the FinTech industry and revealing the lack of an assessment tool for the sustainable growth of the financial technology industry. The First Chapter also introduces the theoretical framework for assessing sustainable development within the financial technology industry and concludes by articulating the aim and main tasks of the current research. On the topic of this chapter, one publication was published (Pauliukevičienė & Stankevičienė, 2024).

1.1. Definition of the Financial Technology Industry

To delineate the sustainable evolution of FinTech, it is imperative to first attain a comprehensive understanding of the concepts of FinTech and the industry itself, alongside grasping the notion of sustainable development within the context of this specific industry.

The term "FinTech" amalgamates "finance" and "technology", first appearing in scholarly literature in 1972. In an academic article, Abraham Leon Bettinger, vice president of Manufacturers Hanover Trust, elucidated models for analysing and resolving daily challenges within the organisation and proposed the following definition for FinTech: "an acronym that stands for financial technology, combining bank expertise with modern management science techniques and the computer" (Bettinger, 1972). Despite 50 years of increasing interest in FinTech, a consensus on its definition remains elusive among scholars and practitioners, as do the theoretical foundations of this domain (Milian et al., 2019).

Research conducted by Schueffel (2016) analysed over 200 sources in the scientific literature spanning 40 years. It concluded that, as of 2016, there remained no universal consensus on the definition of "FinTech". Consequently, the subsequent definition of "FinTech" was suggested based on this analysis: "FinTech is an emerging financial sector that utilises technology to enhance financial operations" (Schueffel, 2016). Gomber (2017) provides a succinct definition of FinTech as "a neologism derived from the terms "financial" and "technology", which generally refers to the integration of contemporary, predominantly Internet-based technologies (e.g., cloud computing, mobile Internet) with traditional business operations within the financial services sector (e.g., money lending, transaction banking)" (Gomber, 2017). Additional investigation into the definition of FinTech uncovers diverse viewpoints. One perspective defines it as "non- or inadequately regulated enterprises seeking to create innovative, technology-driven financial services with an enhanced design that will revolutionise existing financial practices" (Varga, 2017). Another viewpoint regards it as "a cross-disciplinary subject that integrates finance, technology management, and innovation management" (Leong & Sung, 2018).

The recent scientific literature on the definition of FinTech indicates that the overall definition is consistent and mainly grounded in two principal criteria. First, new and innovative technologies are applied to the financial services sector. Second, new business models, applications, processes, or products are developed based on new and innovative technologies (Rupeika-Apoga & Thalassinos, 2020). The most recent scientific literature defines FinTech as "a set of innovations and an economic sector that focuses on applying recently developed digital technologies to financial services" (Wojcik, 2021).

Table 1.1. Definitions of the term "FinTech" in scientific literature in chronological order (made by the author)

The Author / Source	Definition of FinTech
Schueffel, 2016	"FinTech is a new *financial industry* that applies technology to improve financial activities".
Gomber, 2017	"FinTech is *the connection of* modern Internet-related *technologies with* established *business activities* of the financial services industry".
Varga, 2017	"FinTech is non- or not fully regulated *ventures* aiming to develop novel, technology-enabled financial services with a value-added design that will transform current financial practices".
Leong & Sung, 2018	"FinTech is a *cross-disciplinary subject* that combines finance, technology management and innovation management".
Milian et al., 2019	"FinTech – innovative companies active in the financial industry making use of the availability of communication, the ubiquity of the internet, and the automated processing of information".
Rupeika-Apoga & Thalassinos, 2020	"FinTech is the *development of new business models, applications, processes or products* based on new/innovative technologies".
Wojcik, 2021	"FinTech is *a set of innovations and an economic sector* that focuses on applying recently developed digital technologies to financial services".
Siddiqui & Rivera, 2022	"FinTech is a *company that uses technology* to provide financial solutions using the Internet and automated information processing".
Cheng & Qu, 2023	"FinTech is at its core a *technological revolution* and therefore its definition should start with technology; we define FinTech as the *application of emerging technologies* in the financial industry, which includes not only the financial products derived from these technologies but also the management innovations brought to financial institutions by these technological developments".

An examination of the international organisations that regulate FinTech activities reveals a paucity of consensus on the definition of FinTech. The European Commission, in its FinTech Action Plan entitled "A More Competitive and Innovative European Financial Sector", identifies FinTech as "technology-enabled innovation in financial services" (European Commission, 2018). Conversely, the Financial Stability Board, the international body that coordinates at the global

level the work of national financial authorities and international standard-setting bodies to develop and promote the implementation of effective regulatory, supervisory and other financial policies, identifies FinTech as "a technology-enabled innovation in financial services that could result in new business models, applications, processes or products with an associated material effect on the provision of financial services" (Financial Stability Board [FSB], 2019).

Table 1.2. Definitions of the term "FinTech" by international financial organisations and leading economic entities' national legislation, presented in chronological order (made by the author)

The Author / Source	Definition of FinTech
IOSCO, 2017	"A variety of innovative business models and emerging technologies that have the potential to transform the financial services industry".
European Commission, 2018	"Technology-enabled innovation in financial services".
IMF, 2018	"The *advances in technology that can transform the provision of financial services,* spurring the development of new business models, applications, processes, and products".
OECD, 2018	"*Innovative applications of digital technology for financial services*". "FinTech involves not only the application of new digital technologies to financial services but also the development of business models and products which rely on these technologies and more generally on digital platforms and processes".
FSB, 2019	"A *technology-enabled innovation in financial services* that could result in new business models, applications, processes, or products with an associated material effect on the provision of financial services"
World Bank Group, 2020	"Encompassing advances in technology and changes in business models that have the potential to transform the provision of financial services through the development of innovative instruments, channels and systems". "A set of activities contributing to the provision of financial services facilitated predominantly by entities emerging from outside the traditional finance system".

The Basel Committee on Banking Supervision (BCBS) utilises the Financial Stability Board's (FSB) definition of FinTech (BIS, 2018). The BCBS contends that regulatory bodies in various nations have not explicitly defined FinTech, partly due to existing definitions, such as those from the FSB, and partly due to the premature nature of characterising a swiftly evolving phenomenon. Those who

define FinTech characterise it as a company that offers innovative services, a novel business model, or a new technology start-up in the financial industry (Rupeika-Apoka & Thalassinos, 2020).

The Oxford English Dictionary (n.d.) defines FinTech as "digital and online *technology* used to support banking and other financial activities such as investment services". The Oxford Advanced Learner's Dictionary (n.d.) defines FinTech as "computer programs and other *technology* used to provide banking and financial services". The Merriam-Webster English dictionary provides a similar definition, stating that FinTech is "*products and companies that employ* newly developed digital and online *technologies* in the banking and financial services industries" and "a business that uses or creates such technologies" (Merriam-Webster, n.d.). Conversely, an alternative online English dictionary offers a different definition of FinTech, namely "*digital technological innovations* utilised by customers or institutions in the financial services industry" or "a *company that uses* or develops *digital technological innovations* in the financial services industry" (Dictionary, n.d.).

As demonstrated in the preceding definitions of FinTech, it is evident that there is currently no consensus or universally accepted concept of FinTech. However, concerning FinTech as an industry sector, the European Commission defines the FinTech sector as "*firms that use technology-based systems* either to provide financial services and products directly or to make the financial system more efficient" (Karakas & Stamegna, 2019).

To clarify the definition of FinTech and the FinTech industry for this dissertation, it is essential to analyse the evolution and development of the FinTech industry.

1.2. Overview of the Financial Technology Industry and Its Growth Analysis

The FinTech industry is characterised by continuous development and innovation, constantly influencing and transforming the traditional financial industry (Mei et al., 2018). Within the scientific literature, the evolution of the FinTech industry is measured in stages or eras, the details of which are outlined in Table 1.3.

Evidence suggests that the FinTech industry has evolved in response to global events and needs (Arner, 2016; Gomber et al., 2018; Giglio, 2021; Barroso & Laborda, 2022; Cumming et al., 2023; Tsanis & Stouraitis, 2025). The initial phase of FinTech, designated as "FinTech 1.0", was characterised by developing an infrastructure to support globalised financial services and introducing technologies to bolster the economic system.

The advent of FinTech 2.0 marked the onset of the online revolution and the transition to digital banking. The global financial crisis 2008 created the conditions and necessity for FinTech start-ups, thereby addressing the deficiencies of traditional banking institutions and exerting influence not only on the launch of FinTech 3.0 but also on the emergence of Open Banking, cryptocurrencies, and blockchains.

The advent of FinTech 3.5 was precipitated by the underdeveloped status of banking and financial services, the rapid proliferation of mobile phones in Africa, the relatively limited investment in technology by traditional Asian developing banks, public distrust of the public banking system, and increased smartphone use (Arner et al., 2016). The development of FinTech 3.5 has also been accelerated by the growing need for and priority of financial inclusion in developing countries, which began in 2015.

Table 1.3. Evolution of the FinTech industry (source: compiled by the author based on Arner (2016), Nicoletti (2017), Nicoletti et al. (2017), Lomachynska (2020), Arner et al. (2021), Giglio (2021))

Era	FinTech 1.0	FinTech 2.0	FinTech 3.0	FinTech 3.5	FinTech 4.0
Period	1866–1967	1967–2008	2008–2015	2010– now	2020– now
Geography	Global / Developed	Global / Developed	Developed	Africa, emerging/developing Asia countries	Global
Key Elements	Infrastructure/communication	Banks	Start-ups	Pursuing financial inclusion/emerging markets	E-Commerce: digital finance and payment platforms
Shift Origin	First transatlantic telegraph cable	The first ATM, the first handheld calculator	2008 financial crisis, iPhone, mobile money M-Pesa	Development of large technology companies (Alibaba, Tencent)	Sustainable development, data protection, and financial regulation

In the aftermath of the ratification of the Paris Climate Agreement and the Sustainable Development Goals by the United Nations, and with the advent of the global 2020 pandemic of the novel coronavirus, which compelled society to adopt

a more sedentary and closed way of life for a considerable period, electronic commerce experienced a period of significant growth. The rapid development of digital finance and payment platforms has led to the challenge of reconciling Sustainable Development Goals, data protection goals and financial regulatory goals, which is increasingly being described as the beginning of the evolutionary era of FinTech 4.0.

The transition to FinTech 4.0 is also reflected in the numbers. As demonstrated in Figure 1.1, the annual number of investment deals in the FinTech sector exhibited a gradual upward trend from 2018 to 2020, with 4,038 transactions in 2018 and 4,379 transactions in 2020. In 2021, the number of deals increased significantly to 7,321 transactions (KPMG, 2023).

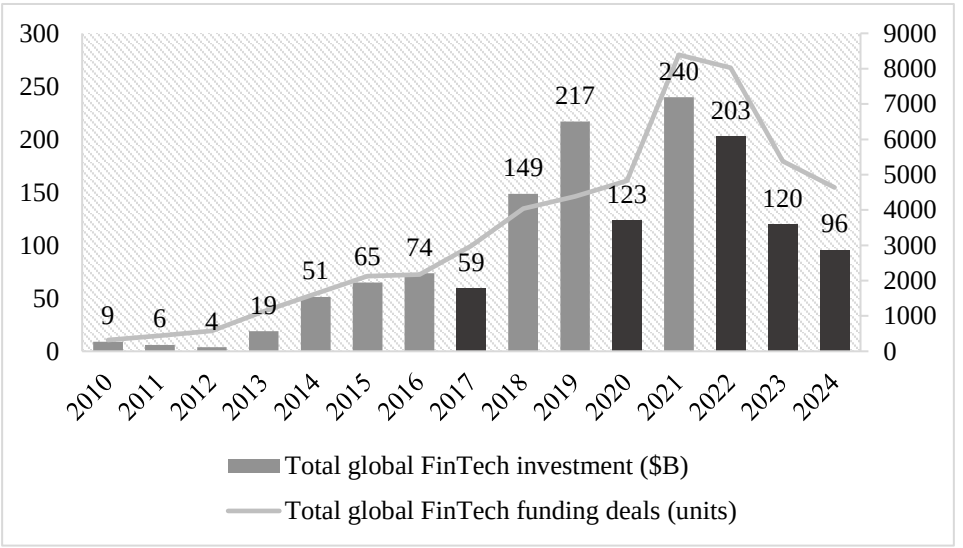


Fig. 1.1. The growth of the FinTech industry (source: compiled by the author based on KPMG & CB Insights (2016), KPMG (2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025))

Following the global pandemic of the 2020s, total global investment in financial technology increased substantially, reaching USD 238.9 billion in 2021 (KPMG, 2023). While this figure is comparatively low, 2022 was the third-best year for FinTech investment ever recorded and the second-best year for deal volume. However, in 2023, global investment in FinTech witnessed a decline to a five-year low of USD 113.7 billion across 4,547 deals, as investors adopted a more cautious approach, withdrawing from large deals amid concerns over persistently high interest rates, geopolitical tensions in Ukraine and the Middle East, declining FinTech valuations, and the challenging exit environment (KPMG, 2024).

Consequently, the evolution of the FinTech industry is significantly influenced by the prevailing external environment, which, in turn, is shaped by global political and economic dynamics.

1.3. Overview of the Financial Technology Industry Environment and Analysis of Growth Drivers

In recent times, considerable global expansion within the FinTech industry has occurred, with specific countries emerging as leaders due to their favourable environments. The growing attention of researchers and analysts on this topic highlights the significance of the FinTech industry's advancement and its external environment. In the preceding decade, the determinants affecting the expansion of the FinTech sector have emerged as a significant research focus. Factors affecting industry growth are analysed, and countries and cities are compared across a variety of dimensions (Hieminga et al., 2016; fDi Intelligence, 2019; Frost, 2020; Boitan & Barbu, 2021; Findexable, 2021; Gauthier et al., 2022; Findexable, 2022; Wardle & Mainelli, 2025). The European Commission prioritises the advancement of FinTech through the FinTech Action Plan 2018 and the Digital Finance Strategy 2020, highlighting the need for suitable legislation in conjunction with the development of digital resilience. It is evident from the numerous strategic documents and studies, along with their findings, that external environmental factors play a pivotal role in the development of the FinTech industry. Nonetheless, one could argue that the existing research lacks integrity and universality, as it highlights the impact of varying environments and factors, and the suggested indices apply only to a select number of countries. A universal environmental assessment tool for the FinTech industry is necessary, highlighting the primary drivers.

The Global Financial Centres Index (GFCI), a compendium inaugurated in 2007 by Z/Yen and the City of London, provides assessments and rankings of the world's primary financial centres. For 18 years, researchers at Z/Yen Partners and the China Development Institute have been responsible for publishing biannual reports to monitor the advancement of the world's premier financial centres. The GFCI 37 (th edition employs a set of criteria to evaluate financial centres (cities) on a global scale. These criteria are drawn from the "Areas of Competitiveness", encompassing the business environment, human capital, infrastructure, financial sector development, and reputation. An evaluation of 115 cities was conducted to assess the extent of their FinTech offerings, with a primary focus on the U.S. and China (Wardle & Mainelli, 2025).

In 2016, a FinTech Index was developed by scholars from ING Bank's Economics Department for application in low- and middle-income nations worldwide.

The index was designed to evaluate the necessity for FinTech-driven financial inclusion, as well as FinTech infrastructure and country-specific factors such as demographics and governance (Hieminga et al., 2016). This research constituted the inaugural investigation to establish a foundation for subsequent research on the significance of the external environment for FinTech development. Nevertheless, the authors did not proceed with the matter.

The 2017–2018 period is notable for lacking research on this subject, as scholars have not introduced any novel FinTech indices or rankings.

In 2019, a consortium of researchers proposed a novel methodology. It established a Global FinTech Index (GFI) to identify and rank various nations and metropolitan areas globally based on the robustness of their FinTech ecosystems and enterprises. This approach posits that the primary indicators affecting FinTech development include the number of financial technology firms and ecosystem developers, the interrelation of company entities within a locale, and the prevailing business climate (Findexable, 2019). The proposed assessment instrument, although innovative, only addresses one aspect of the complex political and economic landscape of financial technology advancement.

During that particular period, further contributions from the research community were proposed as an alternative hierarchical classification of urban centres on a global scale, emphasising the infrastructure of financial technology, the performance of foreign direct investment, efficiency in terms of cost, potential for economic impact, innovative capacity, and the extent to which it is appealing to users. These indicators primarily address the technological and economic landscape of the financial technology industry (fDi Intelligence, 2019).

The Global FinTech Ranking was launched in 2020 by Startup Genome, a leading research and policy advisory organisation dedicated to fostering public-private partnerships and collaborations with governmental entities to enhance startup ecosystems. The Global FinTech Ranking assesses FinTech ecosystems (cities) based on several key performance indicators, including financial performance, funding availability, talent attraction and retention, focus on innovation, and the ecosystem's legacy (Gauthier et al., 2020).

In 2021, Bucharest University of Economic Studies scholars introduced a European Union (EU) FinTech Index. This index employed methodological procedures and variables identical to the ING FinTech Index 2016, emphasising European Union (EU) nations. The index aimed to evaluate the potential for FinTech expansion within these countries. It partially encompassed the political, economic, social, and technological landscape of FinTech development (Boitan & Barbu, 2021).

Over the past decade, various studies have investigated the development of financial technology (Arner et al., 2015; EY, 2015, 2017, 2019; Nicoletti et al., 2017; Mention, 2019) and the impact of its external environment (Sahay et al.,

2020; Goo & Heo, 2020; Frost, 2020), and they have been integrated into the subsequent research of this dissertation.

A chronological analysis of the existing academic research was conducted, culminating in comparative research of the current instruments and assessment elements utilised within the FinTech environment. Table 1.4 highlights a notable research gap: a universal assessment tool for the FinTech industry that can be tailored to each country is currently lacking. Factors such as the target demographic, contextual conditions, and metrics constrain current instruments.

Researchers examine various methodologies for strategic analysis to evaluate the business environment. The predominant structures in scholarly publications include an analysis of strengths, weaknesses, opportunities, and threats (SWOT analysis); an assessment of the political, economic, social, and technological factors that could affect a business now and in the future (PEST analysis); a technique used to help organisations understand the relationships between different elements of their business (GRID analysis); identification of company assets and liabilities (SNW analysis); and External Factors Analysis Summary to organise the external factors into the generally accepted categories of opportunities and threats (EFAS form) (Shtal et al., 2018). As Vlados and Chatzinikolaou (2019) argue, methodological reorientations for an evolutionary approach to the external business environment are under consideration. However, PEST analysis is the predominant method for assessing the external business environment. It serves as a framework for macro-environmental elements used in the ecological scoping aspect of strategic management (Gupta, 2013). An exemplary, straightforward illustration of utilising PEST analysis to capture the FinTech landscape is presented in the Estonian FinTech Report 2019 (Tirmaste et al., 2019). The author proposes an assessment tool for the FinTech industry by conducting a PEST analysis that is applicable and adaptable to any country. Table 1.5 presents the framework of a FinTech industry environmental assessment tool derived from a PEST analysis of external environmental indicators pertinent to the FinTech industry. The suggested composition was formulated: A compilation of potential indicators for each environment was established based on the literature review; inter-correlated indicators were eliminated; data collection was conducted; indicators missing 2020 data when collected were discarded. The outcome was an evaluative instrument comprising four distinct environments, each featuring eight indicators, culminating in 32 indicators, as delineated in Tables 1.5, 1.6, 1.7, and 1.8.

Table 1.4. A comparative analysis of the instruments and elements used in the assessment of the FinTech environment (made by the author)

		Instruments / Elements													
Authors	Objects to be assessed (target group)	Necessity for financial inclusion driven by FinTech	Infrastructure	The FinTech ecosystem as an environment that fosters business and innovation	Political and regulatory environment as a key consideration in the context of investment climate	Foreign direct investment / Funding	The issue of cost-effectiveness	Economic viability	Notion of innovation intertwined with attractiveness	The number of private FinTech companies	The superiority of private FinTech companies	Prevailing conditions within the business sector of the given locale	Human Capital	Reputation	Knowledge
Hiemingа et al., 2016	Developing and emerging countries	+	+	+	+										
fDi Intelligence, 2019	Global locations (cities)		+			+	+	+	+						
Boitan & Barbu, 2021	EU countries	+	+	+	+										
Findexable, 2021	Global ecosystems and companies									+	+	+			
Gauthier et al., 2022	Global ecosystems (cities)			+		+				+	+		+	+	+
Findexable, 2022	EU countries		+		+	+				+			+		
Wardle & Mainelli, 2025	Global financial centres (cities)		+	+	+							+	+	+	

Table 1.5. Composition of the political environment as part of a FinTech industry assessment tool based on PEST analysis (made by the author)

Indicator	Indicator explanation
Access to finance (P1)	The robustness of credit reporting systems and the efficacy of collateral and bankruptcy legislation in promoting lending (World Bank, 2020).
Governance efficiency (P2)	Outcomes of fundamental state sectors and investments, establishing a framework for enduring and sustainable wealth creation (SolAbility, 2023).
Government size (P3)	Government expenditure, tax liability, and fiscal well-being (Miller et al., 2024).
Openness to business (P4)	Degrees of bureaucracy and corruption, production expenses, tax environment favourability, and governmental transparency (U.S. News & World Report LP, 2023).
Open Markets (P5)	Freedom of trade, freedom of investment, and financial autonomy (Miller et al., 2024).
Political globalisation (P6)	Quantity of international embassies, missions, NGOs, and other organisations, treaties, and investment partners (KOF Swiss Economic Institute, 2023).
Regulatory environment for starting a business (P7)	Quantity of procedures, duration, expenses, and mandated minimum capital investment for a small and medium-sized enterprise to commence and officially function in the economy's largest business city (World Bank, 2020).
Rule of law (P8)	Property rights, governmental integrity, and judicial efficacy (Miller et al., 2024).

Table 1.6. Composition of the economic environment as part of a FinTech industry assessment tool based on PEST analysis (made by the author)

FinTech activity in a country (E1)	FinTech operations and the advancement of the regional FinTech ecosystem (Findexable, 2019).
Number of FinTechs in the capital (E2)	Number and calibre of enterprises within the ecosystem, regional business climate (Findexable, 2019).
Economic globalisation (E3)	Degree of financial and trade globalisation (KOF Swiss Economic Institute, 2023).
Inflation rate (E4)	Annual percentage change in average consumer prices (International Monetary Fund, 2023).
GDP per capita (E5)	Contemporary prices, purchasing power parity; international dollars per capita (International Monetary Fund, 2023).
Natural capital (E6)	The existing natural environment encompasses resource availability and the extent of resource depletion (SolAbility, 2023).

End of Table 1.6

Real GDP growth (E7)	Yearly percentage variation (International Monetary Fund, 2023).
Resource efficiency and intensity (E8)	The efficacy of utilising available resources indicates operational competitiveness in a resource-constrained environment (SolAbility, 2023).

Table 1.7. Composition of the social environment as part of a FinTech industry assessment tool based on PEST analysis (made by the author)

Entrepreneurship (S1)	Entrepreneurial activity (U.S. News & World Report LP, 2023).
Intellectual capital and innovation (S2)	Ability to create wealth and employment through innovation and value-added industries in global markets (SolAbility, 2023).
Population (S3)	A potentially adequate customer base of millions of individuals for sector development (International Monetary Fund, 2023).
Progress of human development (S4)	Life expectancy, health, human knowledge, and standard of living (UNDP, 2024).
Social capital (S5)	Security, liberty, equality, and life satisfaction within a nation (SolAbility, 2023).
Social globalisation (S6)	Degree of interpersonal, informational, and cultural globalisation (KOF Swiss Economic Institute, 2023).
Talent availability (S7)	Quantity of skilled labour and its sustainability in light of emerging and ageing workforce trends (ManpowerGroup Talent Solutions, 2020).
Quality of life (S8)	Economic stability, family friendliness, income equality, political stability, security, affordability, the labour market, and the advancement of public health and education systems (U.S. News & World Report LP, 2023).

Table 1.8. Composition of the technological environment as part of a FinTech industry assessment tool based on PEST analysis (made by the author)

Digitalisation (T1)	Advancement of the digital economy (Chakravorti et al., 2020).
E-Participation (T2)	Access to information and public services for citizens (United Nations, 2022).
Internet speed (T3)	Fixed broadband and mobile speeds, measured in Mbps (Speedtest, 2024).

End of Table 1.8

National cyber security (T4)	Cybersecurity proficiency, readiness to avert and combat cyber-attacks and offences (National Cyber Security Index, 2024).
Network readiness (T5)	Utilisation and influence of Information and Communication Technology in the economy (Portulans Institute, 2023).
Online service (T6)	Extent and calibre of digital services (United Nations, 2022).
Research and development (T7)	Researchers, total expenditure on research and development, international research and development firms, and QS university rankings (Dutta et al., 2023).
Telecommunication infrastructure (T8)	Internet users and subscribers of mobile, mobile broadband, and fixed broadband services (United Nations, 2022).

1.4. Concept of Sustainable Development

Sustainable development was first articulated 36 years ago by the World Commission on Environment and Development (WCED) in the report "Our Common Future", commonly referred to as the Brundtland Report, as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Keeble, 1988).

In recent years, the importance of this subject has escalated; sustainability and sustainable development are indisputably among the most prevalent themes in scientific publications (Portney, 2015; Sachs, 2015; Scoones, 2016; Weitzman, 2017; Tomislav, 2018; Holmberg et al., 2019; Ascher et al., 2020). Despite the concept introduced in 1988 still informing sustainable development efforts, global challenges are escalating; the population is expanding while natural resources remain finite (Mensah, 2019). Consequently, economic activities inflict environmental harm (Awais et al., 2023). These global issues affect the present and future economic, social and ecological well-being that make up the three pillars of sustainable development (Basiago, 1998; Pope et al., 2004; Gibson, 2006; Waas et al., 2011; Moldan et al., 2012; Schoolman et al., 2012; Boyer et al., 2016; Purvis et al., 2019). It jeopardises the realisation of the 2030 Agenda for Sustainable Development, along with its 17 goals and 169 targets, endorsed in 2015 by UN member states as a strategic framework for humanity, the environment, and economic well-being to enhance global peace and freedom. Agenda 2030 aims to introduce a set of 17 interconnected global objectives designed as a framework for attaining a more equitable and sustainable future for all, commonly referred to as the Sustainable Development Goals (SDGs): No Poverty (SDG 1), Zero Hunger

(SDG 2), Good Health and Well-Being (SDG 3), Quality Education (SDG 4), Gender Equality (SDG 5), Clean Water and Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8), Industry, Innovation, and Infrastructure (SDG 9), Reducing Inequality (SDG 10), Sustainable Cities and Communities (SDG 11), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Life Below Water (SDG 14), Life On Land (SDG 15), Peace, Justice, and Strong Institutions (SDG 16), and Partnerships for the Goals (SDG 17) (UN General Assembly, 2015).

The academic literature categorises the SDGs into three primary groups: SDG 6, SDG 13, SDG 14, and SDG 15 pertain to biosphere or environment; SDG 1, SDG 2, SDG 3, SDG 4, SDG 5, SDG 7, SDG 11, and SDG 16 relate to society; SDG 8, SDG 9, SDG 10, and SDG 12 concern the economy; and SDG 17 is designated as the overarching goal (Folke et al., 2016; Schoenmaker & Schramade, 2018).

1.5. Links between the Financial Technology Industry Environment, Sustainable Development, and Its Goals

FinTech investment continues to grow and diversify, leading to the active exploration of this industry as a research topic by academic and policy communities, focusing on linking it to sustainable progress and attaining the Sustainable Development Goals (SDGs). In 2014, to improve the financial system's effectiveness in mobilising capital for a green and inclusive economy or sustainable development, the UN Environment Programme launched the Inquiry on the Design of a Sustainable Financial System (The Inquiry) (Castilla-Rubio et al., 2016). For the first time, the seminal 2015 report unveiled the “quiet revolution” already underway and its capacity to rejuvenate the financial system’s purpose within the sustainable development framework. Since its launch, the Inquiry has addressed three key questions: Under what conditions should measures be implemented to ensure the financial system prioritises sustainable development? What actions have been implemented and could be more broadly adopted to enhance the alignment of the financial system with the principles of sustainable development? What can be the most effective use of these measures? (UN Environment Programme, 2015). In addressing these enquiries, FinTech is regarded as a principal solution. The Inquiry published research at the end of 2016 assessing the impact of financial technology on sustainable development. The report explores the capacity of financial technology to promote the attainment of the SDGs, highlighting that the evolution of the finance system is propelled by both sustainable development and financial

technology, which share the intrinsic capacity to act as catalysts for change and impact and are conducive to the establishment of innovative, sustainable models of business (Castilla-Rubio et al., 2016). The concept of a "FinTech for Sustainable Development" (FT4SD) innovation portfolio is also presented in this report.

The Paris Agreement on climate change, a pivotal global strategic document from the last decade, was adopted in late 2015 and came into effect in late 2016, underscoring the significance of financial and technology applications for sustainability (United Nations, 2015).

In 2015, six industry matrices providing industry-specific practical examples and actionable ideas for SDGs were developed by the UN Global Compact and KPMG International. The financial services industry has been identified as one of the six sectors that can contribute to implementing the SDGs. The financial services industry matrix indicates that numerous solutions for implementing the SDGs will incorporate blended finance, novel funding instruments, and the utilisation of emerging technologies, collectively referred to as FinTech (UN Global Compact & KPMG International, 2015).

The European Commission has concentrated on sustainable finance and FinTech to advance the SDGs within the 2030 Agenda, exemplified by the establishment of the International Platform on Sustainable Finance in 2018 and the subsequent strategic papers adopted: The FinTech action plan (2018); action plan on sustainable finance (2018); the European Green Deal growth strategy (2019), and its' investment plan (2020), Digital Finance Package (2020), including a Digital Finance Strategy and legislative proposals on crypto-assets and digital resilience, for a competitive EU financial sector that gives consumers access to innovative financial products while ensuring consumer protection and economic stability (European Commission, 2020); and the Sustainable Finance Package (2021), including the EU Taxonomy Climate Delegated Act, the Corporate Sustainability Reporting Directive and amendments to delegated acts, encouraging the financial system to support companies on their way to sustainability and to support existing sustainable companies (European Commission, 2021).

In 2018, the UN Secretary-General established the Taskforce on Digital Financing of the SDGs, with a mandate for 2019–2021 to recommend and catalyse ways to leverage digitalisation to accelerate SDGs financing as part of a broader roadmap for financing the 2030 Agenda. The Taskforce's final report set out an action plan for eight stakeholders, each with a central role to play. FinTech and global digital platforms play a crucial role in channelling finance towards the SDGs by developing innovative products and services that meet customer demand, committing to principles for digital finance that align with the SDGs, and establishing corporate governance mechanisms to operationalise them (Bersudskaya et al., 2020).

Research entitled "Sustainable Finance and FinTech in Europe" was published in 2019 by the European platform of the UN Environment Financial Centres for Sustainability (FC4S) in collaboration with Stockholm Green Digital Finance. As shown in Figure 1.2, this research launched the FC4S Europe FinTech Innovation Workstream at the convergence of finance, sustainability, and technology. This intersection seeks to assist EU policymakers in understanding the synergies between sustainable finance and financial technology (UN Environment FC4S, 2019).

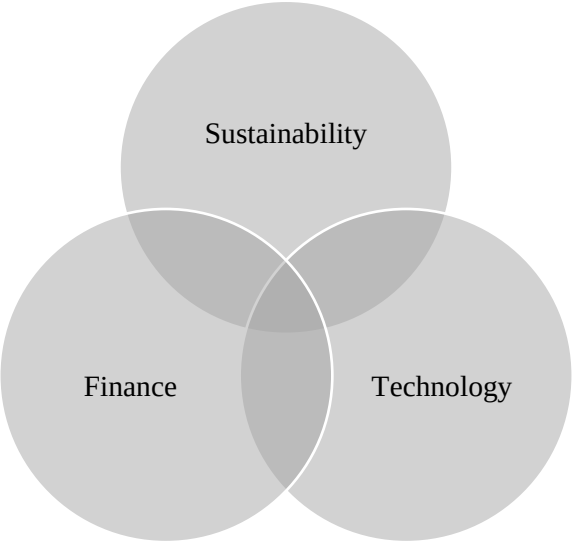


Fig. 1.2. Convergence of sustainability, finance and technology (source: UN Environment FC4S, 2019)

From a scholarly research standpoint, financial technology facilitates green finance and sustainable development (Cen & He, 2018) and is essential for an effective SDG strategy (Arner et al., 2020). It is also an innovative way to mobilise resources for various purposes, including financing sustainable development (Michael, 2020). The capacity of the financial technology industry to enhance public savings and investment, channel capital towards SDG-aligned initiatives, and augment the level of transparency and liability in the financial services industry is essential for achieving the SDGs (Sgro et al., 2019). Financial technology is regarded as a catalyst for sustainable economic growth, distinguished by its unique characteristics compared to traditional financial sectors (Ryu et al., 2020). It is estimated that between three and thirteen per cent (ranging from USD 50 to USD 150 billion) of the funding needed to attain the SDGs may be derived from

a "FinTech dividend" (Michael, 2020). Consequently, researchers have begun examining the convergence between the FinTech industry and the Sustainable Development Goals by identifying specific SDGs. The 2020 Global Trends Report on Strengthening the Rules-Based International Order indicates that FinTech complements several Sustainable Development Goals, notably SDG 1, SDG 5, SDG 7, SDG 8, SDG 9, and SDG 10 (Sgro et al., 2019). Recent scientific research on Islamic FinTech's advancement of SDGs indicates that FinTech companies' initiatives to enhance financial inclusion through financing underdeveloped sectors, mobilising and allocating social funds, and launching charitable programs for disadvantaged communities align with the promotion of SDG 1, SDG 2, and SDG 10 (Hudaefi, 2020). The vice president of BNP Paribas stated that the increasing adoption of AI, IoT, and blockchain, combined with open banking regulations, has led to intensified competition, expedited processes, enhanced automation, and increased transparency and collaboration. By transforming traditional financial services, these emerging technologies and FinTech are advancing SDG 9 (Hausemer, 2020).

Future growth must be sustainable and inclusive, as growth is vital to the viability and vitality of industries and economies (Manyika et al., 2016). Since the 2008 global financial crisis, GDP growth in the advanced G7 countries has averaged 1% per year (IMF, 2021). A similar trend can be observed in emerging economies (excluding China and India). Here, growth has recently slowed compared with two decades ago.

Academic research indicates that financial inclusion can facilitate the growth of the economy as a whole and the attainment of broader developmental objectives (Nkwede, 2015; Sharma, 2016; Williams et al., 2017; Sulong & Bakar, 2018; Mushtaq & Bruneau, 2019; Ratnawati, 2020; Bayar et al., 2021; Van et al., 2021). Financial inclusion, which appears as a target in eight of the 17 goals, is prominently recognised as a facilitator of the SDGs. The list comprises SDG 1 "No Poverty", SDG 2 "Zero Hunger", SDG 3 "Good Health and Well-being", SDG 5 "Gender Equality", SDG 8 "Decent Work and Economic Growth", SDG 9 "Industry, Innovation, and Infrastructure", and SDG 10 "Reduced Inequalities". SDG 17, "Partnership for the Goals", implicitly promotes enhanced financial inclusion by facilitating increased mobilisation of savings for investment and consumption, thereby stimulating growth (UNCDF, 2022).

Financial technology promotes inclusive finance by providing equitable and attainable financial services to the impoverished (Cen & He, 2018). Boosting annual economic growth by as much as 2.2 per cent, the digital financial services of the FinTech industry have emerged as a crucial catalyst for financial inclusion (IMF, 2021). The findings of the correlative analysis validated a direct relationship between GDP per capita and specific indicators of digitalisation of the bank-

ing sector, suggesting that the development of FinTech fosters economic expansion by enhancing the GDP produced in the financial industry (Sadigov et al., 2020). Consequently, the swift advancement of the FinTech industry improves financial inclusion, intensifies competition, expands employment opportunities, and fosters sustained economic growth. Furthermore, green finance and environmentally friendly FinTech are significant catalysts for sustainable economic development (Cen & He, 2018). Thus, analysing the relationship between financial technology, green finance, and sustainable development is of both theoretical and practical significance (Cen & He, 2018). That is why it is imperative to ensure that FinTech continues to develop sustainably.

The significance of the interconnection between finance, sustainability, and technology has been underscored by the 2020 global coronavirus outbreak, which has prompted countries to reassess conventional approaches and rely on technology and sustainability (Macchiavello & Siri, 2022). Both governments and global organisations have begun to recognise the need to leverage the financial technology industry to advance financial inclusion (Faust et al., 2023). The World Bank Group has developed a coherent and holistic approach to helping countries achieve financial access and responsible financial inclusion, emphasising five interconnected pillars that utilise FinTech policies, strategies, and FinTech-related data (World Bank, 2022). Other established development agendas and initiatives, including the Addis Ababa Action Agenda on Financing for Development (2015) and the Bali FinTech Agenda (2018), acknowledge the significance of sustainable development and the contribution of FinTech in realising it (United Nations, 2015; International Monetary Fund, 2018). Moreover, the interplay of elevated interest rates and expanding market share indicates that consumer demand for FinTech services will likely rise as technology advances (Buchak et al., 2018). Statistics shed light on the attitude of governments and policymakers towards financial technology: global investment in the FinTech sector surged steadily from USD 6 billion and 445 investment units in 2011 to USD 239 billion and 7321 investment units in 2021. From 2011 to 2021, global financial inclusion increased by 25%, from 51% of the adult population (aged 15 and older) with a bank account in 2011 to 76% in 2021 (Fig. 1.3).

Over the past decade, the proliferation of mobile money account holders has been facilitated by FinTech; by 2021, more than 10% of the global population had a mobile money account. The swift advancement of the FinTech industry over the past decade has significantly enhanced global financial inclusion, providing digital access to bank accounts for billions of adults worldwide. According to Chen et al. (2023), FinTech for social good represents a significant area of discourse that transcends mere financial outcomes. Financial technology enhances environmental quality in the short term and over time (Udeagha & Muchapondwa, 2023).

Nonetheless, significant progress remains: in 2021, merely 64% of the global population aged 15 and above engaged in digital payments, despite 76% possessing either a bank account or a mobile money account. Furthermore, nearly 86% of the population owned a mobile phone, and 63% had Internet access in 2021, indicating substantial growth potential for mobile money accounts, constituting 10% of the total (World Bank, 2025).

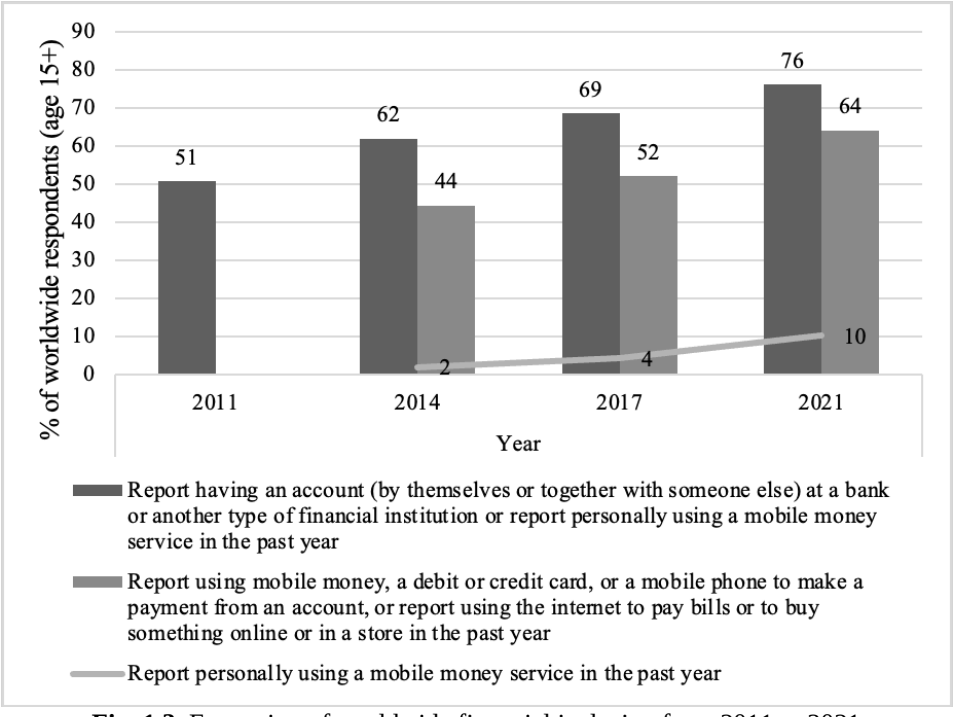


Fig. 1.3. Expansion of worldwide financial inclusion from 2011 to 2021 (source: made by the author based on World Bank statistics, 2025)

Recent scholarly literature highlights the direct impact of FinTech on sustainable development and the achievement of the SDGs. Hoang et al. (2022) assert that the potential of digital applications in the financial sector to overcome significant obstacles to financing inclusive and sustainable growth is increasingly evident. FinTech, shaped by business imperatives, affects sustainable development (Legowo et al., 2020). FinTech can significantly enhance the quality of financial products, particularly in the realm of sustainable development, and catalyse value creation. Consequently, FinTech can effectively contribute to achieving the SDGs (Farahani et al., 2022). A 2022 content analysis of journal articles and other sources from 2000 to 2022 revealed the significance of development patterns,

governments, and civil society in advancing financial inclusion through FinTech, which serves as a mechanism to mitigate climate-related risks and achieve the SDGs (Mhlanga, 2022). A 2022 bibliometric review and content analysis of 59 articles and 35 journals on the relationship between FinTech and sustainability, conducted within the Q1 and Q2 quartiles of the *Scopus* database, highlighted the need for researchers to undertake studies that enhance understanding of FinTech's significant role in promoting sustainable economic development. Additionally, it identified a gap in the literature concerning the connections between FinTech and sustainability disclosure practices, deemed an underexplored research domain related to disclosure practices (Ellili, 2022).

A 2022 bibliometric analysis of 497 articles on FinTech in the *Web of Science* (*WoS*) database up to 2022 indicates that researchers in the FinTech domain are eager to investigate innovative methods to influence the future of the financial sector, particularly emphasising green finance and FinTech, as they recognise the significant role these areas play in mitigating the adverse effects of global climate change and promoting sustainability (Kwong et al., 2022). Nonetheless, FinTech presents significant technological and legal challenges that must be resolved to realise its promises and potential within the sustainable finance sector (Macchiavello & Siri, 2022). The sustainable development of the FinTech industry remains undefined, with ambiguity surrounding its assessment and measurement.

The existing academic and policy literature on regulation identifies a relationship between FinTech and specific Sustainable Development Goals. As stated in the 2018 report by the UN Secretary-General's Special Advocate on the role of digital finance in achieving the SDGs, digital finance has the potential to improve educational outcomes (SDG 4) by facilitating the management of educational expenses, enhancing the financial administration of education systems, and reallocating resources for educators, materials, and technologies. Moreover, digital finance can foster cost-effective business models that generate millions of new jobs and contribute to global GDP (SDG 8). Thirdly, digital finance facilitates small enterprises' expansion, innovation and market access, thereby integrating more individuals into the digital economy (SDG 9). Fourthly, digital payments have been shown to significantly enhance transaction transparency between governments and citizens, contributing to SDG 16.

Furthermore, they have been shown to facilitate greater governmental accountability regarding the utilisation of public funds and augment the financial resources available for essential public services, investments, and transfers. As posited by Hinson et al. (2019), the delivery of mobile financial services has the potential to influence health positively (SDG 3), employment (SDG 8), education (SDG 4), and poverty reduction (SDG 1) through enhanced productivity. In contrast, Bedoui and Robbana (2019) argue that digital social finance is crucial in achieving these SDGs. Specifically, the government's expenditure on education is reduced through electronic

payments, with the resulting savings from reduced leakage then being allocated to teacher remuneration, thereby enhancing productivity and decreasing absenteeism (SDG 4). The utilisation of electronic payments has been demonstrated to augment the available savings pool. At the same time, the analysis of substantial data sets referred to as "big data" has been shown to mitigate risks by providing access to historical data from lending institutions (SDG 8). Digital finance has been demonstrated to enhance global entrepreneurship ecosystems by fostering innovative business models, start-ups and products (SDG 9). Digital finance transparency facilitates enhanced oversight of corruption (SDG 16). Shipalana (2019) posits that financial inclusion has been recognised as a facilitator for seven of the 17 SDGs and aids in achieving SDG 8 and SDG 9. Walker (2019) furthermore suggests that legal reform initiatives conducive to the development of FinTech and facilitating fundraising by small businesses can potentially contribute to the realisation of SDG 8. Finally, Hoang et al. (2022) summarise that digital finance increasingly demonstrates the capacity to overcome challenges associated with advancing finance for sustainable development. The existing scientific literature suggests that FinTech substantially contributes to achieving the SDGs and serves as a primary catalyst.

Nevertheless, it must confront numerous fundamental challenges for the FinTech industry to significantly contribute to the transition towards a sustainable global future (Jones et al., 2017). The FinTech industry, like other sectors, is expected to evolve and operate within a distinct framework of external macro-environmental factors characterised by significant dynamism, complexity, and uncertainty (Shtal et al., 2018). Consequently, it is essential to cultivate an external environment conducive to FinTech advancement at the national level and evaluate the correlation between the FinTech PEST environment and attaining the SDGs. Nevertheless, the existing scientific literature exclusively investigates FinTech as a potential financial resource for achieving the SDGs. Consequently, the identified relationship between FinTech and SDGs is unduly constrained, necessitating a more expansive research approach. Therefore, the interrelationships between the FinTech industry and the SDGs require further exploration through relevant research. Specifically, considering that sustainable economic development can only be achieved through the sustainable advancement of all economic sectors and their respective industries, including FinTech.

Moreover, recent academic literature has begun to investigate the interconnections between FinTech and the environment, particularly in the context of energy consumption (Wuaten, 2023; Afroz & Raghutla, 2024; Iftikhar et al., 2024; Jie et al., 2024; Kakar et al., 2024; Oben et al., 2024; Uddin et al., 2024). Therefore, the energy indicator must be integrated into the dissertation research and the SDGs to assess the sustainable development of the financial technology industry. To achieve this objective, the empirical research will incorporate SDG 7 on renewable energy and energy consumption data from the Eurostat database.

1.6. Analysis of Research Methods for the Assessment of the Sustainable Development of the Financial Technology Industry

Selecting the appropriate research methods is essential to assess the FinTech industry's sustainable development. Therefore, it is necessary to review the techniques recommended in the scientific literature for assessing sustainable development. For this purpose, a search was conducted for sources in scientific literature that present the results of a systematic analysis of sustainable development assessment methods. As a result, four systematic analysis articles were identified, which systematised 293 sources for the 54 years from 1967 to 2021. The results of the analysis of methods for assessing sustainable development in the scientific literature are presented in Table 1.9.

Table 1.9. Sustainable development assessment methods in scientific literature (made by the author)

Author	Period analysed	Number of scientific sources analysed	Sustainable development assessment methods
Ness et al., 2007	1981–2005	89	(1) Integrated index; (2) product-related life cycle assessment; (3) integrated assessment: conceptual modelling, system dynamics, multi-criteria analysis, risk analysis, uncertainty analysis, vulnerability analysis, cost-benefit analysis, and impact assessment.
De Ridder et al., 2007	1967–2006	58	(1) Rating systems; (2) participation tools; (3) scripting tools; (4) sustainability accounting tools; (5) physical analysis tools and indicator suites; (6) modelling tools; (7) multi-criteria decision analysis.
Bueno et al., 2015	1980–2015	108	(1) Multi-criteria decision analysis; (2) rating system; (3) life cycle assessment; (4) frameworks, models and guidelines.
Saulick et al., 2023	2000–2021	38	(1) Application of established guidelines; (2) normative framework; (3) management system; (4) index system; and (5) rank/ranking system.

Based on the data presented in Table 1.9, it can be concluded that methods such as multi-criteria decision analysis, ranking systems, and integrated indices are preferred in the scientific literature for assessing sustainable development. However, in this case, including FinTech as a key factor is essential. A search in *Scopus* was conducted on 23 February 2024, utilising the keywords "FinTech", "sustainable", "development", and "method" in English-language articles, encompassing two data volumes: all fields and the article title, abstract, and keywords. In both instances, the domain was confined to "Economics, Econometrics, and Finance", accounting for 48% of all subject areas associated with the chosen keywords. The earliest article dates back to 2017, indicating that the search was not confined to a narrower timeframe. The extensive bibliographic search yielded 1,270 results from 2017 to 2024, whereas the more focused search produced 37 findings from 2020 to 2024.

The *WoS* Core Collection search was conducted on the same date, employing identical keywords, language, and data volume. This time, the search area was confined to "Economics", "Business Finance", and "Social Sciences–Mathematical Methods", encompassing 29% of all subject areas related to the selected keywords. The earliest article on this topic was published in 2020. The extensive bibliographic search produced 21 results from 2020 to 2024, whereas the focused search generated 18 results within the same timeframe. The search results were analysed utilising VOSviewer software. A keyword co-occurrence analysis assessed the selected keywords' co-occurrence and the links' overall strength. 1,270 *Scopus* articles were downloaded and uploaded to VOSviewer using the complete count method, whereby each co-occurrence link is assigned equal weight (Van Eck & Waltman, 2012). The selected threshold for the minimum frequency of a keyword was 30. Consequently, of the 5,109 keywords, 35 satisfied the threshold criteria. The cumulative strength of co-occurrence links with other keywords was computed for each of these keywords. Consequently, 35 keywords exhibiting the highest cumulative link strength were chosen. The identical procedure was reiterated for the *WoS* data. Nevertheless, their findings are excluded as they do not present any novel information.

Figure 1.4 illustrates a network visualisation of the co-occurrence analysis of the keywords "FinTech", "sustainable development", and "method" in *Scopus*, generated using VOSviewer software. Three clusters of keywords have been identified: the largest encompasses sustainable development, with 26 keywords; the second, smaller cluster pertains to the FinTech industry, with six keywords; and the smallest cluster relates to financial markets and trade, with three keywords. Notwithstanding the varying cluster sizes, the interconnections between sustainable development and FinTech are apparent when evaluating the quantity of links. Both "FinTech" and "sustainable development" are equally significant keywords

in academic literature, while "financial inclusion" and "economic growth" demonstrate the most important relevance.

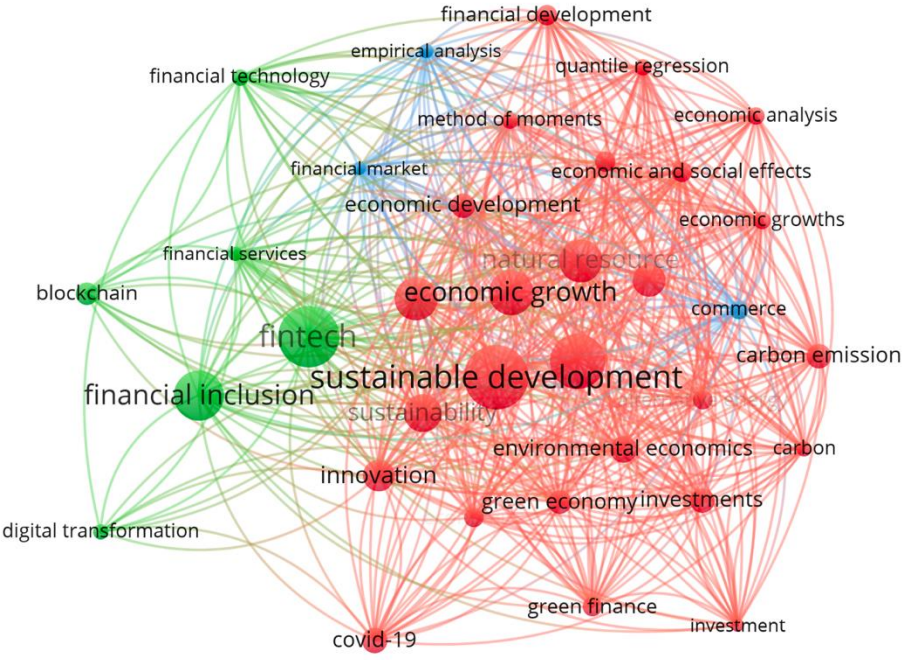


Fig. 1.4. Network visualisation of the co-occurrence analysis of the keywords "FinTech", "sustainable development", and "method" in *Scopus* (Source: compiled by the author utilising *Scopus* data through VOSviewer software, 2024)

This research identifies five methods closely related to FinTech and sustainable development through co-occurrence analysis, as illustrated in Figures 1.4 and 1.5 and detailed in Table 1.10. The aim is to ascertain the most appropriate approaches for analysing the interconnections between FinTech and sustainable development and to define the sustainable development of the FinTech industry.

The predominant methods identified in the scientific literature are "regression analysis" and "economic analysis". Nonetheless, it is crucial to assess the novelty factor at this juncture. Consequently, the overlay visualisation of the co-occurrence analysis of the keywords "FinTech", "sustainable development", and "method" by year in *Scopus* was executed utilising VOSviewer.

Table 1.10. Research methods derived from a *Scopus* bibliometric analysis utilising the keywords "FinTech," "sustainable development," and "method" (Source: compiled by the author based on *Scopus* data employing VOSviewer software, 2024)

No.	Keyword (research method)	Occurrences	No.	Keyword (research method)	Total link strength
1.	Regression analysis	44	1.	Economic analysis	294
2.	Economic analysis	38	2.	Regression analysis	291
3.	Quantile regression	36	3.	Method of moments	252
4.	Method of moments	35	4.	Quantile regression	213
5.	Empirical analysis	31	5.	Empirical analysis	177

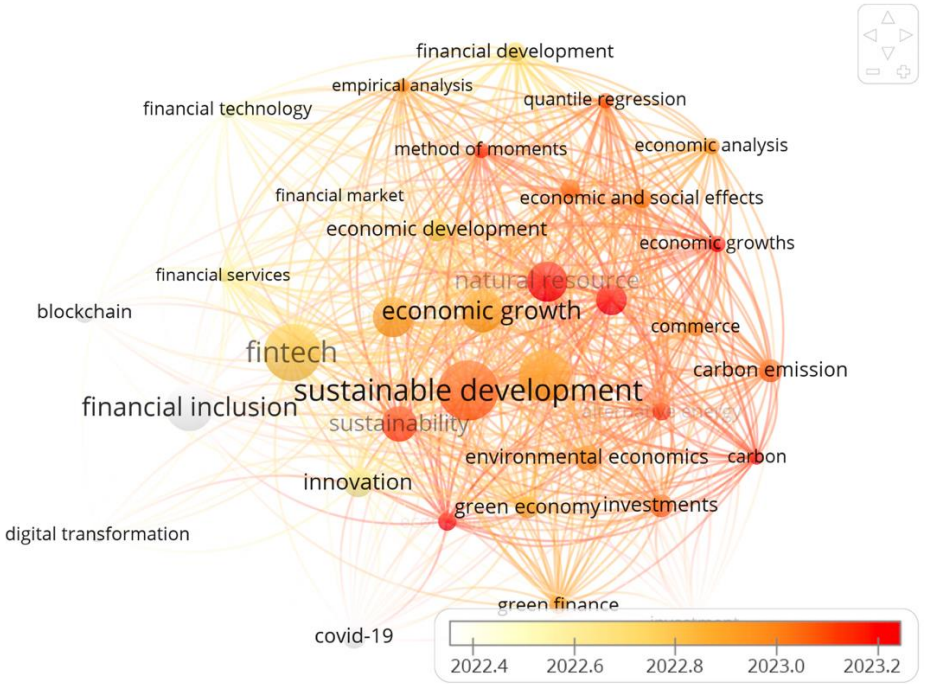


Fig. 1.5. Overlay visualisation depicting the co-occurrence analysis of the keywords "FinTech", "sustainable development", and "method" by year in *Scopus* (Source: compiled by the author utilising *Scopus* data through VOSviewer, 2024)

As demonstrated in Figure 1.5, the "method of moments" and "quantile regression" represent the most innovative concepts identified within the scientific literature. Consequently, a more comprehensive analysis of these keywords as

methods was conducted. To achieve this objective, the titles, abstracts, and keywords of 1,270 *Scopus* articles, selected based on the keywords "FinTech", "sustainable development", and "method", were refined using the keyword "method of moments". This search yielded 14 articles published between 2023 and 2024. A parallel search was subsequently conducted using the keyword "quantile regression", yielding 11 articles published between 2023 and 2024, 9 of which corresponded with the findings of the initial search. The analysis of these searches indicated that the "method of moments" and "quantile regression" are identical novel techniques known as method of moments quantile regression, abbreviated as MMQR (Lisha et al., 2023; Zhang, 2023; Chen & Liu, 2024; Lin et al., 2024; Lv et al., 2024; Ren, 2024; Wang et al., 2024; Xia & Liu, 2024; Zeng et al., 2024; Zhang & Cui, 2024). Two other less predominant methods that have been identified are the Generalised Method of Moments (GMM) (Kong & Xu, 2023; Taghizadeh-Hesary et al., 2023; Ullah et al., 2023; Zhang, 2023) and Two-stage Least Squares (2SLS) regression (Kashif et al., 2023; Ullah et al., 2023). It is noteworthy that the remaining advanced econometric techniques are employed in the literature only once, namely: fully modified ordinary least squares (FM-OLS) regression, dynamic ordinary least squares (DOLS) estimation, fixed effects ordinary least squares (FE-OLS), fixed effects (FE), feasible generalised least squares (FGLS), cross-quantile correlation, multivariate quantile-on-quantile regression, and sparse quantile models. *Web of Science* (*WoS*) employed the same search methodology, resulting in three articles that matched the search criteria. However, these articles overlapped with those found in the *Scopus* search. Thus, the *WoS* search did not produce any novel findings. This analysis indicates that the Method of Moments Quantile Regression is the most appropriate approach for examining the intersection of FinTech and sustainable development.

MMQR was presented to the scientific community in the Journal of Econometrics in 2019 by researchers Machado and Santos Silva, who examined the conditions under which regression quantiles can be estimated by estimating conditional means. This approach enables the application of methods specifically designed for estimating conditional means while also providing insights into the impact of regressors on the entire conditional distribution (Machado & Santos Silva, 2019). The relevance of its application to the intersection of FinTech and sustainable development warrants further examination, as detailed in Table 1.11, which outlines the comprehensive application of MMQR to research. An analysis of the extant literature reveals that all nine research articles employing MMQR have been published by the UK-based "Resources Policy" journal. It is, therefore, evident that the present journal is currently at the vanguard of research regarding the connections between FinTech, sustainable development and methods.

Table 1.11. Utilisation of the Method of Moments Quantile Regression to investigate the relationship between FinTech and sustainable development (Source: compiled by the author based on *Scopus* data, 2024)

Year	Authors	Research Subject	Research Sample	Scientific Journal
2024	Lin et al.	*Interconnections* among natural resources, FinTech, green technologies, and the sustainable environment in E7 countries.	2000–2020	Resources Policy
2024	Ren	*The role* of FinTech, Natural Resources, Green Growth, and Economic Development in promoting Environmental Sustainability.	N/A	Resources Policy
2024	Chen & Liu	The *potential impacts* of FinTech on the consumption-based material footprint in BRICS countries.	2001–2021	Resources Policy
2024	Lv et al.	*The role* of natural resources and green technologies in energy transition and CO2 emissions, critical indicators of sustainable development, is moderated by FinTech in resource-rich nations.	2000–2021	Resources Policy
2024	Xia & Liu	*The asymmetric impact* of FinTech, natural resources, and environmental regulations on the ecological footprint in G7 nations.	2000–2020	Resources Policy
2024	Zhang & Cui	*The asymmetric impact* of FinTech, regulatory frameworks, and urbanisation on natural resource rent in the G10 countries.	2001–2020	Resources Policy
2024	Wang et al.	FinTech and digital commerce's *role* in trade-adjusted resource consumption in E7 nations.	2005–2020	Resources Policy
2024	Zeng et al.	*The effectiveness* of FinTech and sustainable financing in facilitating low-carbon energy transitions; *the relationship* between these mechanisms and the necessities of biodiversity and sustainable natural resource utilisation in the framework of BRICS economies.	2000–2021	Resources Policy
2023	Lisha et al.	*The nexus* between sustainability, green innovations, FinTech, financial development, and natural resources within BRICS economies.	2000–2019	Resources Policy

Summarising the information presented in Table 1.11, it can be concluded that all the studies that applied MMQR were conducted to determine one of the following: role, potential, asymmetric impact, effectiveness, or interlinkages/nexus. Therefore, this method could be applied in studies on the sustainable development of the FinTech industry. However, statistics on indicators from selected countries for the 15- to 21-year period would be required to perform comprehensive research using MMQR.

1.7. Framework for Assessing the Sustainable Development of the Financial Technology Industry

To summarise, the scientific literature analysed in the dissertation's First Chapter indicates that the advancement of the FinTech industry is contingent upon favourable external environmental factors. Moreover, to delineate the sustainable development of the FinTech industry, it is essential to integrate widely recognised sustainability assessment indicators that serve as benchmarks for the SDGs.

It is therefore proposed that the sustainable development of the FinTech industry be defined as the coherent development of the FinTech industry in a favourable external environment that meets the digital financial inclusion needs of today's society without compromising the prospects for future prosperity. Following the definition above, a framework for assessing the sustainable development of the FinTech industry has been developed and is illustrated in Figure 1.6.

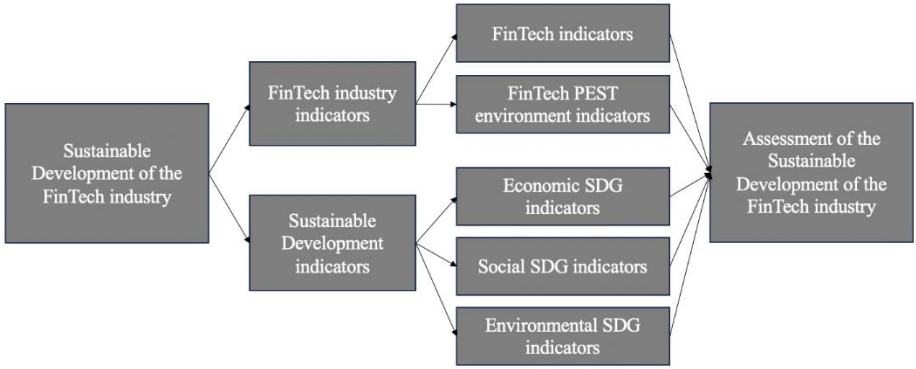


Fig. 1.6. Framework for assessing the sustainable development of the FinTech industry (made by the author)

In particular, the external environment of the FinTech industry should be assessed in terms of its favourability for development.

Second, the existence of a statistical relationship between the external environment of the FinTech industry and the selected SDG indicators should be assessed.

Thirdly, the impact of the SDG indicators on the FinTech industry's sustainable development should be assessed.

Finally, the FinTech industry, its external environment, and the SDG indicators should be integrated into a single tool.

1.8. Conclusions of the First Chapter and Formulation of the Dissertation Tasks

In summary of the literature review, the subsequent conclusions may be derived:

1. A detailed literature analysis has revealed the growth potential of the FinTech industry, showing that external environmental factors strongly influence its development.
2. A comparative analysis of the components of existing FinTech indices revealed their limitations regarding target group, indicators or environment. As a result, a framework for analysing the external environment of the FinTech industry based on PEST analysis is proposed.
3. The literature review highlighted the significance of the relationship between the FinTech industry and sustainable development, as the advancement of the FinTech industry has a positive impact on the expansion of digital financial inclusion. The literature review also revealed that the development of the FinTech industry has the most significant connections with SDG 4, SDG 8, SDG 9, and SDG 16.
4. An analysis of the scientific literature on sustainable development assessment methods revealed that multi-criteria decision analysis, ranking, and integrated indices are the preferred approaches in this context. The literature analysis using VOSviewer revealed that the Method of Moments Quantile Regression (MMQR) is the most recent approach to explore the linkages between FinTech and sustainable development.
5. While the development of the FinTech industry depends on the favourability of external environmental factors, defining the sustainable development of the FinTech industry is crucial. To achieve this, it is essential to incorporate indicators that assess sustainability, which are generally accepted as indicators of the Sustainable Development Goals (SDGs). Therefore, it is proposed that the sustainable development of the FinTech industry be defined as the *coherent development of the FinTech industry in a favourable external environment, responding to today's society's dig-*

ital financial inclusion needs without compromising the prospects for future prosperity. Based on this definition, a framework for assessing the sustainable development of the FinTech industry has been developed and is presented in this chapter.

In light of these conclusions, the subsequent objectives are delineated to fulfil the dissertation's aim:

1. To propose a methodology and a set of indicators for the quantitative assessment of the sustainable development of the FinTech industry at the national level.
2. To assess the applicability of the proposed methodology for the sustainable development of the FinTech industry through empirical research in selected countries.

2

Methodology of the Assessment of the Sustainable Development of the Financial Technology Industry

This chapter delineates the assessment of sustainable development within the FinTech industry, systematically outlining the methods for assessing the external environment of the FinTech industry, the statistical correlation between this environment and the attainment of Sustainable Development Goals, the impact of Sustainable Development Goals indicators on the FinTech industry's sustainable development, and the evaluation of the applicability of the sustainable development assessment framework for the FinTech industry. On the topic of this chapter, one publication was published (Pauliukevičienė & Stankevičienė, 2024).

2.1. Description of the Research Model to Assess the Sustainable Development of the Financial Technology Industry

The analysis of the scientific literature in the First Chapter of the dissertation revealed the lack of a methodology to assess the sustainable development of the FinTech industry.

Therefore, based on the main external and SDG factors that shape the sustainable development of the FinTech industry, as analysed in the scientific literature, a sequence of empirical studies for the dissertation was developed and presented in Figure 2.1.

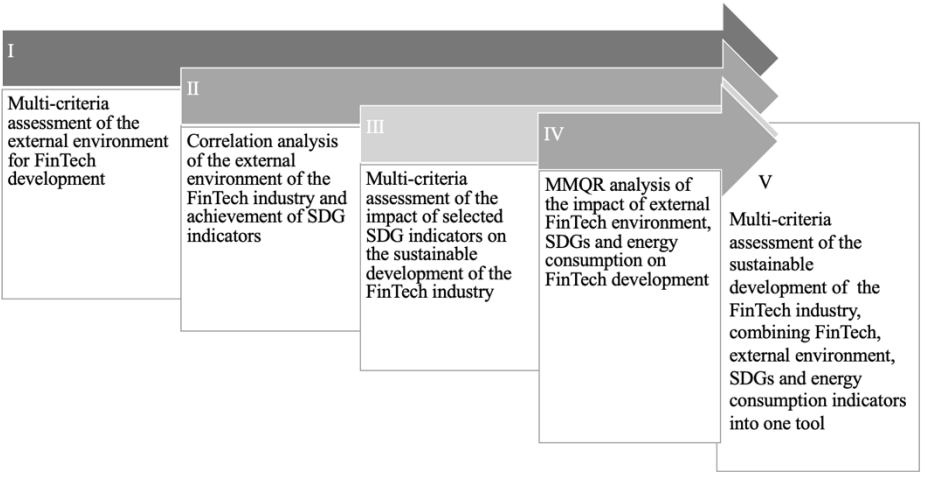


Fig. 2.1. Sequence of empirical studies of the dissertation (made by the author)

The dissertation comprises five empirical studies employing three methods: three multi-criteria assessments, one statistical assessment, and one applied regression assessment. Accordingly, the execution procedures of the three research methods selected are presented in the three sub-chapters below.

2.2. Multi-criteria Assessment Method in the Context of Assessing the Sustainable Development of the Financial Technology Industry

This sub-chapter introduces the multi-criteria assessment method in assessing the sustainable development of the FinTech industry, as applied in three out of five

empirical dissertation studies. Figure 2.2 presents the step-by-step execution procedure for the multi-criteria assessment method in evaluating the sustainable development of the FinTech industry.

A thorough literature analysis informed the selection of indicators for the multi-criteria evaluation, and the latest relevant and research-suitable data for these indicators were collected. To ensure data standardisation, the data were expressed as percentages.

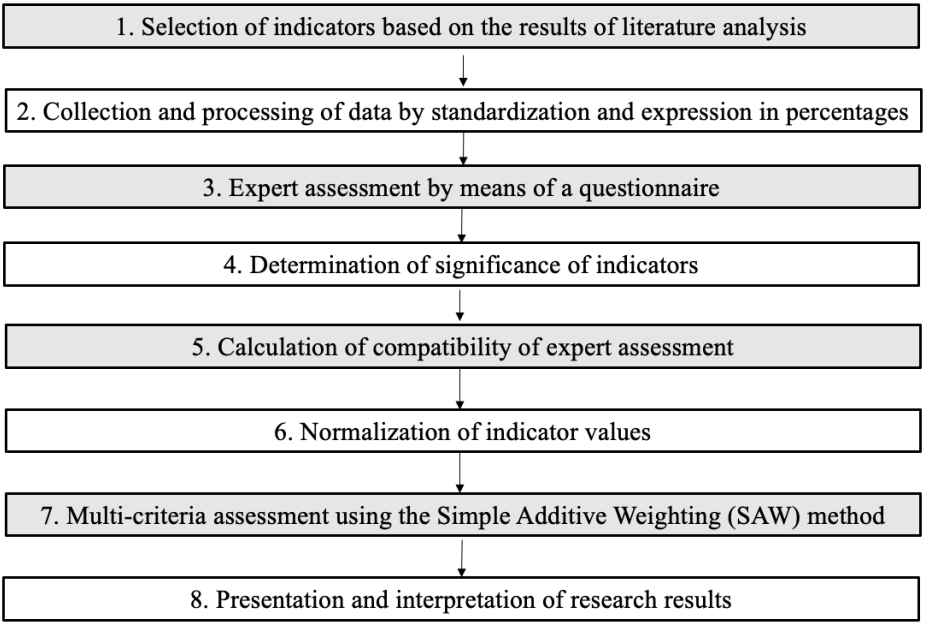


Fig. 2.2. Step-by-step execution procedure of the multi-criteria assessment method for assessing the sustainable development of the FinTech industry (made by the author)

As Gedvilaitė (2019) argued, expert assessments are frequently employed to ascertain the significance of indicators. An expert assessment was conducted through a questionnaire, establishing explicit prerequisites regarding qualifications and experience for the experts involved in each multi-criteria research.

The number of indicators was considered when grouping indicators across all three survey templates. Theoretical research and empirical evidence suggest that experts can reliably evaluate only a finite number of indicators, with a maximum of 12 (Ginevičius, 2009). Given that the total number of indicators exceeded 12 in all three cases when applying a multi-criteria method, they were linked to subsystems.

Kendall's Coefficient of Concordance (W) was calculated to ensure the reliability of expert evaluation results. This coefficient reflects the degree of compatibility among expert opinions, signifying the consensus among their assessments – the values of Kendall's Coefficient of Concordance range from 0 to 1. Values approaching 1 signify unanimous expert assessments, while values nearing 0 indicate substantial variability in expert evaluations. The calculation of the concordance is achieved through the implementation of Kendall's W coefficient. It is achieved by ranking each object, as outlined in Formulas 2.1 and 2.2. These formulas are applicable in scenarios where there are no ties present in the rankings of each expert:

$$W = \frac{12S}{n^2(m^3-m)}, \tag{2.1}$$

where n – the number of experts and m – is the number of objects to evaluate.

$$S = \sum_{i=1}^{m}\left(\sum_{j=1}^{n} r_{ij} - \overline{r}\right)^2, \tag{2.2}$$

where S – a sum-of-squares statistic over the row sums of ranks, m_i, r_{ij} – a sum of ranks, and $\overline{r}$ – an average of the sum of ranks.

The average of the experts' evaluations was computed to determine the importance of the indicators. Subsequently, the weights for the indicators were established, and the normalisation of the indicator values was executed. Given that the indicators are represented in various dimensions, they must be rendered mutually comparable to amalgamate them into a singular summarising metric (using a multi-criteria approach). It is accomplished by normalising the values of the indicators. The normalisation method is contingent upon the objectives of the multi-criteria evaluation. Ultimately, to establish the priority sequence of the variants of the examined phenomenon, the normalisation of the indicator values is executed using the formula (Ginevičius et al., 2015):

$$q_{ij}^{*} = \frac{q_{ij}}{\sum_{i=1}^{n} q_{ij}}, \tag{2.3}$$

where q_{ij}^{*} – the normalised value of the i indicator of the j variant, q_{ij} – the value of the i indicator of the j variant, and n – the number of indicators.

Following the standardisation of indicator values, a multi-criteria assessment method must be selected. There is a paucity of clear recommendations regarding selecting and implementing a particular method in a given context, and the optimal method remains undetermined. However, in the event of a complex, hierarchically structured system of indicators, as in this dissertation, it is deemed appropriate to utilise a simpler, less computationally intensive, yet more complex, multi-criteria evaluation method that does not compromise accuracy. The simple additive weighting (SAW) method is the most established, recognised, and exten-

sively utilised approach in multi-criteria assessment. It is attributed to its straightforwardness and capacity to evaluate complex phenomena represented by multiple indicators. Consequently, the SAW method was selected and employed as a multi-criteria decision support tool for expert evaluation in the empirical research of the dissertation. The values of the examined phenomenon, as per the SAW method, are computed using the formula (Hwang & Yoon, 1981):

$$K_p = \sum_{i=1}^{n} w_i q_{ij}^* , \tag{2.4}$$

where K_p – the significance of multi-criteria evaluation by the SAW method, w_i – the significance of the i indicator, and q_{ij}^* – the normalised value of the indicator.

Formula 2.4 stipulates that the values of multi-criteria assessment are derived by multiplying the significance of the indicators by their normalised values.

The SAW multi-criteria assessment method can be used when all indicators change in the same direction, for example, when maximised. Therefore, minimising indicators need to be transformed into maximising ones, and their transformation into uniform ones is done in the following way (Podvezko, 2011):

in the maximising case: $$r_{ij}^{max} = \frac{r^{min}}{r_{ij}} , \tag{2.5}$$

in the minimising case: $$r_{ij}^{min} = \frac{r^{max}}{r_{ij}} , \tag{2.6}$$

The optimal values of the maximised indicators are the highest, indicating that the condition of the phenomenon in question improves as the indicator value increases. In contrast, the ideal values of the indicators to be minimised are the least. It is because as the indicator's value increases, the condition of the phenomenon deteriorates.

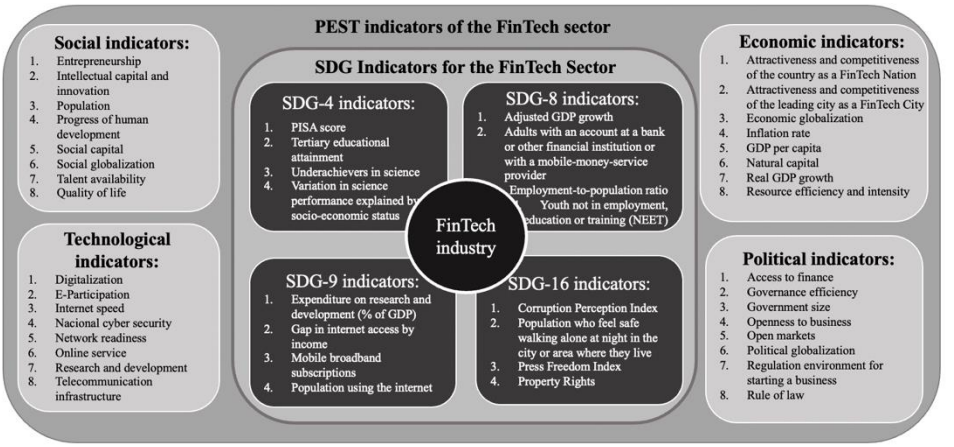


Fig. 2.3. Proposed set of indicators for the assessment of sustainable development of the FinTech industry (made by the author)

The results obtained are presented and interpreted in the following chapter of the dissertation. Figure 2.3 presents the suggested set of indicators for assessing the sustainable development of the FinTech industry.

The proposed set of indicators comprises PEST indicators specific to the FinTech sector and SDG indicators relevant to the FinTech industry. The list of indicators was obtained after a detailed analysis of the literature in the initial sub-chapter of this dissertation.

2.3. Correlation Analysis Method in the Context of the Relationship between the External Environment of the Financial Technology Industry and Sustainable Development Goals Indicators

This sub-chapter introduces the correlation analysis method used to assess the sustainable development of the FinTech industry, as applied in one of the five empirical dissertation studies. Figure 2.3 presents the step-by-step execution procedure for the statistical assessment method in evaluating the sustainable development of the FinTech industry. This procedure involves assessing the statistical link between the external environment of the FinTech industry and the achievement of Sustainable Development Goals.

For this research, data on the progress of achieving the SDGs were collected (Ziolo et al., 2021). A small sample of data was then used to compare the results obtained by applying two different correlation calculation methods.

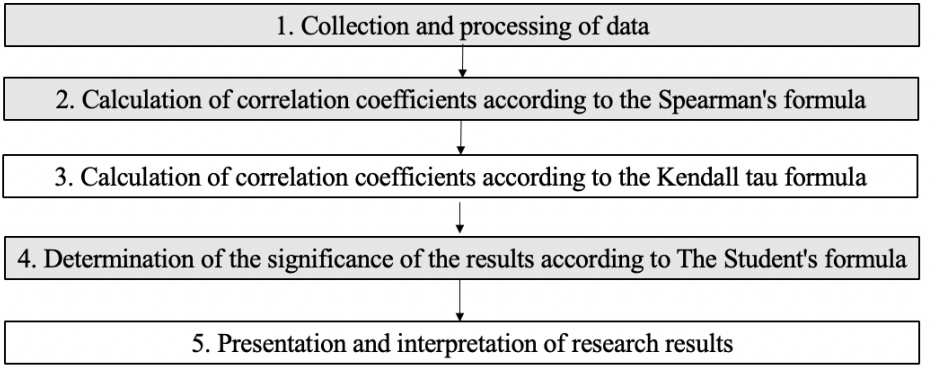


Fig. 2.4. Step-by-step execution procedure of the statistical assessment method in the context of assessing the sustainable development of the FinTech industry (made by the author)

Spearman's rank correlation coefficient is presented as Formula 2.7:

$$r_s = 1 - \frac{6\sum D^2}{n(n^2-1)}, \tag{2.7}$$

where D – the difference between ranks and n – the total number of data pairs.

The Kendall's tau rank correlation coefficient is expressed as Formula 2.8:

$$\tau = \frac{n_c - n_d}{n(n-1)/2}, \tag{2.8}$$

where n_c – the number of concordant pairs, n_d – the number of discordant pairs, and n – the total number of data pairs.

The Student's statistical formula was employed to ascertain the significance of the correlation coefficient, delineated as Formula 2.9:

$$t = \frac{r}{\sqrt{1-r^2}}\sqrt{n-2}, \tag{2.9}$$

where r – the value of the correlation coefficient and n – the number of data pairs in the sample.

Kendall's correlation coefficient is easier to interpret than Spearman's correlation coefficient (Venclovienė, 2010). It can more accurately estimate the true correlation in the general population and is, therefore, more generalisable (Field et al., 2012). It is also more suitable for small samples with repeated values (Field et al., 2012). In absolute terms, Kendall's correlation coefficient is slightly lower than Spearman's, but the conclusions drawn are equally significant if the coefficients are used correctly (Čekanavičius & Murauskas, 2008). Both correlation coefficients are therefore calculated.

The results were statistically processed using the Microsoft Excel software.

2.4. Regression Analysis in the Context of the Financial Technology Industry Environment, Sustainable Development Goals, and Energy Consumption Impacts on the Financial Technology Industry Development

This sub-chapter introduces the regression analysis method, the Method of Moments Quantile Regression (MMQR). The context in which the technique is utilised is the FinTech industry, with particular reference to its environmental and sustainable development goals (SDGs) and energy consumption impacts on FinTech industry development. The MMQR is applied in one out of five empirical dissertation studies.

The subsequent step-by-step execution of the applied regression analysis method, in the context of the impact of the FinTech industry's environment, SDGs, and energy consumption on FinTech industry development, is presented in Figure 2.4.

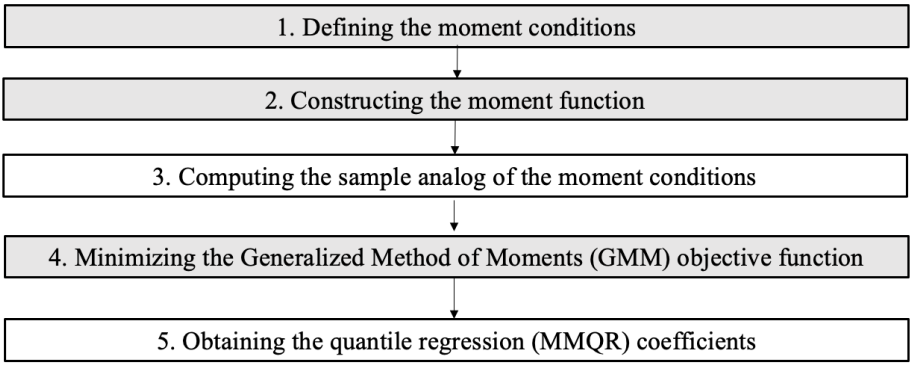


Fig. 2.5. Step-by-step execution procedure of the Method of Moments Quantile Regression (MMQR) in the context of the FinTech industry's environment, SDG and energy consumption impacts on FinTech industry development (made by the author)

The traditional Quantile Regression (QR) model, initially introduced by Koenker and Bassett in 1978, can be seen as a generalisation of the Ordinary Least Squares (OLS) approach in linear regression. While the OLS approach focuses on estimating the relationship between predictor variables and the mean of the dependent variable, the QR model provides the flexibility to analyse how predictors are associated with various quantiles of the dependent variable's distribution. Mathematically, for a random variable Y, its probability distribution function can be described as follows (Koenker & Hallock, 2001):

$$F(Y) = P(Y \leq y) \tag{2.10}$$

and τ quantile of Y can be defined as

$$Q(\tau) = \inf\{y: F(y) \geq \tau), \tag{2.11}$$

where $0 < \tau < 1$. Key points of interest include the first quartile Q (0.25), the median Q (0.5), the third quartile Q (0.75), as well as the first and ninth deciles, Q (0.1) and Q (0.9). After including the independent variable in the QR model:

$$Q_Y(\tau|X = x) = \beta_\tau x_i'. \tag{2.12}$$

To estimate the coefficients for the explanatory variables, the following minimisation problem must be solved:

$$\hat{\beta}_\tau = argmin \sum_{i=1}^{n} \rho_\tau(y_i - \beta x_i'), \tag{2.13}$$

where $\rho_\tau(u) = u(\tau - I(u < 0))$, u represents the residual, or the difference between the observed and predicted values, in the context of quantile regression. I is the indicator function. The function $\rho_\tau(u)$ assigns different weights to positive and negative residuals, allowing quantile regression to focus on specific parts of the conditional distribution of the response variable.

The Method of Moments Quantile Regression (MMQR) methodology is an extension of traditional quantile regression, leveraging the method of moments principle for parameter estimation. While standard quantile regression minimises the quantile loss function, MMQR constructs and solves moment conditions derived from the underlying quantile regression equations. The fundamental principle of MMQR is to define a set of moment conditions that the quantile regression coefficients must satisfy. For a given quantile τ, the moment conditions are derived from the property of quantiles (Koenker, 2005):

$$E\left[\psi_\tau\left(y - x^\top \beta(\tau)\right) \cdot x\right] = 0, \tag{2.14}$$

where $\psi_\tau(u) = \tau - I(u < 0)$ is the function of the quantile loss and $x^\top$ the transpose of the vector of explanatory variables x.

The estimation process involves solving the moment conditions for the parameter $\beta(\tau)$. It is achieved through the Generalised Method of Moments (GMM). The steps involved are as follows (Greene, 2018):

1. Moment Function Construction:

$$g(y, x; \beta(\tau)) = (\tau - I(y - x^\top \beta(\tau) < 0)) \cdot x. \tag{2.15}$$

2. Computation of the sample analogue of the moment conditions:

$$\hat{g}\left(\beta(\tau)\right) = \frac{1}{n} \sum_{i=1}^{n} \left(\tau - I\left(y_i - x_i^\top \beta(\tau) < 0\right)\right) \cdot x_i. \tag{2.16}$$

3. GMM Estimation – solution for $\beta(\tau)$ by minimising the GMM objective function:

$$J(\beta(\tau)) = \hat{g}(\beta(\tau))^\top W \hat{g}(\beta(\tau)), \tag{2.17}$$

where W is a positive-definite weighting matrix – the inverse of the covariance matrix of $\hat{g}(\beta(\tau))$.

The thesis applies the latest version of the MMQR calculations for different quartiles (0.05, 0.25, 0.50, 0.75, and 0.95) as pairwise regression (Machado & Silva, 2019), as the aim is to assess the impact of each index or indicator on FinTech separately. The results were statistically processed using Microsoft Excel and R software.

2.5. Data Description and Sources

The annual panel data of 15 European countries across four geographic European regions (United Nations, 1999) for 12 years was selected, spanning from 2012 to 2023: Eastern Europe (Poland), Northern Europe (Denmark, Estonia, Finland, Latvia, Lithuania, Sweden, and the UK), Southern Europe (Italy, Portugal, and Spain), and Western Europe (Austria, France, Germany, and the Netherlands). All the countries selected reflect the three key financial markets: frontier/emerging small countries with an illiquid stock market consisting of thinly traded shares (Estonia, Latvia, and Lithuania), an emerging country (Poland) that has some characteristics of a developed market but does not fully comply with its standards, and developed countries (Austria, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom) with the most advanced economies and capital markets. The selection of 12 years for the research was based on the FinTech growth trends presented in Figure 1 and the availability of the indicators included. It is because some indicators or indices related to technological developments have been recorded or calculated since 2012.

The research was conducted in three stages. Initially, the paired estimates of the dependent FinTech Index (FIN) and the independent indices (FinTech External Environment Index [PEST], Sustainable Development Index [SDG], and environmental factors [SDG 7, ENERGY]) were explored through the MMQR. The descriptions of these variables, along with their corresponding measurement units, are provided in Tables 2.1, 2.2, and 2.3.

Table 2.1. Variable description (made by the author)

Variables	Acronyms	Measurement units	Source
FinTech Index	FIN	PCA Index using mobile cellular subscriptions (per 100 people), individuals using the Internet (% of population), fixed broadband subscriptions (per 100 people), domestic credit to private sector by banks (% of GDP), and the Financial Development Index	Self-estimated from WorldBank and IMF databases
FinTech External Environment Index	PEST	PCA Index using the measurement units from Table 3	Self-estimated from Table 3

End of Table 2.1

Variables	Acronyms	Measurement units	Source
Sustainable Development Index	SDG	PCA Index using the SDG 4, SDG 8, SDG 9, and SDG 16 measurement units from Table 4	Self-estimated from the UN SDG database (Sachs et al., 2024)
Sustainable Development Goal No. 7 Index	SDG 7	PCA Index using two SDG 7 indicators: CO2 emissions from fuel combustion per total electricity output (MtCO2/TWh), renewable energy share in total final energy consumption (%)	Self-estimated from the UN SDG database (Sachs et al., 2024)
Energy Consumption	ENERGY	Final energy consumption by commercial and public services (standard international energy product)	Eurostat database

The FinTech Index (FIN) comprises five indicators, the FinTech External Environment Index (PEST) consists of 21 indicators, the Sustainable Development Index (SDG) consists of 16 indicators, the Sustainable Development Goal 7 Index (SDG 7) consists of two indicators, and Energy consumption (ENERGY) utilises one indicator. It is also important to note that the FinTech External Environment Index (PEST) comprises indicators of the political, economic, social, and technological environment, as detailed in Table 2.2.

Table 2.2. PEST variable description (made by the author)

FinTech external environment variable components	Acronyms	Measurement units	Source
Political environment	POL	PCA Index using governance, government size, open markets, political globalisation, regulatory efficiency, and rule of law scores	Self-estimated from GSCI, IEF, and KOF databases
Economic environment	ECON	PCA Index using Inflation, GDP deflator (annual %), economic globalisation, natural capital, resource intensity scores, insurance and financial services (% of service imports,	Self-estimated from WorldBank, KOF, and GSCI databases

End of Table 2.2

FinTech external environment variable components	Acronyms	Measurement units	Source
		Balance of Payments), and insurance and financial services (% of service exports, Balance of Payments)	
Social environment	SOC	PCA Index using Population (total), social capital, intellectual capital, social globalisation scores, and the labour force with advanced education (% of total working-age population with advanced education)	Self-estimated from WorldBank, KOF, and GSCI databases
Technological environment	TECH	PCA Index using Network Readiness Index, E-Government Development Index, E-Participation Index, and high-technology exports (current billion USD)	Self-estimated from UN E-Government Knowledgebase, Portulans Institute database, WorldBank databank

Meanwhile, the Sustainable Development Index (SDG) comprises indicators for the four Sustainable Development Goals on FinTech development, as outlined in Table 2.3. The second sub-chapter of the research examined the changes in the paired estimates of the FinTech Index and the SDG Index components (SDG 4, SDG 8, SDG 9, and SDG 16) in the MMQR estimates.

Table 2.3. SDG variable description (made by the author)

SDG variable components	Acronyms	Measurement units	Source
Quality education	SDG 4	PCA Index using tertiary educational attainment (% of the population aged 25 to 34), PISA score, variation in mathematics performance explained by socio-economic status (%), and underachievers in mathematics (% of 15-year-olds)	Self-estimated from the UN SDG database (Sachs et al., 2024)

End of Table 2.3

SDG variable components	Acronyms	Measurement units	Source
Decent work and economic growth	SDG 8	PCA Index using adjusted GDP growth (%), adults with an account at a bank or other financial institution or with a mobile-money-service provider (% of the population aged 15 or over), employment-to-population ratio (%), and youth not in employment, education or training (NEET) (% of the population aged 15 to 24)	Self-estimated from the UN SDG database (Sachs et al., 2024)
Industry, innovation and infrastructure	SDG 9	PCA Index using Expenditure on research and development (% of GDP), The Times Higher Education Universities Ranking: average score of top 3 universities, researchers (per 1,000 employed population), and triadic patent families filed (per million population)	Self-estimated from the UN SDG database (Sachs et al., 2024)
Peace, justice and strong institutions	SDG 16	PCA Index using Crime is Effectively Controlled, Corruption Perceptions Index, Press Freedom Index, and timeliness of administrative proceedings	Self-estimated from the UN SDG database (Sachs et al., 2024)

Finally, the third sub-chapter of the research examines the changes in the MMQR estimates of the paired FinTech Index and SDG 4 Index subcomponents (specific to SDG 4 indicators) and the paired FinTech Index and SDG 16 Index subcomponents (specific to SDG 16 indicators).

However, the FinTech Index (FIN) was constructed as a principal component analysis (PCA) index, and the weights of its components have not yet been established in the scientific literature. Two versions of the FinTech Index were employed for the research to address this: FIN I and FIN II.

- FIN I Index is constructed when the weights of all five indicators in Table 2.1 are proportional.
- The FIN II Index is constructed when the weights are not proportional and are determined according to the recurrence of the Index's sub-indicators in the most recent scientific literature in Table 2.5. The greater the frequency with which an indicator is cited in scientific literature, the more significant its assigned weight.

Table 2.4. Weights of FIN I and FIN II Indexes (made by the author)

FinTech Index	Indicators				
	Internet users (% of the total population)	Mobile cellular subscription (per 100 people)	Fixed Broad Band subscription (per 100 people)	Financial development index (IMF)	Domestic credit by the banking sector (% of GDP)
FIN I	0.200	0.200	0.200	0.200	0.200
FIN II	0.333	0.333	0.067	0.167	0.100
	Weights				

Table 2.5. Main components of the FinTech PCA index in recent academic literature (made by the author)

Author / Indicator	Internet users (% of the total population)	Mobile cellular subscription (per 100 people)	Fixed Broad Band subscription (per 100 people)	Financial development index (IMF)	Domestic credit by the banking sector (% of GDP)
Chen & Liu (2024)	+	+		+	
Gao et al. (2024)	+	+		+	
Liu & Yang (2024)	+	+			+
Lv et al. (2024)	+	+	+		
Razzaq (2024)	+	+		+	
Wang et al. (2024)	+	+			+
Wei et al. (2024)	+	+			+
Xia & Liu (2024)	+	+	+		
Xu et al. (2024)	+	+			+
Zhang & Cui (2024)	+	+			+

Therefore, FIN I provide a more generalised insight without prioritisation, and FIN II offers a more nuanced understanding, aligning more closely with

prevailing scientific insights, highlighting the importance of "mobile cellular subscriptions" and "individuals using the Internet" indicators.

The data were collected, organised, processed, and normalised in Microsoft Excel, and the MMQR calculations were performed using R software for statistical computing. The graphs were then prepared in Microsoft Excel.

2.6. Conclusions of the Second Chapter

1. Examining the scientific literature in the dissertation's initial chapter has revealed two principal issues. There is currently no consensus among scientists on the definition of sustainable development within the FinTech industry. Secondly, there is a dearth of research assessing the sustainable development of the FinTech industry, both in the scientific literature and in practice. In light of these findings, the First Chapter of the dissertation proposes a definition of sustainable development for the FinTech industry and a framework for assessing its sustainable development based on this definition. The subsequent chapter of the dissertation then proposed a methodology based on this framework for the quantitative assessment of the sustainable development of the FinTech industry. This methodology integrates FinTech, the external (PEST) environment of FinTech, the Sustainable Development Goals (SDGs), and energy consumption.
2. Based on the main external environment and sustainable development factors that shape the sustainable development of the FinTech industry, a sequence of empirical studies of the dissertation was developed and presented, consisting of five empirical studies using three different methods: three multi-criteria assessments, one statistical assessment and one applied regression analysis. Based on the comprehensive review of scientific literature, the most suitable methods identified are the Simple Additive Weighting (SAW) multi-criteria decision-making method, Kendall's and Spearman's correlation coefficients, and the Method of Moments Quantile Regression (MMQR).
3. A set of indicators has been established for the integrated assessment of the sustainable development of the FinTech industry. The following groups are included: FinTech indicators, indicators of FinTech's political, economic, social, and technological environment, economic, social, and environmental sustainability indicators and energy consumption.

3

Assessment of the Sustainable Development of the Financial Technology Industry

This chapter employs the author's methodology to assess the sustainable development of the FinTech industry. The chapter uses a multi-criteria assessment of the external environment's propensity to facilitate the development of the FinTech industry, alongside a statistical evaluation of the relationship between the external environment of the FinTech industry and selected SDG indicators, multi-criteria assessment of the impact of the selected SDG indicators on the sustainable development of the FinTech industry, MMRQ analysis of impact of political, economic, social, technological, environmental indicators on FinTech development, and multi-criteria assessment of the sustainable development of the FinTech industry by combining external indicators of the FinTech industry environment with selected SDG and energy consumption indicators into one tool, an overview of the current situation of sustainable development of the FinTech industry in selected countries and recommendations for the future to achieve sustainable further development of the FinTech industry at the level of the countries. Three publications were published on the topic of this chapter (Pauliukevičienė & Stankevičienė, 2025; Pauliukevičienė & Stankevičienė, 2022; Pauliukevičienė & Stankevičienė, 2021).

3.1. Multi-criteria Assessment of the External Environment's Favourability for the Development of the Financial Technology Industry

This sub-chapter presents a multi-criteria assessment of the external environment's favourability for the development of the FinTech industry, along with its results.

The practical applicability of the assessment tool for the FinTech industry environment, as outlined in Table 1.3 of Sub-chapter 1.2, was substantiated through an analysis of 15 European countries across four distinct regions (UN Statistics Division, 2019), reflecting the three key financial markets:

1) Eastern Europe: Poland is an emerging country.
2) Northern Europe: Denmark, Finland, Sweden, and the United Kingdom, as developed countries and Estonia, Latvia, and Lithuania, as frontier countries.
3) Southern Europe: Italy, Portugal, and Spain as developed countries.
4) Western Europe: Austria, France, Germany, and the Netherlands as developed countries.

Quantitative empirical research was conducted by analysing publicly available data on external environmental indicators for these countries from 2020. The rankings of countries in international assessments were transformed into a percentage format, normalised, and displayed in Tables 3.1, 3.2, 3.3, and 3.4 for subsequent calculations.

Table 3.1. Normalised values of FinTech political environment indicators and their significance as assessed by experts (made by the author)

Political environment	P1	P2	P3	P4	P5	P6	P7	P8
Austria	0.077	0.097	0.053	0.101	0.094	0.091	0.049	0.097
Denmark	0.114	0.099	0.056	0.120	0.100	0.089	0.113	0.100
Estonia	0.114	0.105	0.271	0.081	0.096	0.067	0.137	0.094
Finland	0.088	0.093	0.082	0.111	0.098	0.091	0.124	0.101
France	0.069	0.083	0.011	0.076	0.086	0.095	0.119	0.090
Germany	0.114	0.103	0.130	0.097	0.089	0.094	0.051	0.090
Italy	0.057	0.086	0.045	0.064	0.078	0.094	0.072	0.082
Latvia	0.141	0.103	0.252	0.054	0.088	0.065	0.128	0.094
Lithuania	0.114	0.092	0.347	0.069	0.085	0.067	0.122	0.088
Netherlands	0.057	0.090	0.133	0.116	0.100	0.093	0.130	0.096

End of Table 3.1

Political environment	P1	P2	P3	P4	P5	P6	P7	P8
Poland	0.123	0.102	0.204	0.071	0.090	0.084	0.048	0.074
Portugal	0.057	0.099	0.106	0.088	0.078	0.090	0.099	0.086
Spain	0.088	0.087	0.101	0.078	0.094	0.086	0.073	0.086
Sweden	0.088	0.061	0.072	0.114	0.098	0.092	0.118	0.098
United Kingdom	0.123	0.091	0.141	0.080	0.095	0.093	0.134	0.095
Significance of an Indicator	0.110	0.126	0.101	0.194	0.138	0.063	0.180	0.098

Table 3.2. Normalised values of FinTech economic environment indicators and their importance as assessed by experts (made by the author)

Economic environment	E1	E2	E3	E4	E5	E6	E7	E8
Austria	0.076	0.063	0.096	0.077	0.098	0.116	0.088	0.059
Denmark	0.086	0.082	0.098	0.100	0.099	0.119	0.152	0.129
Estonia	0.105	0.089	0.099	0.104	0.084	0.177	0.126	0.063
Finland	0.097	0.078	0.097	0.091	0.094	0.161	0.162	0.097
France	0.093	0.110	0.090	0.098	0.092	0.105	0.043	0.106
Germany	0.103	0.114	0.091	0.097	0.096	0.023	0.104	0.082
Italy	0.078	0.087	0.080	0.105	0.087	0.050	0.036	0.091
Latvia	0.030	0.052	0.092	0.092	0.080	0.172	0.103	0.123
Lithuania	0.116	0.100	0.090	0.075	0.086	0.149	0.200	0.124
Netherlands	0.112	0.103	0.103	0.076	0.099	0.025	0.123	0.056
Poland	0.068	0.088	0.082	0.042	0.082	0.068	0.169	0.028
Portugal	0.070	0.067	0.091	0.106	0.082	0.087	0.040	0.075
Spain	0.099	0.097	0.087	0.111	0.084	0.077	0.021	0.077
Sweden	0.110	0.096	0.097	0.086	0.095	0.175	0.144	0.127
United Kingdom	0.120	0.119	0.093	0.086	0.091	0.018	0.042	0.130
Significance of an Indicator	0.171	0.151	0.143	0.110	0.136	0.085	0.091	0.113

Table 3.3. Normalised values of FinTech social environment indicators and their importance as assessed by experts (made by the author)

Social environment	S1	S2	S3	S4	S5	S6	S7	S8
Austria	0.088	0.091	0.067	0.092	0.099	0.098	0.070	0.094
Denmark	0.093	0.099	0.056	0.096	0.094	0.096	0.119	0.107
Estonia	0.052	0.088	0.028	0.086	0.096	0.090	0.110	0.042
Finland	0.090	0.096	0.055	0.096	0.100	0.094	0.105	0.097
France	0.091	0.091	0.115	0.088	0.089	0.093	0.065	0.086
Germany	0.113	0.093	0.117	0.098	0.091	0.099	0.107	0.095
Italy	0.083	0.080	0.115	0.086	0.083	0.080	0.051	0.079
Latvia	0.039	0.078	0.032	0.082	0.079	0.081	0.093	0.036
Lithuania	0.041	0.076	0.038	0.083	0.075	0.091	0.068	0.039
Netherlands	0.099	0.092	0.085	0.097	0.095	0.093	0.123	0.101
Poland	0.074	0.090	0.104	0.083	0.083	0.070	0.049	0.077
Portugal	0.074	0.087	0.072	0.081	0.093	0.082	0.100	0.085
Spain	0.082	0.074	0.110	0.088	0.092	0.086	0.089	0.083
Sweden	0.104	0.100	0.073	0.098	0.100	0.100	0.121	0.106
United Kingdom	0.108	0.098	0.116	0.095	0.078	0.102	0.124	0.092
Significance of an Indicator	0.136	0.156	0.081	0.116	0.104	0.079	0.195	0.133

Table 3.4. Normalised values of indicators of the FinTech technological environment and their importance as evaluated by experts (made by the author)

Technological environment	T1	T2	T3	T4	T5	T6	T7	T8
Austria	0.091	0.102	0.087	0.085	0.090	0.092	0.090	0.086
Denmark	0.112	0.099	0.103	0.094	0.102	0.099	0.097	0.103
Estonia	0.092	0.105	0.085	0.100	0.086	0.098	0.070	0.098
Finland	0.113	0.098	0.092	0.096	0.099	0.098	0.096	0.096
France	0.086	0.094	0.098	0.096	0.091	0.090	0.094	0.092
Germany	0.095	0.072	0.090	0.093	0.097	0.087	0.098	0.093
Italy	0.066	0.083	0.080	0.089	0.079	0.081	0.085	0.080
Latvia	0.075	0.055	0.079	0.087	0.075	0.074	0.062	0.089
Lithuania	0.082	0.071	0.090	0.099	0.081	0.089	0.068	0.087
Netherlands	0.109	0.101	0.099	0.093	0.101	0.095	0.095	0.100

End of Table 3.4

Technological environment	T1	T2	T3	T4	T5	T6	T7	T8
Poland	0.074	0.100	0.085	0.098	0.078	0.087	0.075	0.082
Portugal	0.076	0.082	0.086	0.086	0.080	0.082	0.083	0.081
Spain	0.079	0.085	0.096	0.098	0.084	0.091	0.086	0.090
Sweden	0.107	0.082	0.100	0.074	0.103	0.097	0.099	0.101
United Kingdom	0.101	0.102	0.084	0.090	0.096	0.096	0.096	0.097
Significance of an Indicator	0.173	0.083	0.136	0.144	0.115	0.086	0.114	0.150

The number of indicators was considered when grouping them in the survey template. Theoretical research and empirical evidence indicate that specialists can precisely evaluate a maximum of 12 indicators. Since the total number of indicators addressed in the sub-chapter surpasses 12, they were categorised into four subsystems reflecting distinct external environments. Consequently, experts were requested to:

1) Evaluate the importance of eight indicators for advancing the FinTech political landscape in one hundred segments.
2) Evaluate the importance of eight indicators for advancing the FinTech economic landscape in one hundred segments.
3) Evaluate the importance of eight indicators for advancing the FinTech social ecosystem in one hundred segments.
4) Evaluate the importance of eight indicators for advancing the FinTech technological ecosystem in one hundred segments.
5) Evaluate the significance of four subgroups within the FinTech industry's development, focusing on the evolution of four distinct external environments in one hundred components.

The importance of the indicators was assessed through expert evaluation, i.e., a survey of experts using an e-questionnaire. Eight experts from the business, science, and public sectors, each possessing a minimum of five years' experience in a senior management role, contributed to the findings of this research. The results are presented in Tables 3.1, 3.2, 3.3, and 3.4.

Kendall's Coefficient of Concordance (W) was computed to yield dependable expert evaluation results, as shown in Table 3.5. The assessment of the external environment components indicated a W range of 0.45 to 0.61, signifying a degree of consensus among experts concerning the political, economic, social, and technological landscapes of the FinTech industry.

Table 3.5. Compatibility of Expert Evaluation (made by the author)

Components of the External Environment	Kendall's Coefficient of Concordance (W)
Political environment	0.58
Economic environment	0.45
Social environment	0.61
Technological environment	0.55
Overall external environment	0.17

However, evaluating the overall external environment (W) yields an outcome of 0.17, indicating that the consensus among experts is inadequate. The assessed consistency of the experts' opinions does not suggest that their evaluations are exceptional. Consequently, this part of the research should be refined and repeated.

In light of the findings of the expert's evaluation of the importance of the indicators, the following conclusions can be drawn:

- The principal indicators for evaluating the conduciveness of the political environment for advancing the FinTech industry in the country are business openness and the regulatory framework for business initiation. In contrast, the least consequential indicators are the rule of law and political globalisation.
- The primary indicators for evaluating the conducive economic environment for the development of the FinTech industry in the country are its attractiveness and competitiveness as a FinTech nation, along with the prominence of its leading city as a FinTech hub. The least consequential indicators are natural capital and real GDP growth.
- The primary indicators for evaluating the social environment's capacity to foster the FinTech industry's growth in a specific country are talent availability, intellectual capital, and innovation. Conversely, population and social globalisation are the least significant indicators.
- The foremost indicators for evaluating the technological environment's capacity to foster the growth of the FinTech industry in the country are digitalisation and telecommunication infrastructure, as they serve as the principal catalysts. Conversely, e-participation and online services emerge as the least significant indicators.
- The most critical environment for evaluating the country's context regarding the advancement of the FinTech industry is technological, whereas the least critical environment is social.

Each country's performance in various environments was evaluated using a multi-criteria assessment, specifically the SAW method. The indicators presented

in Tables 3.1, 3.2, 3.3 and 3.4 were multiplied by their respective weights, as determined by experts, and the resulting values were then summed for each environment. Table 3.6 presents the findings of an empirical research regarding the existing values of the FinTech sector environment assessment across 15 countries.

Table 3.6. Results of an empirical research utilising the multi-criteria decision support method SAW (made by the author)

Country / Environment	Political	Economic	Social	Technological	Total Environment
Austria	0.082	0.083	0.086	0.090	0.085
Denmark	0.102	0.104	0.099	0.102	0.102
Estonia	0.119	0.102	0.077	0.091	0.098
Finland	0.102	0.104	0.094	0.099	0.100
France	0.081	0.093	0.087	0.092	0.089
Germany	0.093	0.092	0.103	0.092	0.094
Italy	0.071	0.079	0.078	0.080	0.077
Latvia	0.110	0.085	0.067	0.076	0.085
Lithuania	0.118	0.113	0.064	0.084	0.095
Netherlands	0.105	0.091	0.101	0.100	0.099
Poland	0.094	0.077	0.076	0.084	0.083
Portugal	0.089	0.077	0.086	0.082	0.083
Spain	0.085	0.085	0.087	0.089	0.086
Sweden	0.096	0.112	0.103	0.096	0.101
United Kingdom	0.106	0.094	0.103	0.095	0.099
Significance of an Indicator	0.245	0.239	0.215	0.301	

Research indicates that:

- Northern Europe presents the most advantageous political climate for advancing the FinTech industry, with the Baltic States (Estonia, Lithuania, and Latvia) occupying the top three ranks, followed by the United Kingdom, the Netherlands, Denmark, Finland, and Sweden. The most unfavourable political environment for FinTech development exists in Austria, France, and Italy.
- Northern Europe presents the most advantageous economic conditions for advancing the FinTech industry, with Lithuania, Sweden, and Denmark at the forefront. Conversely, the Eastern and Southern European

regions, notably Italy, Poland, and Portugal, are identified as having less favourable economic conditions for FinTech development.

Table 3.7. Values of the assessment of FinTech political, economic, social and technological environments, arranged in descending order (made by the author)

Rank	Political environment		Economic environment	
1	Estonia	0.119	Lithuania	0.113
2	Lithuania	0.118	Sweden	0.112
3	Latvia	0.110	Denmark	0.104
4	UK	0.106	Finland	0.104
5	Netherlands	0.105	Estonia	0.102
6	Denmark	0.102	UK	0.094
7	Finland	0.102	France	0.093
8	Sweden	0.096	Germany	0.092
9	Poland	0.094	Netherlands	0.091
10	Germany	0.093	Latvia	0.085
11	Portugal	0.089	Spain	0.085
12	Spain	0.085	Austria	0.083
13	Austria	0.082	Italy	0.079
14	France	0.081	Poland	0.077
15	Italy	0.071	Portugal	0.077
Rank	Social environment		Technological environment	
1	Sweden	0.103	Denmark	0.102
2	UK	0.103	Netherlands	0.100
3	Germany	0.102	Finland	0.099
4	Netherlands	0.101	Sweden	0.096
5	Denmark	0.099	UK	0.095
6	Finland	0.094	Germany	0.092
7	France	0.087	France	0.092
8	Spain	0.087	Estonia	0.091
9	Portugal	0.086	Austria	0.090
10	Austria	0.086	Spain	0.089
11	Italy	0.078	Poland	0.084
12	Estonia	0.077	Lithuania	0.084
13	Poland	0.076	Portugal	0.082
14	Latvia	0.067	Italy	0.080
15	Lithuania	0.064	Latvia	0.076

- The most conducive social environment for advancing the FinTech industry is in Northern and Western Europe, with Sweden, the United Kingdom, and Germany occupying the top three positions. The most unfavourable social environment for FinTech development exists in all three Baltic States and Poland, indicating that the social environment is a significant weakness in post-Soviet states.
- The most conducive technological environment for advancing the FinTech industry is in Northern and Western Europe, particularly Denmark, the Netherlands, and Finland. In contrast, the least conducive environments are in Southern Europe, including Portugal and Italy, as well as in Poland, Lithuania, and Latvia.

As illustrated in Table 3.8, research indicates that the most conducive PEST environment for advancing the FinTech industry is in Northern Europe. Denmark, Sweden, Finland, the Netherlands, the United Kingdom, Estonia, and Lithuania occupy the top seven positions.

Table 3.8. Values of the overall FinTech PEST environment assessment, arranged in descending order (made by the author)

Rank	Total external environment	
1	Denmark	0.102
2	Sweden	0.101
3	Finland	0.100
4	Netherlands	0.099
5	UK	0.099
6	Estonia	0.098
7	Lithuania	0.095
8	Germany	0.094
9	France	0.089
10	Spain	0.086
11	Austria	0.086
12	Latvia	0.085
13	Poland	0.083
14	Portugal	0.083
15	Italy	0.077

The most unfavourable PEST environment for FinTech development is in Eastern and Southern Europe, with Poland, Portugal, and Italy ranking lowest in the FinTech PEST environment evaluation.

3.2. Correlation Analysis of the External Environment of the Financial Technology Industry and Achievement of Sustainable Development Goals Indicators

This sub-chapter presents the statistical assessment of the relationship between the external environment of the FinTech industry and the achievement of SDG indicators and its results.

To conduct a correlation analysis and elucidate the strength of the relationship between the FinTech PEST environment and the implementation of the Sustainable Development Goals, the statistical data about SDGs presented by Ziolo et al. (2021) were utilised, wherein the indicators delineating the 17 SDGs were employed to compute the values of the SDGs. Nonetheless, not all SDGs intersect with the FinTech industry, as specific goals pertain to third countries and environmental conservation. Consequently, the values of eight SDGs were chosen for further examination: SDG 1, SDG 3, SDG 4, SDG 8, SDG 9, SDG 11, SDG 16 and SDG 17. The selection of these SDGs is further substantiated by the findings of the scientific literature analysis presented in the inaugural chapter of the dissertation, thereby negating the necessity for expert evaluation in this particular instance. The relationship between four distinct FinTech environments – political, economic, social, and technological – and the selected SDGs was evaluated using two calculation methods: Spearman's and Kendall's ranking correlation coefficients, as detailed in Table 3.9. It is worth noting that in specific calculations, the correlation was found to be statistically insignificant. Consequently, these instances are indicated in the table. In all other calculation cases, the correlation was determined to be statistically significant at either the 0.01, 0.05, or 0.10 level.

Table 3.9. Spearman's and Kendall's correlation coefficients quantifying the strength of association between FinTech political, economic, social, and technological environments and SDG scores (made by the author)

			SDG 1	SDG 3	SDG 4	SDG 8
Spearman's	PE	r_s	.071*	-.393*	.411*	.393*
		p (2-tailed)	.800	.147	.128	.147
		N	15	15	15	15
	EE	r_s	.404*	-.096*	.536	.561
		p (2-tailed)	.136	.732	.040	.030
		N	15	15	15	15
	SE	r_s	.404*	.632	.204*	.621
		p (2-tailed)	.136	.011	.467	.013
		N	15	15	15	15

End of Table 3.9

			SDG 1	SDG 3	SDG 4	SDG 8
	TE	r_s	.664	.439*	.586	.754
		p (2-tailed)	.007	.101	.021	.001
		N	15	15	15	15
Kendall' s	PE	tau	.067*	-.219*	.257*	.276*
		p (2-tailed)	.767	.276	.198	.166
		N	15	15	15	15
	EE	tau	.314*	-.048*	.467	.371
		p (2-tailed)	.113	.843	.018	.060
		N	15	15	15	15
	SE	tau	.276*	.524	.162*	.448
		p (2-tailed)	.166	.008	.428	.023
		N	15	15	15	15
	TE	tau	.448	.352	.410	.543
		p (2-tailed)	.023	.075	.038	.006
		N	15	15	15	15
			SDG 9	SDG 11	SDG 16	SDG 17
Spearman' s	PE	r_s	.079*	.000*	.386*	.389*
		p (2-tailed)	.781	1	.156	.151
		N	15	15	15	15
	EE	r_s	.600	.154*	.604	.304
		p (2-tailed)	.018	.585	.017	.079
		N	15	15	15	15
	SE	r_s	.732	.618	.514	.304*
		p (2-tailed)	.002	.014	.050	.271
		N	15	15	15	15
	TE	r_s	.804	.521	.782	.529
		p (2-tailed)	< .001	.046	< .001	.043
		N	15	15	15	15
Kendall' s	PE	tau	-.010*	.067*	.276*	.276*
		p (2-tailed)	1	.767	.166	.166
		N	15	15	15	15
	EE	tau	.429	.086*	.410	.333
		p (2-tailed)	.029	.692	.038	.092
		N	15	15	15	15
	SE	tau	.543	.467	.295*	.219*
		p (2-tailed)	.006	.018	.138	.276
		N	15	15	15	15
	TE	tau	.600	.410	.619	.352
		p (2-tailed)	.002	.038	.002	.075
		N	15	15	15	15

* The correlation lacks statistical significance.

The research results indicated that the highest correlation between the two indicators, as assessed by Spearman's and Kendall's ranking correlation coefficients, frequently occurred within the technological FinTech environment. Consequently, the technological FinTech landscape is paramount in evaluating the relationship between various FinTech environments and the execution of SDGs. Table 3.10 presents the allocation of SDGs to various FinTech environments based on the correlation strength.

Table 3.10. Allocation of SDGs to various FinTech environments based on the strength of statistically significant correlations (made by the author)

Environment / Correlation metric	Political	Economic	Social	Technological
Spearman's	-	-	SDG 3, SDG 11	SDG 1, SDG 4, SDG 8, SDG 9, SDG 16, SDG 17
Kendall's	-	SDG 4	SDG 3, SDG 11	SDG 1, SDG 8, SDG 9, SDG 16, SDG 17

The relationship between the overall FinTech PEST environment and SDGs was evaluated and is displayed in Table 3.11. Based on Spearman's correlation coefficient, six of the eight values range from 0.575 to 0.807, indicating a moderate to strong correlation. This suggests that elevated FinTech PEST environment scores correspond with high SDG scores and vice versa.

Table 3.11. Spearman's and Kendall's correlation coefficients quantifying the strength of association between the FinTech PEST environment and SDGs (made by the author)

Correlation metric	SDG 1	SDG 3	SDG 4	SDG 8	SDG 9	SDG 11	SDG 16	SDG 17
Spearman's r_s	.575	.246*	.657	.764	.739	.386*	.807	.586
p (2-tailed)	.025	.376	.008	< .001	.002	.156	< .001	.021
N	15	15	15	15	15	15	15	15
Kendall's tau	.410	.162*	.524	.619	.562	.295*	.619	.390
p (2-tailed)	.038	.428	.008	.002	.004	.138	.002	.048
N	15	15	15	15	15	15	15	15

* Correlation is not statistically significant.

Kendall's correlation analysis indicates that four of the eight values range from 0.524 to 0.619, demonstrating a moderate positive correlation, which suggests that elevated FinTech PEST environment scores are associated with high SDG scores and vice versa. However, it is essential to note that the correlation was determined to be statistically insignificant in specific calculations. Consequently, these instances are indicated in the table. In all other calculation cases, the correlation was determined to be statistically significant at either the 0.01 or 0.05 levels.

Table 3.12 presents the SDG ranking according to the correlation strength for both correlation measurement methodologies. This ranking indicates that the FinTech PEST environment exhibits the most robust statistical correlation with SDG 16, as it secured the top position in both measurement methodologies. SDG 8 exhibits the second-strongest correlation, while SDG 9 ranks third.

Table 3.12. SDG ranking based on the strength of association between FinTech PEST environment scores and SDG scores, where the correlation was statistically significant (made by the author)

SDG rank	Spearman's	Kendall's
1	SDG 16	SDG 16 (tie)
2	SDG 8	SDG 8 (tie)
3	SDG 9	SDG 9
4	SDG 4	SDG 4
5	SDG 17	SDG 1
6	SDG 1	SDG 17
7		
8		

The results of the correlation research indicate a statistical association between the FinTech PEST environment and SDG 4, SDG 8, SDG 9, and SDG 16, with correlation coefficients exceeding 0.5 for both measurement methods. Consequently, it can be asserted that the FinTech PEST environment is interdependent with SDG 4, SDG 8, SDG 9, and SDG 16, with the strongest correlation observed between the FinTech PEST environment and SDG 16.

To illustrate the relationship between the FinTech PEST environment and SDGs 4, 8, 9, and 16 and to visualise the establishment of a conducive environment for the sustainable development of the FinTech industry, the framework of the 17 SDGs was modified concerning the biosphere foundation and the secure operating space for humanity on Earth (Folke et al., 2016). The SDGs were categorised into economy, society, and biosphere, alongside a framework addressing sustainable development challenges at various tiers (Schoenmaker, 2017), identified as economy, society, and environment. Given that SDG 4 and SDG 16 have

a significant influence on society. At the same time, SDG 8 and SDG 9 predominantly affect the economy, fostering a conducive environment for the sustainable development of the FinTech industry, which is fundamentally rooted in societal aspects—specifically quality education (SDG 4) and peace, justice, and robust institutions (SDG 16). It is also predicated on the economy: hazardous employment and economic advancement (SDG 8), alongside industries, innovation, and infrastructure (SDG 9), as primary influencing factors and drivers.

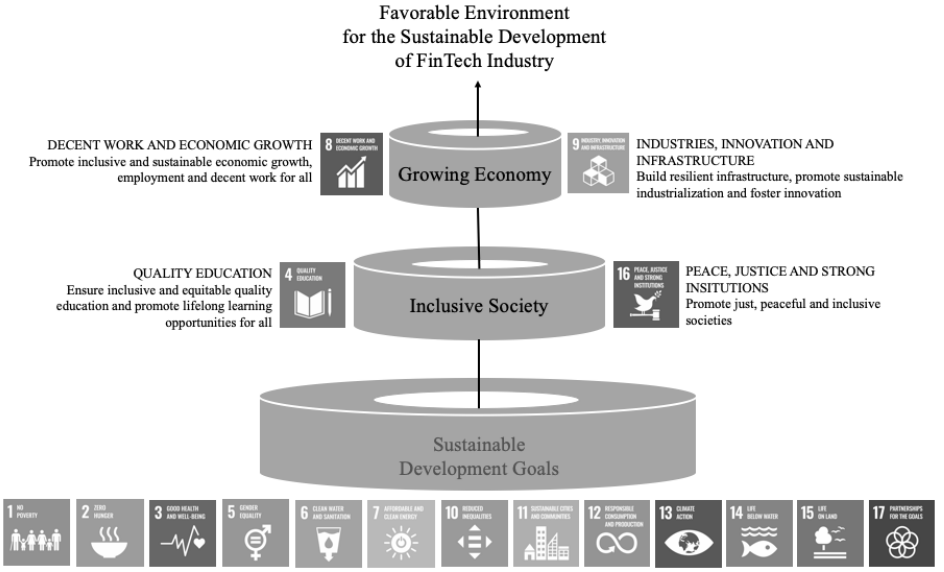


Fig. 3.1. Correlation between the FinTech PEST environment and the four SDGs (made by the author)

The correlation analysis indicates that society is characterised by inclusivity and the economy is experiencing expansion, which aligns with the fundamental principles of the objectives, targets, and indicators of Sustainable Development Goals 4, 8, 9, and 16. Accordingly, Figure 3.1 depicts the correlation between the FinTech PEST environment and the aforementioned four SDGs. While the figure conveys the notion that the 17 SDGs underpin global sustainable development, the findings of this research illustrate that establishing an inclusive society and a burgeoning economy is paramount in fostering an enabling external environment for the sustainable development of FinTech. As such, these elements are excluded from the overall SDG circle and emphasised. It is posited that an inclusive society facilitates the development of a growing economy; consequently, society is elucidated as the foundation for economic growth.

3.3. Multi-criteria Assessment of the Impact of Selected Sustainable Development Goals Indicators on the Sustainable Development of the Financial Technology Industry

This sub-chapter delineates the multi-criteria evaluation of the impact of specific Sustainable Development Goal (SDG) indicators on the sustainable development of the FinTech industry and its outcomes.

Given that empirical research in Sub-chapter 3.2 has established a statistical correlation between the external (political, economic, social, and technological) environment of the FinTech industry and SDG 4, SDG 8, SDG 9, and SDG 16, the indicators of these goals were chosen for additional empirical investigation.

Table 3.13. Composition of indicators for assessing sustainable development within the FinTech industry (made by the author)

SDG	No.	Indicator
SDG 4	1.1	PISA score
	1.2	Tertiary educational attainment
	1.3	Underachievers in science
	1.4	Variation in science performance explained by socio-economic status
SDG 8	2.1	Adjusted GDP growth
	2.2	Adults with an account at a financial institution
	2.3	Employment-to-population ratio
	2.4	Youth not in employment, education or training
SDG 9	3.1	Expenditure on R&D
	3.2	Gap in Internet access by income
	3.3	Mobile broadband subscriptions
	3.4	The population using the Internet
SDG 16	4.1	Corruption Perception Index
	4.2	Proportion of the population that feels safe walking alone around the area they live in
	4.3	Press Freedom Index
	4.4	Property rights

Given that each Sustainable Development Goal encompasses a distinct array and quantity of indicators, four indicators most relevant to the FinTech industry were selected from each SDG. This selection process entailed the exclusion of

irrelevant indicators, those with minimal numerical significance, and indicators for which values were unavailable for all fifteen countries analysed in the dissertation. Table 3.13 displays the definitive composition of sustainable development assessment indicators concerning the FinTech industry. Data from the Sustainable Development Report 2022, which is publicly accessible, was collected and partially processed (Sachs et al., 2022); all data were standardised and presented as percentages.

An expert evaluation was conducted in the spring of 2023. Thirty experts were consulted, comprising 12 specialists from the business sector, ten from the scientific community, and eight from the public sector. Following the methodological principles articulated in classical test theory, the reliability of decisions correlates with the number of decision-makers through a rapidly declining, nonlinear relationship. Therefore, the evaluations rendered by a limited cohort of 7–9 experts may possess a reliability comparable to that of a larger assembly, provided that the standard deviation for the eighth expert remains virtually unchanged (Libby & Blashfield, 1978). The primary criteria for selecting experts encompassed a minimum of ten years of relevant professional experience within the FinTech industry and a comprehensive understanding of concepts and objectives related to sustainable development.

Experts were requested to prioritise the indicators corresponding to each of the four SDGs according to their significance for the sustainable development of the FinTech industry. Subsequently, they were required to assess the importance of these indicators on a scale of one hundred. Additionally, experts were assigned the responsibility of ranking the SDGs according to their relevance to the sustainable development of the FinTech sector and appraising the significance of these SDGs on a scale of one hundred.

Table 3.14 illustrates the significance of sixteen SDG indicators and the corresponding Sustainable Development Goals, as evaluated by three expert groups from the business, public, and scientific sectors, together with their average rankings and hierarchy of importance.

The research findings indicate that among the four selected Sustainable Development Goals, SDG 9, “Industry, innovation, and infrastructure”, is of utmost importance for the sustainable development of the FinTech sector, as corroborated by the survey results obtained from all three expert groups. Concurrently, all three expert groups evaluated Indicator 3.3, “Mobile broadband subscriptions”, as the most critical indicator within this Sustainable Development Goal. Indicators 3.4, “Population using the Internet”, and 3.2, “Gap in Internet access by income”, are ranked in descending order of significance. Conversely, indicator 3.1, “Expenditure on research and development”, was collectively assessed as the least significant among these Sustainable Development Goals. The research findings suggest

that *unrestricted public access to financial technology, or financial inclusion, represents a paramount factor in the sustainable development of the FinTech industry. In contrast, gross domestic expenditure on scientific research and experimental development (R&D) is regarded as having a secondary role*.

Table 3.14. Importance of SDG indicators and SDGs, assessed by expert groups, along with their average and ranking of significance (made by the author)

Group of Indicators	Indicator	Significance			Weighted Average	Ranking Order
		Business	Public	Science		
SDG 4	1.1.	0.288	0.294	0.275	0.286	2
	1.2.	**0.413**	**0.400**	**0.420**	**0.411**	1
	1.3.	0.104	0.094	0.080	0.093	4
	1.4.	0.196	0.213	0.225	0.211	3
SDG 8	2.1.	0.196	0.200	0.210	0.202	3
	2.2.	**0.408**	**0.400**	**0.430**	**0.413**	1
	2.3.	0.292	0.300	0.275	0.289	2
	2.4.	0.104	0.100	0.085	0.096	4
SDG 9	3.1.	0.104	0.100	0.125	0.110	4
	3.2.	0.196	0.225	0.200	0.207	3
	3.3.	**0.408**	**0.381**	**0.400**	**0.396**	1
	3.4.	0.292	0.294	0.275	0.287	2
SDG 16	4.1.	0.196	0.206	0.250	0.217	3
	4.2.	0.104	0.094	0.085	0.094	4
	4.3.	0.288	0.300	0.275	0.288	2
	4.4.	**0.413**	**0.400**	**0.390**	**0.401**	1
SDGs	SDG4	0.288	0.300	0.275	0.288	2
	SDG8	0.196	0.206	0.225	0.209	3
	SDG9	**0.413**	**0.406**	**0.405**	**0.408**	1
	SDG16	0.104	0.088	0.095	0.096	4

According to expert consensus, SDG 4, “Quality education”, is recognised as the second most vital Sustainable Development Goal for the ongoing growth of the FinTech industry. Among its indicators, tertiary education attainment among individuals aged 25 to 34 was identified as the most critical by all three groups of experts. In that order, indicators pertaining to the capabilities of 15-year-olds, including PISA scores, science underachievement, and the influence of socio-economic status on science performance, were deemed less significant. The findings indicate that enhancing the current workforce's skills is more essential for the sustainability of the FinTech sector than preparing future generations.

SDG 8, “Decent work and economic growth”, is ranked third in significance. All expert groups have identified adult access to financial services, whether

through banks or mobile money, as the most critical indicator. The employment-to-population ratio and adjusted GDP growth are subsequent priorities. Notably, youth not engaged in education, employment, or training (NEET) have been considered the least relevant. These results emphasise that comprehensive financial inclusion is essential for the sustainable development of FinTech, whereas macroeconomic performance and youth engagement are deemed secondary.

In contrast, SDG 16, "Peace, justice, and strong institutions", has been perceived as the least relevant for FinTech development, receiving minimal importance. Nevertheless, within this goal, property rights emerge as the most significant indicator, followed by press freedom, the Corruption Perception Index, and personal safety. It indicates that protecting property and intellectual rights remains a fundamental element for sustainable FinTech advancement, even if broader institutional issues have less direct impact.

Fig. 3.2. Primary determinants affecting the sustainable advancement of the FinTech industry (made by the author)

The research indicates that two key drivers of sustainable FinTech development are widespread public access to FinTech through mobile and Internet technologies and a well-educated working-age population (Fig. 3.2).

Kendall's Coefficient of Concordance (W) was computed for all three expert groups to evaluate the significance of the results obtained in the research study. Table 3.16 illustrates that, in nearly all cases of this research, W is either equal to 1 or closely approximates 1. Kendall's coefficients of 0.9 or above are typically regarded as highly concordant (Jayalath, 2019).

Nevertheless, several instances can be identified in which expert opinions exhibited marginal variation. The business sector expert group demonstrated slightly divergent views concerning the significance of the Sustainable Development Goals (W = 0.703). Conversely, the scientific expert group presented somewhat varied perspectives on the importance of the SDG 9 indicators (W = 0.784). Notably, since the W value exceeds 0.7, the compatibility of these opinions may

be regarded as sufficiently favourable (Kunskaja, 2018; Skačkauskienė & Švogžlys, 2021). Consequently, it can be inferred that the findings of this research are substantial; therefore, further research conclusions are forthcoming.

Table 3.15. Compatibility of opinions of different expert groups (made by the author)

Group of Indicators	Kendall's Coefficient of Concordance (W)		
	Business Sector Expert Group	Public Sector Expert Group	Scientific Expert Group
SDG 4	0.969	1.000	0.964
SDG 8	0.954	1.000	0.964
SDG 9	0.969	1.000	0.784
SDG 16	0.969	1.000	0.892
SDGs	0.703	1.000	0.892

A multi-criteria evaluation using the SAW method was conducted to assess the sustainable development performance of each country within the FinTech sector in relation to the Sustainable Development Goals. Each indicator value corresponding to the SDGs was expressed as a percentage, normalised, and subsequently multiplied by its weight as determined by experts. The resulting figures were then consolidated within each SDG category. In light of the alignment of perspectives among business, public, and scientific expert groups, the results are presented as the averages of evaluations from these three distinct expert cohorts. The rankings of fifteen European nations across the four specified SDGs, derived from the average assessment of the three distinct expert groups regarding sustainable development within the FinTech industry, are presented in Table 3.16.

Table 3.16. Ranking of 15 European nations concerning the four selected SDGs, derived from the average evaluation results of three distinct expert groups concerning the sustainable development of the FinTech industry in 2022 (made by the author)

SDG4		SDG8		SDG9		SDG16	
UK	0.074	Denmark	0.074	Finland	0.081	Finland	0.079
Lithuania	0.073	UK	0.072	Denmark	0.078	Denmark	0.076
Netherlands	0.071	Lithuania	0.070	Poland	0.077	Netherlands	0.075
Sweden	0.069	Netherlands	0.070	Sweden	0.076	Sweden	0.072
Finland	0.068	Estonia	0.069	Netherlands	0.073	Austria	0.072
Estonia	0.068	Sweden	0.069	Estonia	0.072	Estonia	0.068
France	0.068	Finland	0.069	Austria	0.070	Germany	0.067

End of Table 3.16

SDG4		SDG8		SDG9		SDG16	
Spain	0.068	France	0.067	Germany	0.066	UK	0.066
Latvia	0.067	Spain	0.067	Latvia	0.065	Portugal	0.066
Poland	0.066	Poland	0.067	Spain	0.063	France	0.065
Denmark	0.066	Latvia	0.066	France	0.062	Spain	0.063
Austria	0.064	Austria	0.066	UK	0.061	Lithuania	0.061
Portugal	0.064	Portugal	0.065	Lithuania	0.055	Latvia	0.059
Germany	0.060	Germany	0.062	Portugal	0.051	Italy	0.058
Italy	0.056	Italy	0.058	Italy	0.050	Poland	0.054

The research emphasises that the indicators of Sustainable Development Goal 9, “Industry, innovation, and infrastructure, " are essential for assessing the sustainable development of FinTech. Finland leads in this domain among the fifteen European countries examined, followed by Denmark, Poland, and Sweden. Finland, Denmark, and Sweden consistently achieved high scores across all four indicators of SDG 9, whereas Poland distinguished itself for its remarkably high number of mobile broadband subscriptions. Conversely, Italy exhibited the weakest performance in this particular category.

Concerning SDG 4, “Quality Education”, which is recognised as the second most significant SDG pertaining to FinTech sustainability, the United Kingdom, Lithuania, the Netherlands, and Sweden distinguished themselves as the leading performers, particularly concerning tertiary educational attainment within the working-age demographic. Conversely, Italy was positioned at the lowest rank.

Concerning Sustainable Development Goal 8, titled “Decent Work and Economic Growth”, Denmark achieved the highest ranking, followed by the United Kingdom, Lithuania, and the Netherlands. Denmark and the Netherlands demonstrated strong performance across all four indicators. The highest adjusted GDP growth influenced Lithuania’s ranking in 2020, while the United Kingdom was acknowledged for its solid employment-to-population ratio. Once again, Italy recorded the most unfavourable results.

In the assessment of SDG 16, titled “Peace, justice, and strong institutions”, Finland, Denmark, and the Netherlands consistently achieved the highest rankings owing to their exemplary performance across all four indicators. Conversely, Poland and Italy ranked at the lower end of the spectrum, exhibiting low scores across the board.

To generate a comprehensive ranking of the 15 European countries regarding FinTech-related sustainable development, the research employed the Simple Additive Weighting (SAW) method. Each Sustainable Development Goal (SDG) indicator was assigned a weight based on expert evaluations, as detailed in Table 3.14, and the outcomes were subsequently aggregated. The final performance

scores and rankings, which are averaged across assessments from business, public, and academic expert groups, are presented in Table 3.17, providing a definitive comparison of each nation's position in fostering the sustainable growth of the FinTech industry.

Table 3.17. Conclusive outcomes and rankings of 15 European nations regarding the sustainable development of the FinTech industry, derived from the selected SDG indicator data for this research and the assessment results from various expert groups (made by the author)

Rank	Country	Business	Public	Science	Weighted Average
1.	Finland	0.075	0.074	0.075	0.0747
2.	Denmark	0.074	0.073	0.074	0.0737
3.	Netherlands	0.073	0.073	0.073	0.0730
	Sweden	0.073	0.073	0.073	0.0730
4.	Estonia	0.071	0.071	0.071	0.0710
5.	Poland	0.071	0.070	0.070	0.0703
6.	Austria	0.067	0.067	0.068	0.0673
7.	Latvia	0.066	0.066	0.065	0.0657
8.	UK	0.066	0.065	0.065	0.0653
9.	France	0.065	0.065	0.065	0.0650
10.	Germany	0.064	0.065	0.065	0.0647
11.	Lithuania	0.064	0.065	0.064	0.0643
12.	Spain	0.062	0.062	0.061	0.0617
13.	Portugal	0.058	0.058	0.058	0.0580
14.	Italy	0.054	0.054	0.054	0.0540

Upon evaluating the definitive conclusions drawn from the empirical research delineated in this sub-chapter, it is evident that Finland is positioned as the most advanced nation regarding sustainable development within the FinTech industry, closely followed by Denmark. The Netherlands and Sweden are tied for third place, having yielded identical assessment results, while Estonia occupies the fourth position and Poland the fifth. Conversely, the Southern European nations of Spain, Portugal, and Italy are ranked lowest in evaluating sustainable development within the FinTech industry, as the research indicates.

3.4. Method of Moments Quantile Regression Analysis of the Impact of External Financial Technology Environment, Sustainable Development Goals, and Energy Consumption on the Financial Technology Development

This sub-chapter presents the results of the quantile regression analysis, which was executed using the method of moments. The research evaluated both paired and multiple regressions; however, due to the robustness of the results obtained from the former, these are presented in this sub-chapter.

The research method was executed in three consecutive phases, with each phase examining the effects within a specific quantile range (0.05, 0.25, 0.50, 0.75, and 0.95). The resultant data are presented accordingly. The dependent variable is the FinTech PCA index (FIN I and FIN II). In contrast, the independent variables comprise the PCA indices of the FinTech external environment (PEST), Sustainable Development Goals 4, 8, 9, and 16 (SDG), Sustainable Development Goal 7 (SDG 7), and the Final Energy Consumption indicator for the commercial and public services sector (ENERGY). The disparity in the coefficients indicates varying effects of the independent variables throughout the distribution of the dependent FinTech variable, which is elaborated upon below.

3.4.1. Pairwise Regression Results on the Impact of the External Environment, Sustainable Development Goals, and Energy Consumption on Financial Technology Development

As demonstrated in Figure 3.3, the pairwise quantile regression estimates for the FinTech and PEST, SDG, SDG 7, and ENERGY indices illustrate alterations in performance when FinTech indicators are assigned equal (FIN I) or divergent (FIN II) weights.

As demonstrated subsequently, while the PEST Index exhibits the lowest positive coefficients for FIN I and FIN II, it shows a stable and positive influence on FinTech as quantiles increase, suggesting that the PEST Index has a consistently positive effect.

SDG Index reveals a positive effect that becomes highly significant from the 0.75 quantiles onwards, indicating that higher SDG scores significantly boost FinTech growth. This observation is further corroborated by the findings of SDG 7, which underscores the pivotal role of affordable and clean energy sources in catalysing FinTech advancement, as evidenced by its substantial, positive impact commencing from the 0.25 quantile. The research shows a peak impact at the 0.5

quantile, which stabilises, reinforcing energy enhancement's central role in driving FinTech development.

The ENERGY Index shows the most significant changes across quantiles, exhibiting a pronounced impact on FIN I, which displays a marked increase between the 0.05 and 0.25 quantiles, reaching a peak before declining after the 0.75 quantiles.

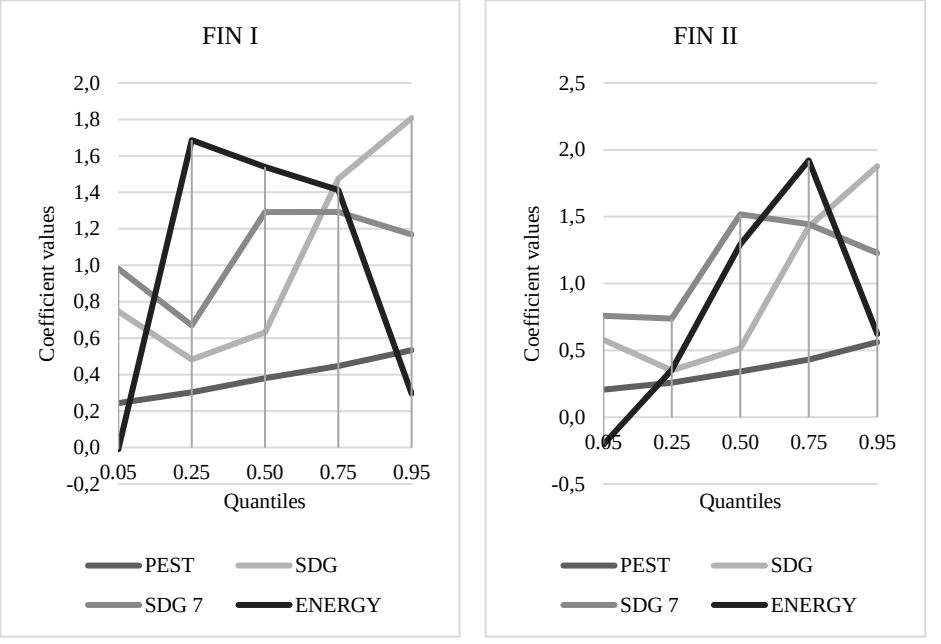


Fig. 3.3. Changes in the pairwise regression results of FinTech and PEST, SDG, SDG 7, and ENERGY indexes (made by the author)

In the context of FIN II, the observed positive increase of ENERGY is characterised by a gradual nature, increasing between the 0.25 and 0.50 quantiles, reaching a peak at 0.75 and subsequently exhibiting a decline. This finding suggests that while energy consumption positively influences FinTech growth to a certain extent, excessive consumption has a deleterious effect.

The rising trends observed in PEST, SDG, SDG 7, and ENERGY indicators imply that as these metrics improve, the associated outcomes in FinTech, particularly in the higher quantiles, are also likely to show enhancement, underscoring their pivotal role in propelling favourable FinTech development outcomes.

To validate the results against the observed data, the pertinent p-values and standard errors were calculated and displayed in Tables 3.18 and 3.19 below.

The results affirmed the importance of the PEST and SDG 7 data, with PEST exhibiting a lower standard error (SE).

Table 3.18. MMQR results of paired FIN I and PEST, SDG, ENERGY, and SDG 7 indexes (made by the author)

FIN I		0.05	0.25	0.50	0.75	0.95
PEST	Beta	**0.244**	**0.302**	**0.380**	**0.447**	**0.534**
	p-value	0.045	0.015	0.025	0.002	0.000
	SE	0.107	0.103	0.144	0.107	0.083
SDG	Beta	0.748	0.483	0.631	1.474	1.808
	p-value	0.120	0.200	0.403	0.238	0.114
	SE	0.440	0.352	0.722	1.176	1.042
ENERGY	Beta	-0.010	1.686	1.539	1.414	0.297
	p-value	0.995	0.338	0.255	0.186	0.814
	SE	1.527	1.677	1.274	0.996	1.225
SDG 7	Beta	**0.981**	0.670	**1.291**	**1.293**	**1.168**
	p-value	0.013	0.088	0.001	0.000	0.000
	SE	0.326	0.355	0.291	0.188	0.115

Table 3.19. MMQR results of paired FIN II and PEST, SDG, ENERGY, and SDG 7 indexes (made by the author)

FIN II		0.05	0.25	0.50	0.75	0.95
PEST	Beta	0.205	0.258	0.342	**0.431**	**0.561**
	p-value	0.202	0.098	0.132	0.031	0.002
	SE	0.150	0.141	0.209	0.172	0.136
SDG	Beta	0.579	0.349	0.515	1.423	1.878
	p-value	0.275	0.392	0.527	0.343	0.178
	SE	0.501	0.390	0.786	1.429	1.294
ENERGY	Beta	-0.205	0.352	1.293	1.921	0.621
	p-value	0.884	0.823	0.371	0.155	0.695
	SE	1.366	1.535	1.380	1.247	1.537
SDG 7	Beta	0.759	0.737	**1.518**	**1.444**	**1.227**
	p-value	0.111	0.141	0.009	0.004	0.001
	SE	0.434	0.462	0.473	0.382	0.258

A synthesis of the p-values and standard errors (SE) presented in the tables indicates that the FIN I model, which employs proportional indicator weights for

the FinTech PCA Index, exhibited statistically more significant and, consequently, more accurate data.

Furthermore, when assessing the influence of the independent variables on the dependent variable, the importance of PEST and SDG 7 in relation to the sustainable development of the FinTech industry must be prioritised.

The following sub-chapter necessitates a comprehensive examination of the influence of the SDG PCA Index components on FinTech, considering its inclusion of four SDGs and their respective indicators, which is particularly pertinent to the advancement of sustainable FinTech.

3.4.2. Pairwise Regression Results on the Impact of Sustainable Development Goals 4, 8, 9, and 16 on the Financial Technology Development

Figure 3 depicts the paired FIN I/FIN II modifications and the MMQR estimates for SDG 4, SDG 8, SDG 9, and SDG 16 indices. The results of the MMQR regarding the influence of SDG 4, SDG 8, SDG 9, and SDG 16 on FinTech can be summarised into two primary observations.

Specifically, it is clear that SDG 8 and SDG 9 significantly enhance the advancement of FinTech. SDG 8 demonstrates a growth trajectory that peaks at the 0.50 quantile, subsequently stabilising. In contrast, SDG 9 peaks at the 0.05 quantile in FIN I and FIN II while maintaining stability across all quantiles. Consequently, SDG 8 has the most substantial influence on FinTech, with a medium to high range, as confirmed by the p-values (Tables 3.20 and 3.21), which indicate the significance of these data. At the same time, SDG 9 demonstrates the most pronounced impact at the inception of growth, sustaining a consistent, albeit marginally diminished, impact throughout the growth phase, as confirmed by the p-values.

Conversely, coefficients for SDG 4 are consistently negative in both models, indicating that an increase in SDG 4 is associated with a decrease in the dependent FinTech variable. Therefore, further examination is necessary using indicators, such as the p-values, especially in FIN II, to confirm the significance of these data.

By comparison, SDG 16 exhibits an upward trend up to the 0.5 quantiles in both models, indicating a positive impact on FinTech; however, it subsequently experiences a sharp decline towards negative coefficient values, a more pronounced trend in FIN II. These results suggest the necessity for further inquiry, although the p-values did not confirm the significance of these data.

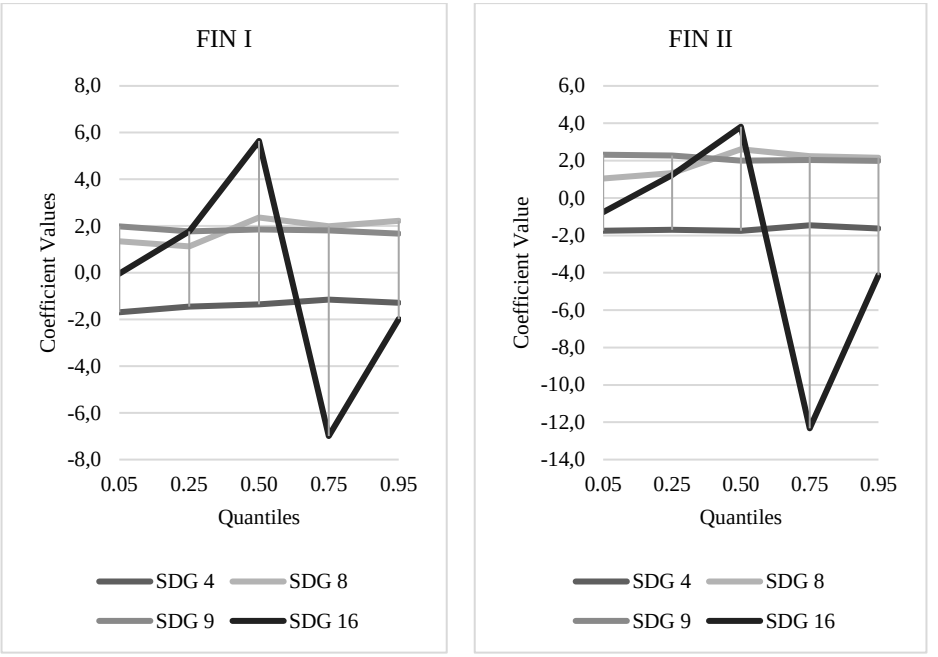


Fig. 3.4. Changes in the pairwise regression results of FinTech and SDG 4, SDG 8, SDG 9 and SDG 16 indexes (made by the author)

Table 3.20. MMQR results of paired FIN I and SDG 4, SDG 8, SDG 9, and SDG 16 indexes (made by the author)

FIN I		0.05	0.25	0.50	0.75	0.95
SDG 4	Beta	–1.691	–1.454	–1.354	**–1.150**	**1.348**
	p–value	0.149	0.091	0.057	0.002	0.000
	SE	1.082	0.778	0.628	0.283	0.202
SDG 8	Beta	**1.348**	1.130	**2.365**	**1.990**	**2.226**
	p–value	0.003	0.000	0.000	0.000	0.000
	SE	0.339	0.575	0.592	0.379	0.311
SDG 9	Beta	**1.985**	**1.767**	**1.856**	**1.811**	**1.675**
	p–value	0.000	0.000	0.000	0.000	0.000
	SE	0.229	0.193	0.184	0.245	0.258
SDG 16	Beta	–0.036	1.777	5.644	–6.991	–1.983
	p–value	0.994	0.788	0.608	0.556	0.840
	SE	4.832	6.419	10.650	11.469	9.587

Table 3.21. MMQR results of paired FIN II and SDG 4, SDG 8, SDG 9, and SDG 16 indexes (made by the author)

FIN II		0.05	0.25	0.50	0.75	0.95
SDG 4	Beta	**–1.757**	**–1.698**	**–1.757**	**–1.460**	**–1.636**
	p–value	0.037	0.013	0.006	0.001	0.000
	SE	0.731	0.562	0.506	0.297	0.206
SDG 8	Beta	1.043	1.331	**2.609**	**2.246**	**2.149**
	p–value	0.081	0.163	0.020	0.003	0.000
	SE	0.537	0.884	0.943	0.586	0.414
SDG 9	Beta	**2.317**	**2.275**	**2.003**	**2.034**	**1.988**
	p–value	0.000	0.000	0.000	0.000	0.000
	SE	0.314	0.329	0.288	0.231	0.198
SDG 16	Beta	–0.763	1.237	3.815	–12.325	–4.134
	p–value	0.874	0.847	0.755	0.383	0.738
	SE	4.705	6.244	11.878	13.495	12.033

A synthesis of the p-values and standard errors (SE) presented in the tables above indicates that the FIN II model, which employs non-proportional indicator weights for the FinTech PCA Index, exhibited statistically more significant and consequently more accurate data in this case.

Moreover, when assessing the influence of the independent variables on the dependent variable, the importance of SDG 4, SDG 8, and SDG 9 to the sustainable development of the FinTech industry warrants paramount attention.

The divergent trends displayed by the different Sustainable Development Goals (SDGs) provide essential insights. The beneficial effects of SDG 8 and SDG 9, alongside the volatility of SDG 16, coupled with the persistently adverse impact of SDG 4, highlight the need for a comprehensive examination of these two indices.

3.4.3. Pairwise Regression Results on the Impact of Sustainable Development Goals 4 and 16 Index Sub-components on the Financial Technology Development

Figure 4 demonstrates an apparent alteration in the paired FIN I/FIN II and SDG 4 index sub-components (indicators) MMQR estimates. Only one indicator, “Tertiary educational attainment (% of the population aged 25 to 34)”, exhibits positive coefficient values. In contrast, the remaining three SDG 4 indicators manifestly demonstrate negative values, with a minor exception being “Variation in mathematics performance explained by socio-economic status” at FIN I.

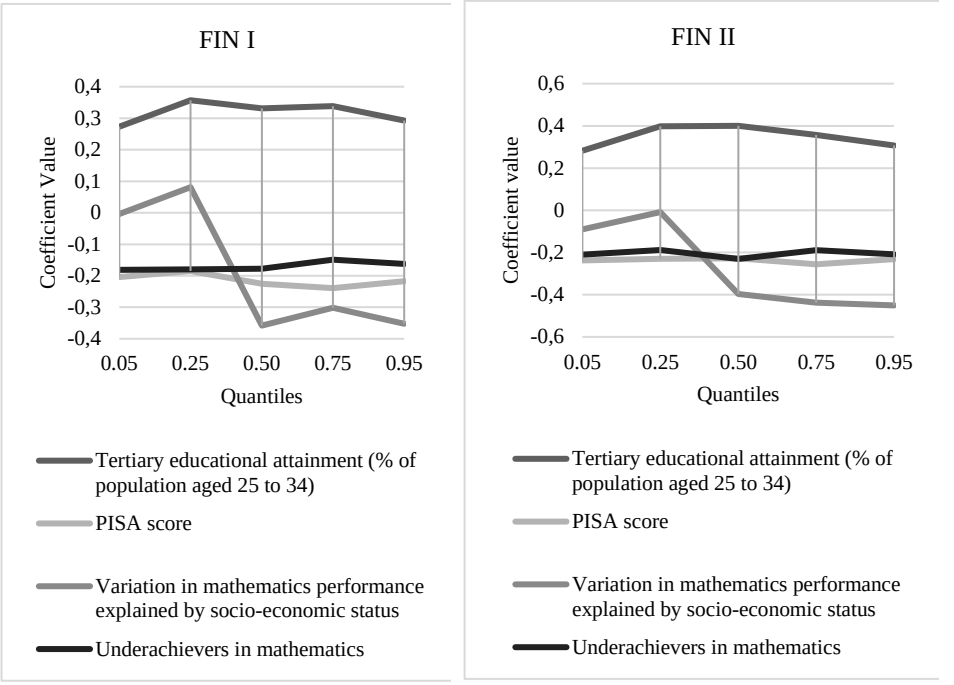


Fig. 3.5. Changes in the pairwise regression results of FinTech and SDG 4 index sub-components (indicators) (made by the author)

Thus, the sole SDG 4 indicator positively influencing FinTech growth is "Tertiary educational attainment (% of the population aged 25 to 34)". However, its positive impact could not be considered highly significant, as it is less than 1 (the highest value is in the FIN II model, which is 0.4). The p-values for these results (Tables 3.22 and 3.23) confirmed the significance of the data, thereby answering the inquiry posed in Sub-chapter 3.4.2 concerning the negative values of the SDG 4 Index coefficients.

As demonstrated in Figure 3.5, the paired FIN I/FIN II and SDG 16 index sub-components (indicators) MMQR estimates reveal noteworthy alterations. Two indicators for SDG 16, "Crime is effectively controlled" and "Timeliness of administrative proceedings", exhibit a marginal increase across quantiles in both FIN I and FIN II, suggesting a growing positive impact at higher quantiles.

Table 3.22. MMQR results of paired FIN I and SDG 4 index sub-components (indicators) (made by the author)

FIN I		0.05	0.25	0.50	0.75	0.95
Tertiary	Beta	**0.273**	**0.357**	**0.331**	**0.338**	**0.292**
	p–value	0.001	0.000	0.000	0.000	0.000
	SE	0.061	0.055	0.044	0.037	0.029
PISA	Beta	**–0.204**	**–0.185**	**–0.226**	**–0.239**	**–0.217**
	p–value	0.000	0.000	0.000	0.000	0.000
	SE	0.025	0.027	0.030	0.025	0.025
Variation	Beta	–0.004	0.081	–0.358	**–0.302**	**–0.353**
	p–value	0.986	0.761	0.070	0.015	0.000
	SE	0.218	0.259	0.176	0.102	0.065
Underachievers	Beta	–0.181	**–0.180**	**–0.177**	**–0.149**	**–0.162**
	p–value	0.064	0.039	0.007	0.003	0.000
	SE	0.087	0.076	0.052	0.039	0.027

Table 3.23. MMQR results of paired FIN II and SDG 4 index sub-components (indicators) (made by the author)

FIN II		0.05	0.25	0.50	0.75	0.95
Tertiary	Beta	**0.282**	**0.397**	**0.400**	**0.357**	**0.307**
	p–value	0.023	0.003	0.002	0.001	0.000
	SE	0.105	0.104	0.094	0.075	0.054
PISA	Beta	**–0.238**	**–0.230**	**–0.228**	**–0.256**	**–0.231**
	p–value	0.000	0.000	0.000	0.000	0.000
	SE	0.019	0.028	0.035	0.035	0.029
Variation	Beta	–0.090	–0.009	**–0.397**	**–0.438**	**–0.451**
	p–value	0.694	0.973	0.039	0.001	0.000
	SE	0.222	0.255	0.167	0.094	0.064
Underachievers	Beta	**–0.210**	**–0.188**	**–0.230**	**–0.189**	**–0.209**
	p–value	0.018	0.005	0.000	0.000	0.000
	SE	0.074	0.052	0.040	0.036	0.026

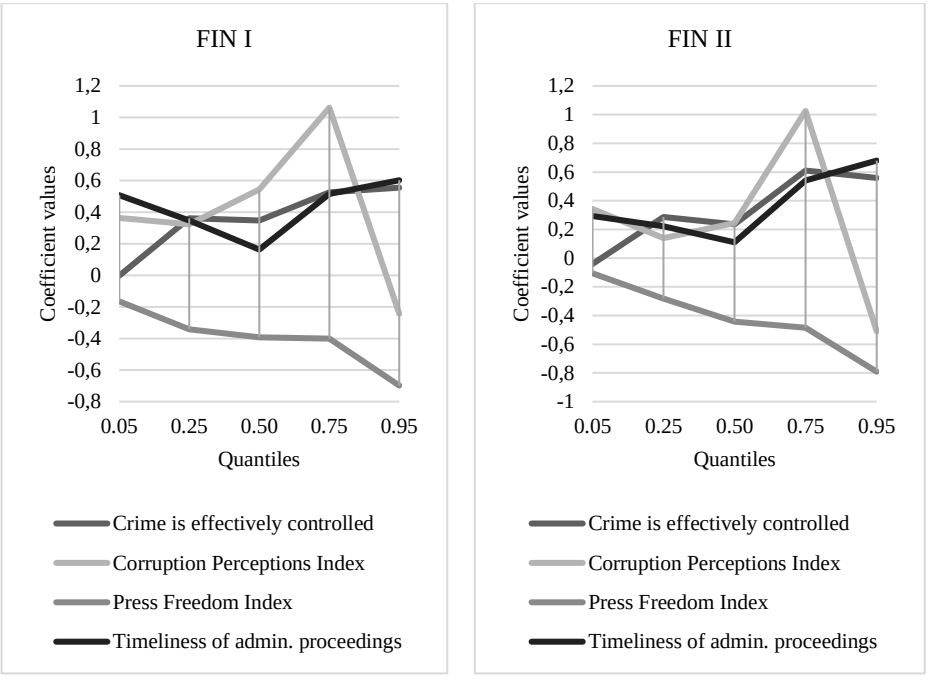


Fig. 3.6. Changes in the pairwise regression results of FinTech and SDG 16 index sub-components (indicators) (made by the author)

However, their values are below 1, so the impact of these indicators is not particularly significant. The Corruption Perceptions Index significantly influences FinTech development within the sustainable development framework, as it increases from the 0.05 quantile to a maximum of 1.1 at the 0.75 quantile before declining precipitously to a minimal negative value at the 0.95 quantile. It suggests that the perceived level of corruption in the public sector significantly enhances FinTech development up to a specific threshold; however, when corruption is regarded as minimal by business representatives and country experts, it begins to hinder FinTech development.

In contrast, the Press Freedom Index is deteriorating, becoming increasingly hostile at higher quantiles in both models, indicating an inverse correlation with FinTech. It suggests that the degree of freedom afforded to journalists correlates with diminished FinTech outcomes within the sustainable development framework, highlighting the intricacies of the relationship between press freedom and the various components of the FinTech Index, independent of the indicators' weights.

Table 3.24. MMQR results of paired FIN I and SDG 16 index sub-components (indicators) (made by the author)

FIN I		0.05	0.25	0.50	0.75	0.95
Crime	Beta	–0.002	0.361	0.347	0.526	**0.555**
	p-value	0.997	0.340	0.236	0.052	0.003
	SE	0.567	0.361	0.275	0.238	0.140
Corruption	Beta	0.364	0.323	0.544	1.062	–0.243
	p-value	0.345	0.589	0.588	0.374	0.844
	SE	0.367	0.579	0.972	1.142	1.203
Press freedom	Beta	–0.165	**–0.343**	–0.393	**–0.401**	**–0.698**
	p-value	0.288	0.004	0.229	0.033	0.024
	SE	0.147	0.092	0.307	0.162	0.262
Timeliness	Beta	0.507	0.347	0.163	0.515	0.602
	p-value	0.190	0.206	0.782	0.577	0.489
	SE	0.361	0.257	0.574	0.892	0.839

Table 3.25. MMQR results of paired FIN II and SDG 16 index sub-components (indicators) (made by the author)

FIN II		0.05	0.25	0.50	0.75	0.95
Crime	Beta	–0.041	0.286	0.235	0.610	**0.559**
	p-value	0.942	0.499	0.557	0.099	0.028
	SE	0.552	0.408	0.387	0.335	0.218
Corruption	Beta	0.342	0.140	0.245	1.025	–0.510
	p-value	0.392	0.832	0.831	0.479	0.747
	SE	0.382	0.641	1.119	1.394	1.540
Press freedom	Beta	–0.106	–0.282	–0.444	**–0.484**	**–0.792**
	p-value	0.669	0.156	0.208	0.004	0.010
	SE	0.240	0.184	0.330	0.132	0.249
Timeliness	Beta	0.294	0.222	0.110	0.541	0.680
	p-value	0.323	0.354	0.872	0.628	0.542
	SE	0.282	0.228	0.665	1.081	1.075

The p-values for these results (Tables 3.24 and 3.25) partially validated the significance of the data at elevated quantiles. Consequently, the adverse effects of elevated Press Freedom Index values on FinTech advancement within the framework of sustainable development constitute a scientific issue that warrants resolution.

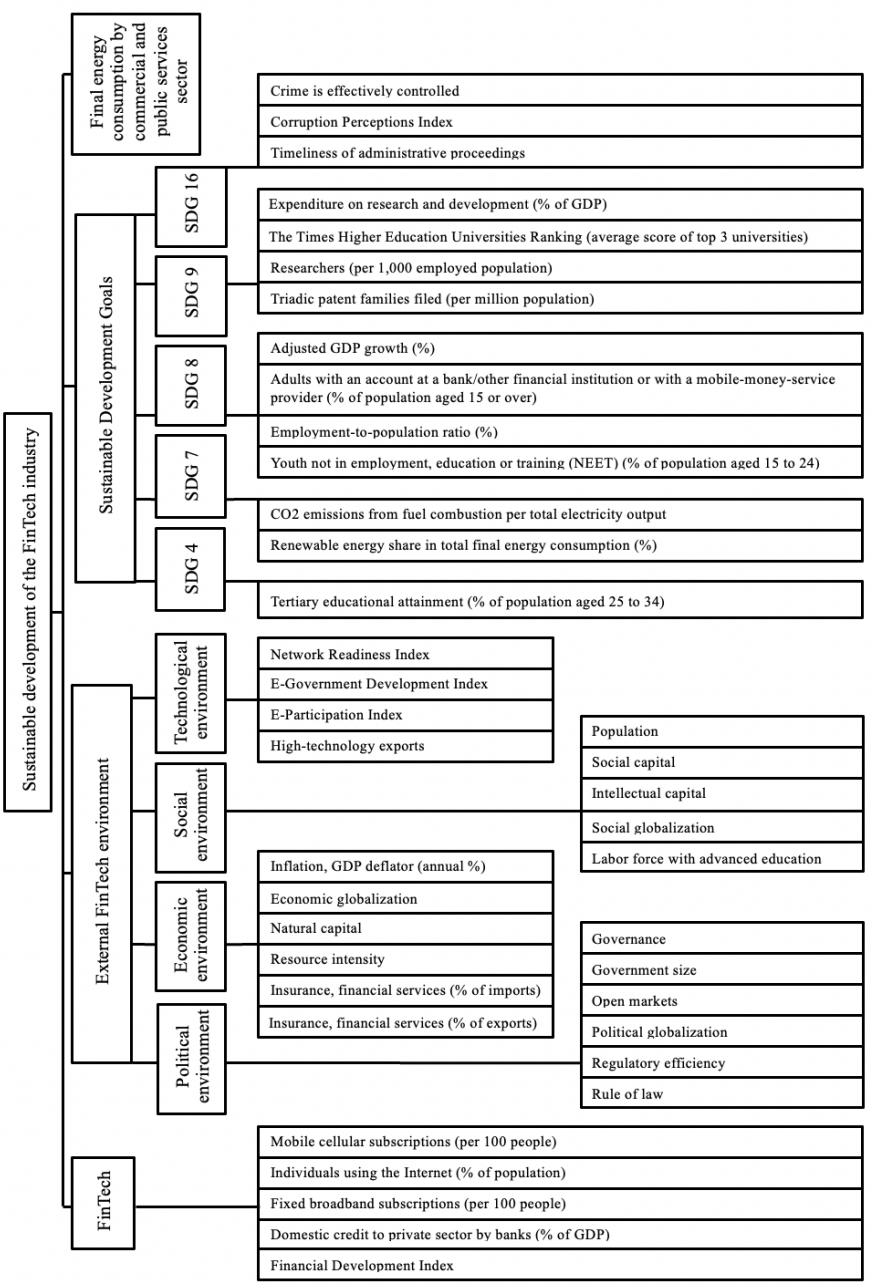


Fig. 3.7. Set of indicators to assess the sustainable development of the FinTech industry (made by the author)

In summary, the findings of the pairwise regression conducted in Sub-chapter 3.4 indicate that four indicators should be excluded from the set used for further assessment of the sustainable development of the FinTech industry, as they are detrimental to its development. These indicators include the "PISA score", the "Variance in mathematics performance explained by socio-economic status", the "Underachievers in mathematics" indicators in SDG 4, and the Press Freedom Index from SDG 16.

3.5. Multi-criteria Assessment of the Sustainable Development of the Financial Technology Industry

This sub-chapter presents the multi-criteria assessment of the sustainable development of the FinTech industry. In light of the preceding dissertation chapters, the assessment incorporates the final set of 41 indicators of FinTech, the external FinTech environment, Sustainable Development Goals, and energy consumption into a unified assessment tool (Fig. 3.7). The primary objective is to determine the significance of indicators and indicator groups in completing the development of a tool for assessing the sustainable development of the FinTech industry, thereby enabling a quantitative evaluation of its sustainable development at the national level.

3.5.1. Expert Survey and Weighting of Indicators

An expert questionnaire was prepared. The indicators in the questionnaire were derived from a comprehensive review of scientific literature and were presented in a random sequence.

To identify suitable experts for the research, explicit and precise competency criteria were established before the expert survey, encompassing education, professional experience, knowledge of sustainable development, and research expertise. A comprehensive definition of these requirements is provided in Table 3.26.

It was intended that the experts meet at least three of the four criteria, as the expert survey invited representatives from business, academia, and the public sector working on FinTech development, and the experience in scientific research cannot apply to everyone.

The expert survey was successfully conducted from 8 to 10 January 2025 using an e-survey form. The survey was conducted by both national and international experts residing in Lithuania. The experts have been respectfully requested to maintain impartiality in completing the questionnaire, which means that the responses are objective and free from personal bias. If the expert cannot comply with these requirements, they were respectfully requested to decline participation

in the survey. However, no bias was encountered in this survey. Therefore, nine experts took part in the survey. The eligibility of these experts for the requirements set out is shown in Table 3.27.

Table 3.26. Specific requirements for the experience and competence of experts conducting the expert survey (made by the author)

No	Requirements	Description of the requirement	Number of experts meeting the requirements
1	Educational background	Education in quantitative social or computer sciences (finance, economics, or a related field); a master's or PhD is preferred. Additionally, courses or additional certifications in sustainable development or FinTech would be advantageous.	9
2	Work experience	Minimum of 3 years of hands-on experience in FinTech across various sectors (public, private, non-profit, research). Demonstrated involvement in sustainable projects or initiatives within FinTech is a plus.	9
3	Knowledge of sustainable development	Deep understanding of sustainable development, including knowledge of the SDGs, relevant indicators, and the implications for the FinTech sector. Experience in sustainability assessments or evaluations would be valuable.	9
4	Experience in scientific research	At least 3–5 peer-reviewed publications or participation in projects relevant to FinTech or sustainable development. Contributions as a speaker or panellist in industry conferences may be considered.	3

As can be seen, all nine experts interviewed meet at least three of the requirements, which is sufficient. However, to obtain the most reliable results, it is essential to consider the experts' qualifications and the number of experts involved. The optimal number of experts was determined based on the methodological principles established in classical test theory, which posits that the reliability of aggregated solutions is associated with the number of decision-makers (experts) through a rapidly diminishing non-linear relationship (Libby & Blashfield, 1978). The findings indicated that, in aggregated expert judgement modules with uniform weights, the accuracy of judgements and estimates from a small group of experts is comparable to that of a larger group of experts. Libby and Blashfield (1978)

asserted that when the number of experts exceeds seven, accuracy exceeds 90%, with negligible variation in accuracy as the number of experts increases. In addition, Baležentis and Žalimaitė (2011) have noted that, in quantitative evaluations, a sufficient number of experts ranges from seven to ten. Thus, the data acquired from this survey are considered sufficient for conducting a credible, notwithstanding the participation of only nine experts in the evaluation process. Therefore, the expert distribution by sector is shown in Figure 3.9.

The predominant experts originate from three FinTech enterprises, followed by three public sector representatives engaged in FinTech regulation and three academics investigating the relationship between FinTech and sustainability.

The reliability of the expert opinions was assessed by calculating Kendall's coefficient of concordance (Kendall's W) in the subsequent analysis. The resulting values are presented in Table 3.27.

Table 3.27. Consistency of expert opinions (made by the author)

Components of sustainable development of the FinTech industry (groups of indicators)	Consistency of expert opinions
FinTech	**0.980**
Political environment	0.989
Economic environment	1.000
Social environment	1.000
Technological environment	1.000
External (PEST) environment	**0.931**
Sustainable Development Goal "Affordable and clean energy" (SDG 7)	1.000
Sustainable Development Goal "Decent work and economic growth" (SDG 8)	1.000
Sustainable Development Goal "Industry, innovation and infrastructure" (SDG 9)	1.000
Sustainable Development Goal "Peace, justice and strong institutions" (SDG 16)	1.000
Sustainable Development Goals (SDGs)	**0.956**
Sustainable development of the FinTech industry *without an* energy consumption indicator	0.827
Sustainable development of the FinTech industry *with* energy consumption indicator	0.644

The data suggest a perfect agreement among the experts regarding the economic, social and technological FinTech environments as well as SDG 7, SDG 8, SDG 9,

and SDG 16, and strong agreement among the experts regarding all the other components of sustainable development of the FinTech industry, as a group of indicators. For instance, the lowest levels of consistency among the expert opinions were observed in the final questions, which addressed the intricacies of evaluating the sustainable development of the FinTech industry by allocating weights to aggregated groups of indicators. Notably, integrating the energy consumption indicator necessitates further investigation or consensus-building. Nevertheless, its value exceeds 0.6, indicating a robust expert consensus.

The results of the expert assessment are presented below, highlighting the importance assigned to each indicator and its respective group. The results are presented starting with the smallest components and in the order of importance of the indicators, as determined by their significance. Table 3.28 presents the elements of FinTech's external political, economic, social, and technological environment, along with their corresponding weights.

Table 3.28. Significance of the components of the external environment of the FinTech industry (made by the author)

Components of the external environment of the FinTech industry			Significance
Political environment	1	Regulatory efficiency	0.444
	2	Open markets	0.239
	3	Rule of law	0.167
	4	Governance	0.100
	5	Political globalisation	0.044
	6	Government size	0.006
Economic environment	1	Resource intensity	0.417
	2	Insurance, financial services (% of imports of services, balance of payments)	0.272
	3	Insurance, financial services (% of services exports, balance of payments)	0.161
	4	Economic globalisation	0.100
	5	Inflation, GDP deflator (annual %)	0.050
	6	*Natural capital*	*0.000*
Social environment	1	Intellectual capital	0.422
	2	Social globalisation	0.267
	3	Population	0.161
	4	Social capital	0.100
	5	Labour force with advanced education	0.050

End of Table 3.28

Components of the external environment of the FinTech industry			Significance
Technological environment	1	E-Participation Index	0.372
	2	E-Government Development Index	0.311
	3	Network Readiness Index	0.222
	4	High-technology exports	0.094

The findings of this research suggest that regulatory effectiveness and open markets are the primary factors in assessing the political environment of the FinTech industry within the context of sustainable FinTech development. Furthermore, resource intensity emerges as the pivotal factor in determining the economic environment of the FinTech industry in the context of sustainable FinTech development. The research also identified intellectual capital and social globalisation as the most significant factors in the social environment of the FinTech industry in the context of sustainable FinTech development. Additionally, the E-Participation Index and the E-Government Development Index were identified as the most essential factors in the technological environment of the FinTech industry in the context of sustainable FinTech development.

Table 3.29. outlines the components of the Sustainable Development Goals and their significance.

Table 3.29. Significance of the Components of the Sustainable Development Goals (made by the author)

Components of sustainable development of the FinTech industry			Significance
SDG 7	1	Share of renewable energy in total final energy consumption (%)	0.578
	2	Amount of CO_2 emissions from fuel combustion in relation to the total electricity generated	0.422
SDG 8	1	Adults with an account at a bank or other financial institution or with a mobile money service provider (% of the population aged 15 and over)	0.378
	2	Employment to population ratio (%)	0.300
	3	Adjusted GDP growth (%)	0.222
	4	Young people not in employment, education or training (% of the population aged 15-24)	0.100
SDG 9	1	Expenditure on research and development (% of GDP)	0.367
	2	Researchers (per 1,000 employed population)	0.294

End of Table 3.29

Components of sustainable development of the FinTech industry			Significance
	3	The Times Higher Education Universities Ranking (average score of the top 3 universities)	0.217
	4	Triadic patent families filed (per million population)	0.122
SDG 16	1	Timeliness of administrative proceedings	0.478
	2	Corruption Perceptions Index	0.344
	3	Crime is effectively controlled	0.178

As can be seen, the importance of the two renewable energy indicators (SDG 7) is quite similar. Regarding SDG 8, the primary indicator relevant to the sustainable development of the FinTech sector is financial inclusion, defined as the percentage of adults aged 15 and over who have an account at a bank, other financial institution, or mobile money service provider. SDG 9 designates research and development expenditure as a percentage of GDP as a crucial indicator, while SDG 16 emphasises the promptness of administrative procedures.

Table 3.30 delineates the weights of the principal indicator groups for sustainable development within the FinTech industry (e.g., FinTech, PEST, and SDGs) along with their corresponding components. Regarding the FinTech components, the Financial Development Index (FDI) is assigned the highest weighting, accounting for just over a third of the total weighting. It signifies that the depth, accessibility, and efficacy of financial institutions and markets are paramount for the sustainable advancement of the FinTech industry. Regarding financial inclusion indicators in FinTech, Internet users are assigned a significantly higher weighting than fixed broadband subscriptions and mobile cellular subscriptions.

Table 3.30. Significance of the components (main groups) of the sustainable development of the FinTech industry (made by the author)

Components			Significance
FinTech	1	Financial Development Index	0.356
	2	Individuals using the Internet (% of the population)	0.267
	3	Fixed broadband subscriptions (per 100 people)	0.189
	4	Domestic credit to the private sector by banks (% of GDP)	0.128
	5	Mobile cellular subscriptions (per 100 people)	0.061
PEST	1	Technological environment	0.378
	2	Economic environment	0.306
	3	Political environment	0.200

End of Table 3.30

Components			Significance
	4	Social environment	0.117
SDGs	1	SDG 9 “Industry, innovation and infrastructure”	0.372
	2	SDG 16 “Peace, justice and strong institutions”	0.317
	3	SDG 8 “Decent work and economic growth”	0.167
	4	SDG 4 “Quality education” (tertiary attainment (% of the population aged 25–34)	0.100
	5	SDG 7 “Affordable and clean energy”	0.044

The external PEST environment indicates that technological and economic factors are the most significant factors in the sustainable development of the FinTech industry. Regarding the Sustainable Development Goals, SDG 9, “Industry, innovation, and infrastructure”, and SDG 16, “Peace, justice, and institutions”, are deemed the most pertinent.

Table 3.31 illustrates two iterations of the significance of the primary components of sustainable development within the FinTech industry, excluding and including energy consumption.

Table 3.31. Significance of the main components of the sustainable development of the FinTech industry (made by the author)

Components			Significance
Sustainable development of the FinTech industry *without* energy consumption	1	FinTech	0.456
	2	SDGs	0.317
	3	PEST	0.228
Sustainable development of the FinTech industry *with* energy consumption	1	ENERGY	0.339
	2	PEST	0.311
	3	FinTech	0.217
	4	SDGs	0.133

All interviewed experts unanimously agreed that energy consumption must be incorporated into evaluating the FinTech industry’s sustainable development. Consequently, the second option in Table 3.31 is the most suitable and definitive choice for evaluating the sustainable development of the FinTech industry. It is particularly significant when viewed in the widely held view that energy consumption represents the most crucial aspect of the sustainability of the FinTech industry development, followed by the external environment, FinTech, and SDG indicators. These countries consistently have the highest FinTech scores, but they

are not in a growth trend. Meanwhile, the Netherlands maintained a similar position until 2020 but fell slightly behind in COVID-19. France, Spain, and Germany are quickly catching up with the leading countries. The results also show that Finland, Portugal, Austria, and Italy exhibit mediocre FinTech performance, while Estonia, Poland, Lithuania, and Latvia display a poor but increasing trend. Overall, for most countries, FinTech performance improves steadily, especially from 2020 to 2022.

3.5.2. Assessment of the Applicability of the Proposed Methodology and Set of Indicators for the Sustainable Development of the Financial Technology Industry

This sub-chapter delineates the findings regarding the applicability of the proposed methodology and indicators for the sustainable development of the FinTech industry. The results are presented sequentially, providing an overview of the differences in scores for the FinTech, external environment, SDGs, and energy consumption components of sustainable FinTech development across 15 European countries.

Figure 3.8 displays the outcomes of the FinTech assessment, organised alphabetically, which indicates specific trends.

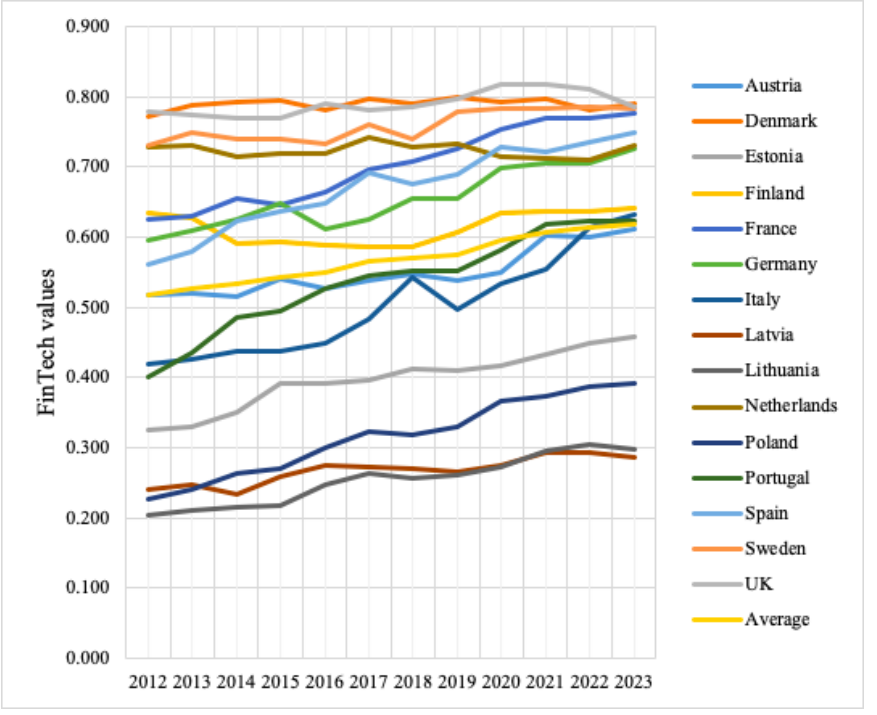


Fig. 3.8. FinTech values (made by the author)

The three European nations that consistently dominated FinTech advancement from 2012 to 2023 are the UK, Denmark, and Sweden. An analysis of the average FinTech performance across 15 countries over 12 years reveals a steady and incremental improvement, indicating that the pandemic and fluctuations in specific countries' performance have not substantially affected regional FinTech performance. Nevertheless, with a mediocre result of 0.517 in 2012 and a slightly above-average result of 0.619 more than a decade later in 2023, it is clear that there is still room for an opportunity in FinTech development in Europe.

Figure 3.9 below illustrates the findings of evaluating the *political* landscape within the FinTech industry, revealing a somewhat divergent trend. The gap in the political environment for FinTech between European countries has narrowed over the past 12 years. While the political climate in most countries has improved between 2021 and 2023, the political environment for FinTech in Denmark, the leader in this area, has deteriorated considerably.

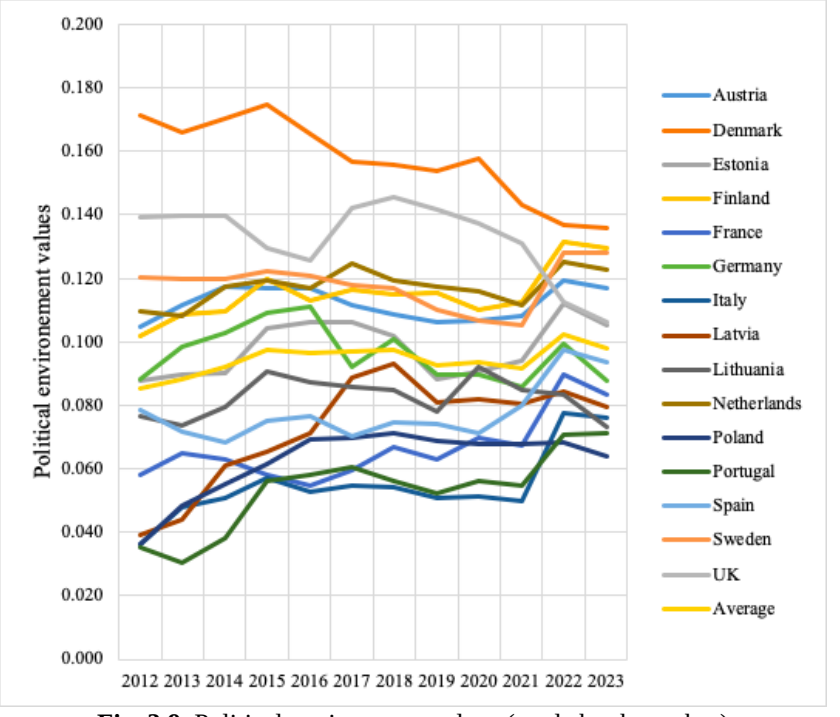


Fig. 3.9. Political environment values (made by the author)

It has also deteriorated, particularly in the formerly leading UK, which, after 2021, reaches the average level of the policy environment for FinTech in European countries and catches up with Estonia, resulting in the UK being overtaken

by Finland, Sweden, the Netherlands, and Spain. It can also be seen that Poland, Portugal and Italy have the worst political environments for FinTech in this case. Examining the average policy environment for FinTech, the overall European environment is improving, albeit slowly.

Figure 3.10 below illustrates the findings of the evaluation of the *economic* landscape of the FinTech industry.

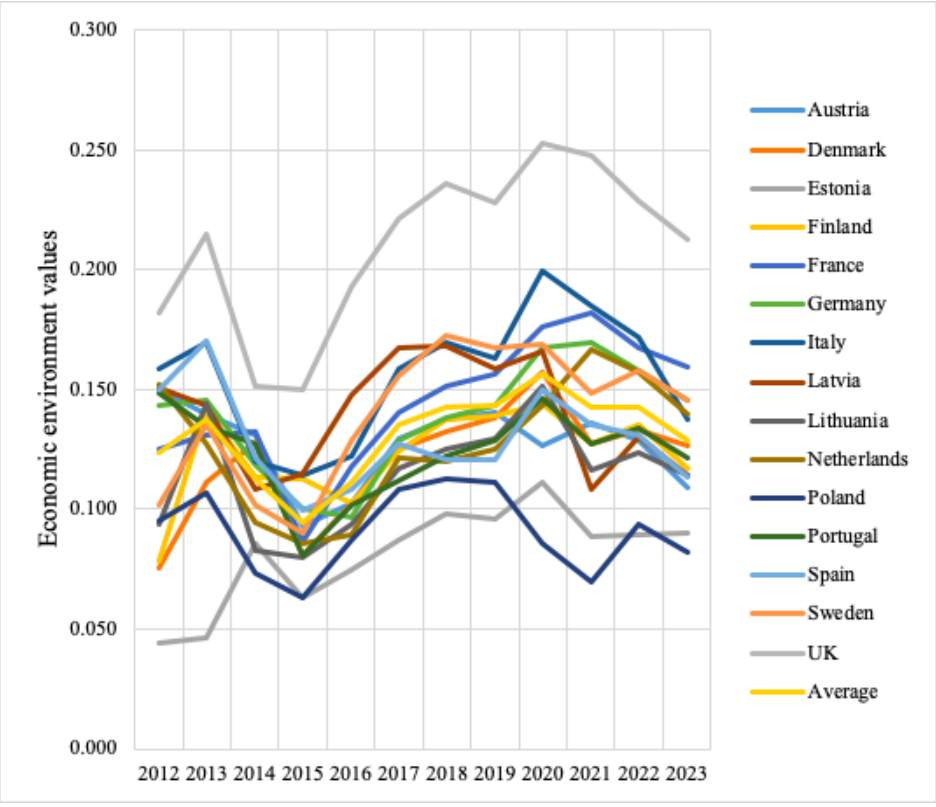


Fig. 3.10. Economic environment values (made by the author)

An assessment of the economic environment for FinTech generally shows specific cycles of change within the economic landscape. There is a clear upturn in 2013 and 2020 and a downturn in 2014–2016 and 2023. Examining the individual country results, the UK is the clear leader in all situations, while Poland and Estonia are the weakest countries in terms of the economic environment for FinTech. All other countries have a moderate economic environment for FinTech

development, maintaining the general trend in peak and downturn periods. Comparing the 12-year averages of the economic environments of the 15 countries only confirms the cyclical nature of the economic climate.

Figure 3.11 below illustrates the findings of evaluating the *social* environment within the FinTech industry.

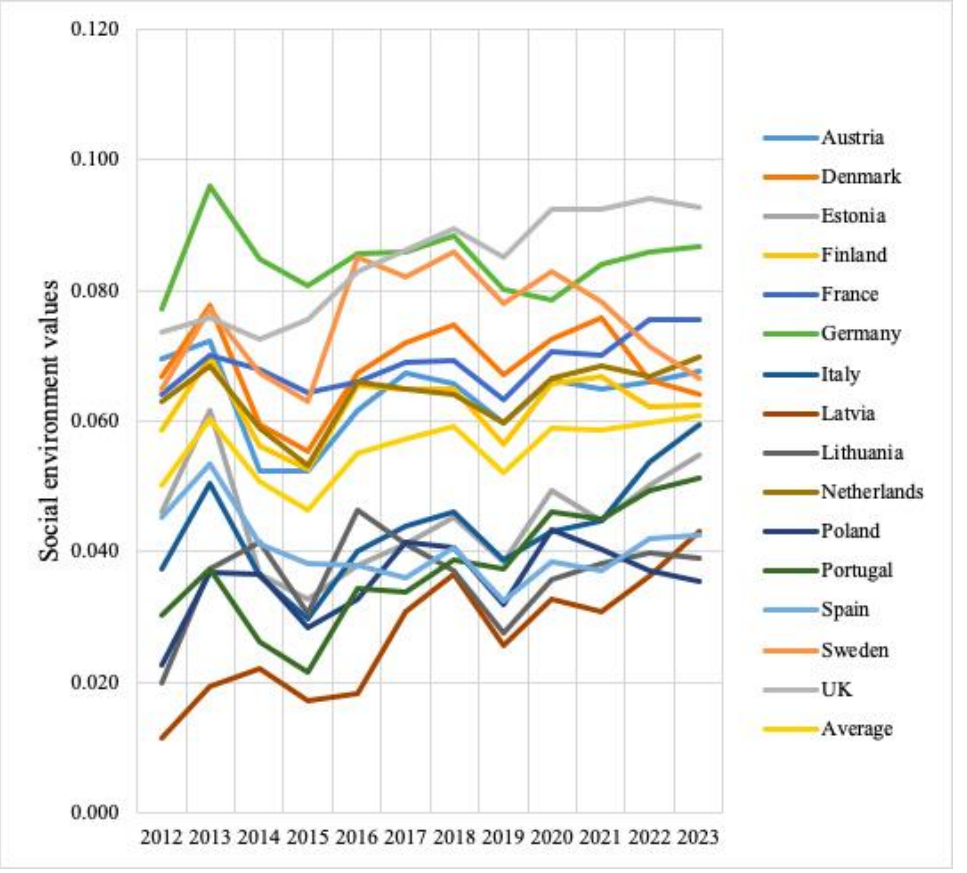


Fig. 3.11. Social environment values (made by the author)

A thorough evaluation of the prevailing social FinTech landscape reveals a notable shift in leadership from Germany, which dominated from 2012 to 2018, to the UK. Additionally, Sweden, which had maintained a steady third position between 2015 and 2021, has been superseded by France recently in 2022–2023. Furthermore, it can be concluded that Denmark, the Netherlands, Finland, and Austria have a moderate social environment for FinTech. In contrast, Poland, Lat-

via, Lithuania, and Spain have a weak social environment in this context. A comparison of the 12-year averages for the social environments of the 15 countries in question reveals the cyclical nature of these environments. The weakest periods are observed in 2012, 2014–2015, and 2019. The period from 2020 to 2023 can be regarded as an improvement in the social environment for FinTech.

Figure 3.12 below illustrates the findings of evaluating the *technological* landscape within the FinTech industry.

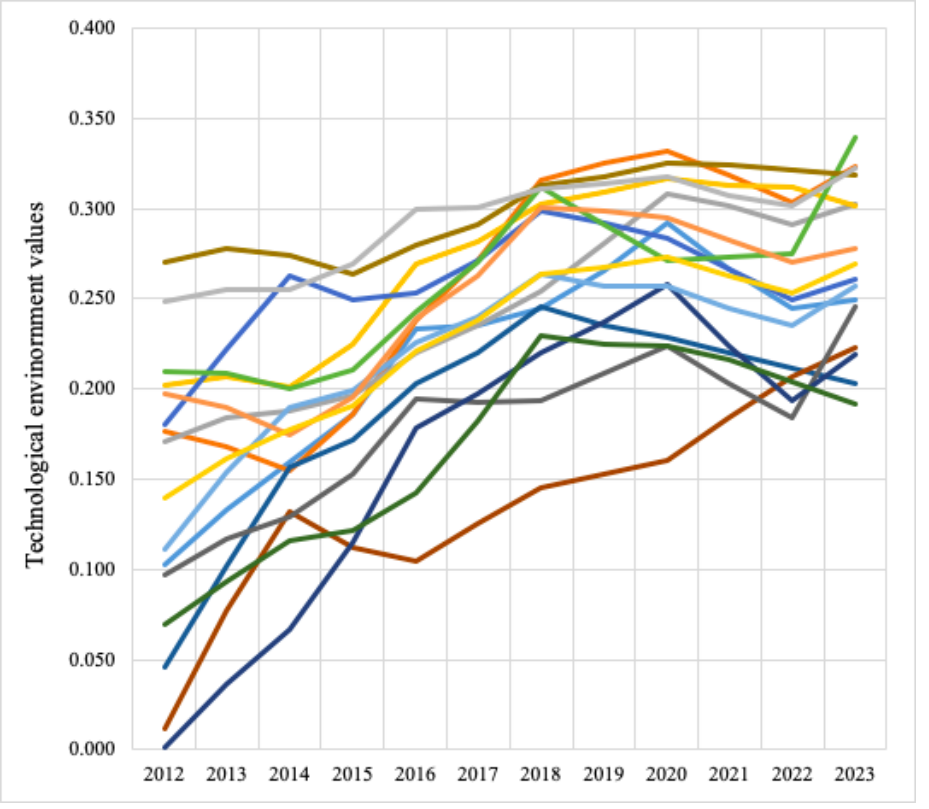


Fig. 3.12. Technological environment values (made by the author)

The technological environment is characterised by an overall growth trend that is both evident and consistent. Furthermore, it is obvious that the gap between European countries, which existed between 2012 and 2015, has started to narrow since 2016. Meanwhile, with Latvia catching up with the overall level in 2021, the gap between countries became even smaller in 2022. Individually assessed, the Netherlands and the UK emerge as leaders in the technological landscape among the selected European countries, having maintained this status for 12 years.

However, Denmark, Finland, Estonia, and Germany are rapidly catching up, with the latter even pulling ahead in 2023. Conversely, Portugal, Italy, Poland, Latvia, and Lithuania exhibit the most underdeveloped technological environments in FinTech, though Lithuania's performance in 2023 approaches the mean average.

Figure 3.13 below illustrates the findings of evaluating the *overall external (PEST)* environment of the FinTech industry. The external environment most conducive to the advancement of FinTech is that of the UK. The Netherlands, Denmark, Sweden, and Germany are in second place, with Poland, Latvia, Portugal, and Lithuania having the least favourable external environments for FinTech development.

When the data values from the 15 countries are examined over 12 years, it is evident that the external environment in Europe is improving in the long term. However, slight deterioration is apparent in 2014–2015, 2019 and 2021–2023.

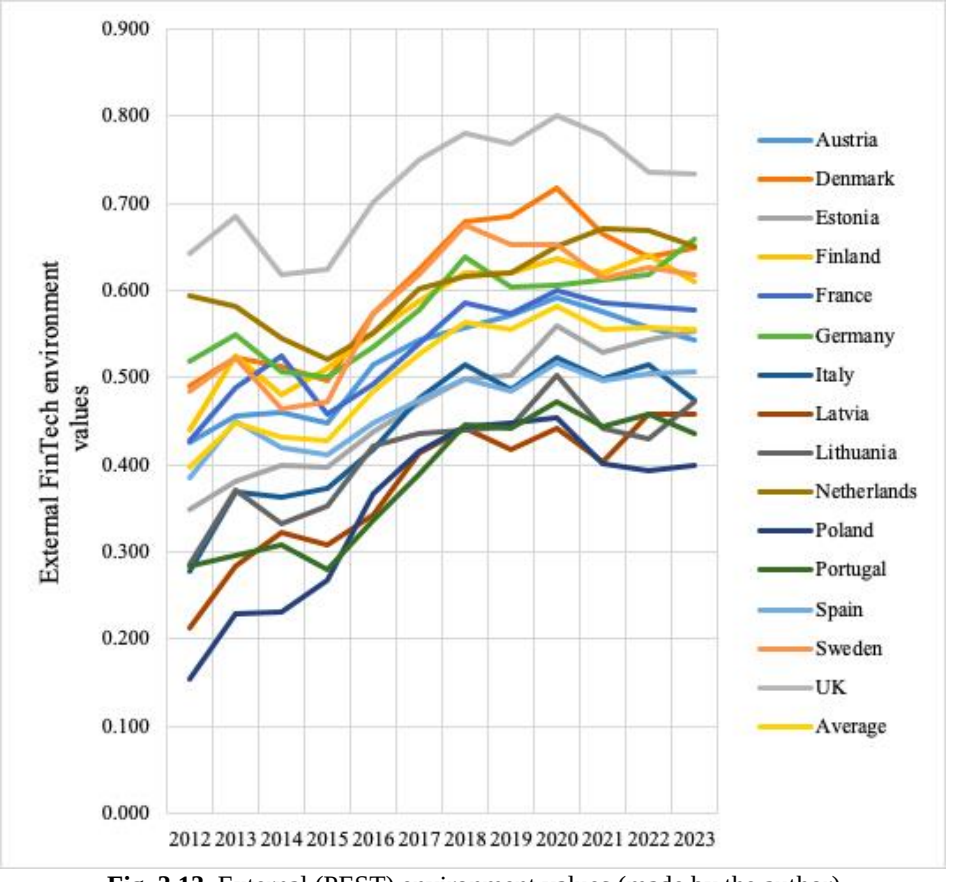


Fig. 3.13. External (PEST) environment values (made by the author)

Figure 3.14 below illustrates the outcomes of evaluating the *Sustainable Development Goals (SDGs)* concerning the FinTech industry. Sweden and Denmark are leaders in the SDG rankings, sharing the best results, while Finland and the Netherlands are also strong performers. Estonia and France perform moderately, and Italy has the worst SDG performance concerning FinTech.

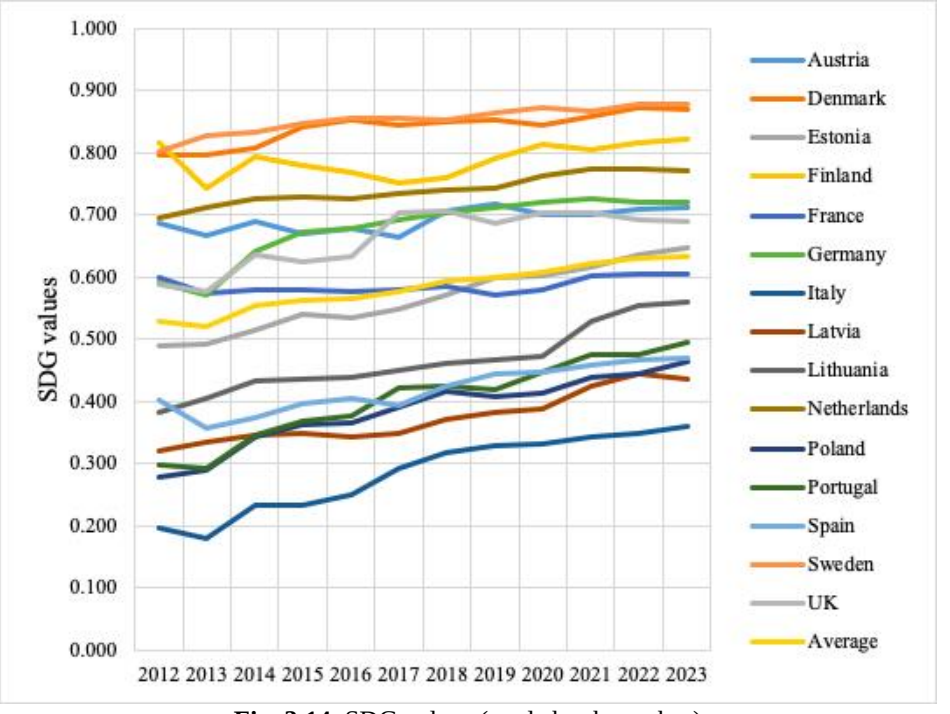


Fig. 3.14. SDG values (made by the author)

When the overall picture is considered, all countries maintain their positions steadily and do not change over time. The analysis of the mean values for all countries reveals a gradual and consistent improvement in the SDG indicators related to FinTech in Europe, indicating a positive trend in the overall situation.

Figure 3.15 below presents the normalised values of the final energy consumption by the commercial and public sectors, which will be incorporated into the final assessment of the sustainable development of the FinTech industry. These values are presented visually to give a general idea of the energy consumption situation in Europe.

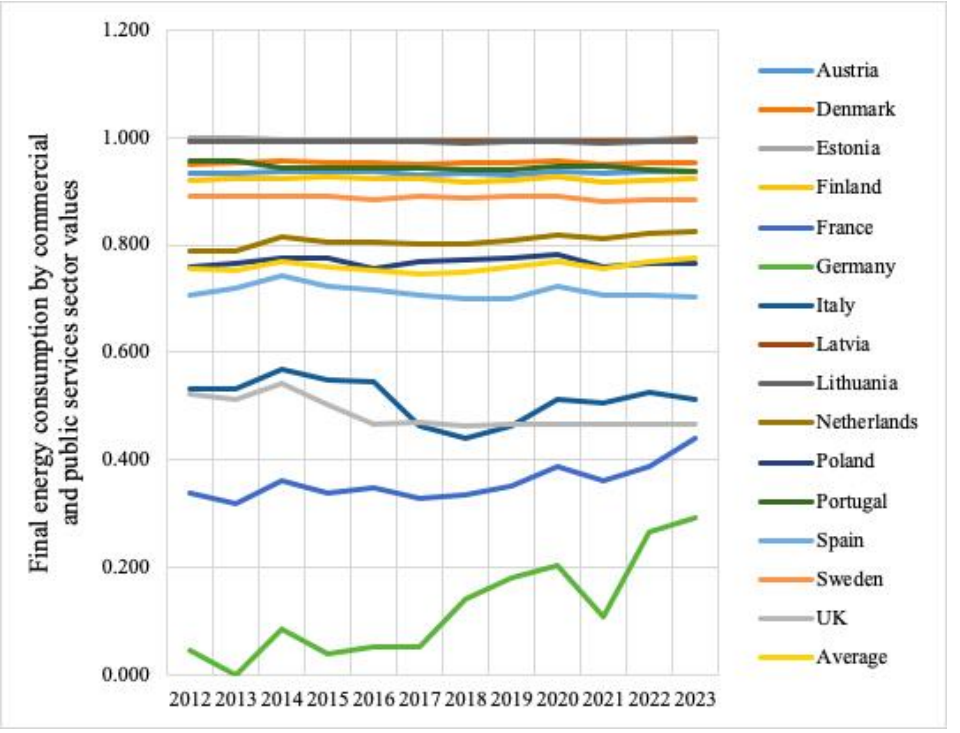


Fig. 3.15. Values of the final energy consumption by the commercial and public sector (made by the author)

Germany has the highest energy consumption of all the countries in question, although efforts have been made to improve this situation since 2017, with gradual progress being made, except in 2021. France, the UK, and Italy also consume significant amounts of energy, but their situation has not improved. All other countries have much lower energy consumption, and the situation remains stable. The aggregate analysis across 15 nations reveals a modest yet consistent increase in commercial and public energy consumption over the 12 years.

Figure 3.16 displays the conclusive outcomes of the assessment of the *sustainable development of the FinTech industry*, integrating all constituent components (FinTech, external (PEST) environment, SDG, and energy consumption).

The conclusive assessment of the sustainable development within the FinTech industry indicates that Denmark, Sweden, Finland, and the Netherlands possess the most sustainable FinTech industries, with Austria, Estonia, and the UK surprisingly trailing behind. Meanwhile, Italy, Germany, Poland, and France were found to have the least sustainable FinTech industry development, which is

undoubtedly partly due to the volume of energy consumption shown in Figure 3.17. The research findings indicate a general trend of increasing sustainability in the development of the FinTech industry over time. It is evidenced by the calculated results in Figure 3.16, which were obtained from 15 countries selected for the research.

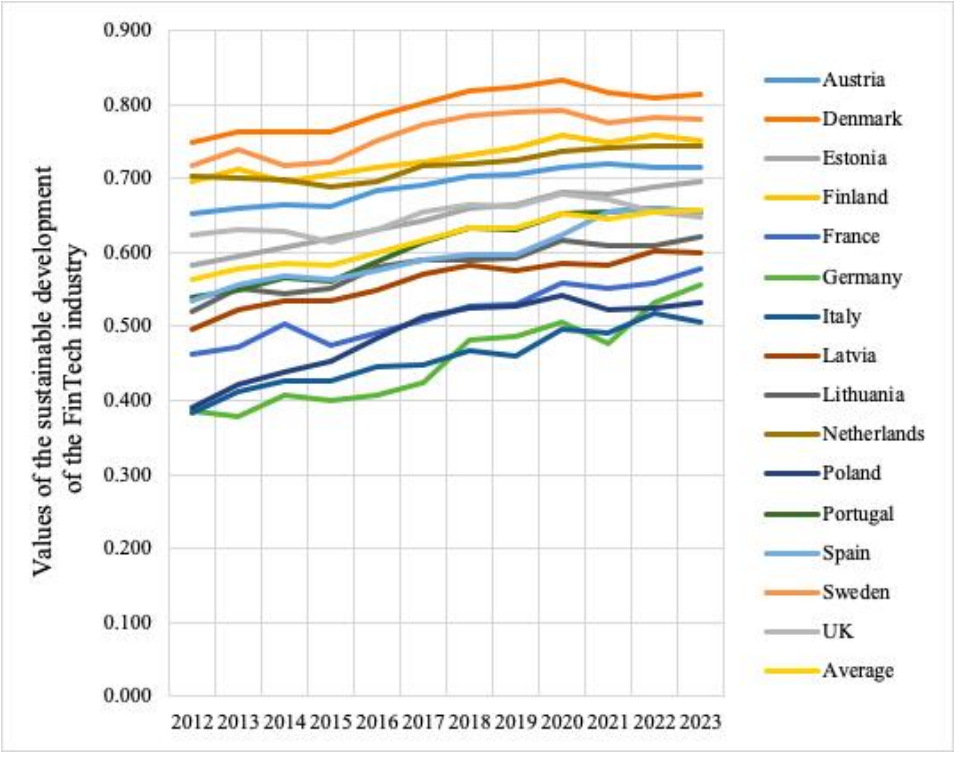


Fig. 3.16. Values of the assessment of the sustainable development of the FinTech industry (made by the author)

The concluding research of the dissertation, a multi-criteria assessment of the sustainable development of the FinTech industry, validated that the indicators of FinTech, the external (PEST) environment, and Sustainable Development Goals, integrated within the methodology, are suitable for assessing the sustainable development of the FinTech industry at the national level and that energy consumption is a significant factor in this context.

3.6. Guidelines for Future Research and Research Limitations

The empirical research undertaken in this dissertation has revealed several potential new research areas that may be explored in future studies:

1) The set of indicators proposed in the dissertation for sustainable FinTech industry development could be applied more broadly, such as the Sustainable FinTech Development Index, to assess the sustainability of FinTech development and its changes at a global level.
2) The final stages of the research revealed the necessity for further research on the interlinkages between science education for young people and the development of the FinTech industry in the context of sustainable development at the European level to shape favourable educational policies for the future sustainable development of financial technology.
3) The final stages of the research indicated a need for further research on the interlinkages between the Press Freedom Index and the development of the FinTech industry in the context of sustainable development at the European level. This research should identify the factors that influence larger market processes and may result in sustainability issues in the FinTech sector.
4) The final phase of the research revealed that the final energy consumption in the commercial and public services sector is substantial in the context of sustainable development for the FinTech industry. It was also determined that future research could focus more on the role of energy consumption in the FinTech sector to support its sustainable development.
5) The final research findings indicate that the Sustainable Development Goals are accorded the lowest priority within the context of the sustainable development of the FinTech sector, despite being the key sustainability targets for all countries worldwide. This state of affairs necessitates further research.

Two principal limitations were encountered during the development of this dissertation. Firstly, the research was hindered by a paucity of data, which was evident at every stage of the research process:

1) In this dissertation, several indicators have been measured on a triennial basis. Consequently, these data have been subject to interpolation to ensure the integrity of the findings. It is particularly evident in the context of the FinTech technological environment and the SDG indicators.
2) It is essential to note that specific indicators were only measured from 2012 onwards, limiting the research timeframe.

3) During the research, the measurement of specific indicators was discontinued. Consequently, these indicators were replaced with others that exhibited greater similarity. This replacement had a significant impact on the adjustment of methodologies.
4) The paucity of data remains a significant issue when measuring the FinTech sector at the country level. It has led to the development of a Principal Component Analysis (PCA) Index, which has influenced the reallocation of indicators in the methodologies. Some of the indicators from SDG 9 have been applied to the FinTech field, leading to the addition of further indicators to SDG 9.

The second limitation pertains to the selection and number of experts involved in the scientific research of this dissertation. FinTech and sustainable development are nascent and evolving domains within the field of research. Identifying sufficient experts with the requisite experience and expertise presents a challenge.

3.7. Conclusions of the Third Chapter

1) Evaluating the political, economic, social, and technological environments relevant to FinTech suggests that Northern Europe, particularly the Baltic States, offers the most favourable political and economic conditions for advancing the FinTech industry. Northern and Western Europe are the most conducive social and technological environments for the FinTech industry's development. The PEST environment assessment for FinTech development in fifteen countries, ranked in descending order of favourability, is as follows: Denmark 0.102, Sweden 0.101, Finland 0.100, the Netherlands 0.099, the United Kingdom 0.099, Estonia 0.098, Lithuania 0.095, Germany 0.094, France 0.089, Spain 0.086, Austria 0.085, Latvia 0.085, Poland 0.083, Portugal 0.083, and Italy 0.077.
2) The correlation analysis results indicate a statistically significant association between the FinTech PEST environment and SDGs 4, 8, 9, and 16, with correlation coefficients exceeding 0.5 for Spearman’s and Kendall’s measurement methods. Consequently, it can be asserted that the FinTech PEST environment is interdependent with SDG 4, SDG 8, SDG 9, and SDG 16, with the strongest correlation observed between the FinTech PEST environment and SDG 16.
3) The evaluation of the significance of the four chosen Sustainable Development Goals indicated that SDG 9, “Industry, innovation, and infrastructure”, holds the highest importance for the sustainable advancement of the FinTech sector, followed by SDG 4, “Quality Education”,

SDG 8, “Decent Work and Economic Growth”, and SDG 16, “Peace, justice, and strong institutions”. The survey results from the three groups, business, public, and science experts, confirmed this.

4) The evaluation of the significance of each SDG indicator revealed two key findings: (1) unrestricted public access to financial technology, or financial inclusion, is the paramount factor in attaining sustainable development within the FinTech industry, while gross domestic expenditure on scientific research and experimental development (R&D) and other general economic indicators of the nation assume a secondary role; (2) the education of the existing workforce is more pertinent to the sustainable development of the FinTech industry than the skills and employment of the younger generation, which is both paradoxical and unexpected, given that they represent the future workforce of FinTech. The primary factors affecting the sustainable development of the FinTech industry are unrestricted public access to FinTech through mobile devices and the Internet, as well as a well-educated working-age population.
5) The evaluation of fifteen selected countries revealed that Northern Europe exhibits the most favourable sustainable development outcomes in the FinTech industry. Finland, Denmark, and the Netherlands occupy the top three positions, followed by North-West and Central Europe. Southern European nations, i.e., Spain, Portugal, and Italy, ranked lowest in the evaluation regarding the sustainable development of the FinTech industry.
6) The findings of MMQR analysis indicate that as quantiles increase, these indices correlate with enhanced FinTech performance. SDG 8 and SDG 9 show favourable effects that affirm their utility as indicators of sustainable FinTech progression. However, the negative values associated with SDG 4 and the fluctuating impact of SDG 16 underscore the need for refinement in these indices to ensure accurate assessments. Among the indicators of SDG 4, only “tertiary educational attainment (% of the population aged 25–34)” has demonstrated a positive influence on FinTech growth. In contrast, within SDG 16, the effectiveness of “Crime is effectively controlled” and “Timeliness of administrative proceedings” is complicated by a deteriorating “Press Freedom Index”. Therefore, it is recommended that future research adjust these indices to reflect their relevance to sustainable FinTech development by removing indicators that negatively affect FinTech development from the overall SDG index and integrating the positively affecting SDG 7 components into it. The research has developed a comprehensive set of 41 indicators

to evaluate the sustainable development of the FinTech industry nationally, providing crucial insights for policymakers and practitioners to refine strategies centred on effective metrics, thereby enhancing the understanding of the intricate relationship between FinTech and sustainability.

7) The final research of the dissertation, a multi-criteria assessment of the sustainable development of the FinTech industry, validated that the indicators of FinTech development, the external environment of FinTech, and Sustainable Development, integrated within the methodology, are suitable for assessing the sustainable development of the FinTech industry at the national level and that energy consumption is a significant factor in this context.

General Conclusions

1. The initial chapter of the dissertation presents a thorough literature review that underscores the research problem: the ambiguity surrounding the sustainable development of the FinTech industry, alongside the absence of assessments regarding this sustainability in both scholarly literature and practical applications. The literature review in the dissertation's First Chapter illustrated the swift expansion of the FinTech industry over the past decade, its potential for continued advancement, and the significance of sustainable development within a global framework in achieving comprehensive digital financial inclusion in society. It was also revealed that the advancement of the FinTech industry is contingent upon favourable external environmental factors, and to ascertain its sustainable development, it is essential to integrate sustainability indicators widely recognised as measures of the Sustainable Development Goals (SDGs). Consequently, it was suggested that the sustainable development of the FinTech industry be defined as *the coherent development of the industry in a favourable external environment, responding to today's society's digital financial inclusion needs without compromising the prospects for future prosperity.* A framework for assessing the sustainable development of the FinTech industry was formulated and presented based on this definition.

2. The second sub-chapter of this dissertation examined the data and methodology employed to assess the sustainable development of the FinTech industry. The Second Chapter of the dissertation presents a methodology grounded in the quantitative assessment framework for the sustainable development of the FinTech industry, as outlined in the First Chapter, which incorporates FinTech, the external PEST environment, and the Sustainable Development Goals (SDGs). Informed by the primary external environment and sustainable development factors influencing the FinTech industry's sustainability, a series of empirical studies for the dissertation was formulated and presented, comprising five empirical studies employing three distinct methods: three multi-criteria assessments, one statistical assessment, and one applied regression analysis. Based on the comprehensive review of scientific literature, the most suitable methods identified include the Simple Additive Weighting (SAW) multi-criteria decision-making method, Kendall's and Spearman's correlation coefficients, and the Method of Moments Quantile Regression (MMQR). A collection of indicators has been established for the comprehensive assessment of sustainable development within the FinTech industry, encompassing the following categories: FinTech indicators, indicators of the political, economic, social, and technological environment of FinTech, and indicators of economic, social, and environmental sustainability.
3. The third sub-chapter of this dissertation evaluated the applicability of the proposed methodology for the sustainable development of the FinTech industry through empirical studies conducted in selected countries. The assessment of the political, economic, social, and technological environments for FinTech revealed that Northern Europe, particularly the Baltic States, offers the most conducive political and economic conditions for the development of the FinTech industry. Northern and Western Europe present the most advantageous social and technological conditions for the development of the FinTech industry. According to the overall assessment, Denmark, Sweden, and Finland exhibit the most favourable PEST environment for FinTech advancement. The results of the correlation analysis between the overall FinTech PEST environment and the Sustainable Development Goals indicated a statistical relationship between the FinTech PEST environment and SDGs 4, 8, 9, and 16, suggesting their interdependence, with the strongest dependency observed between the FinTech PEST environment and SDG 16. The evaluation of the significance of the four chosen Sustainable Development Goals indicated that SDG 9 is paramount for the sustainable development of the FinTech industry, followed by SDG 4, SDG 8, and SDG 16. The survey results from

all three groups, i.e., business, public, and scientific experts, confirmed this. The evaluation of the significance of each SDG indicator revealed two key findings: unrestricted public access to financial technology, or financial inclusion, is the paramount factor in fostering the sustainable development of the FinTech industry, while gross domestic expenditure on scientific research and experimental development (R&D), along with other general economic indicators, assumes a secondary role; furthermore, the training of the existing workforce is more pertinent to the sustainable development of the FinTech industry than the skills and employment of the younger generation. The primary factors affecting the sustainable development of the FinTech industry are unrestricted public access to FinTech through mobile devices and the Internet, as well as a well-educated working-age population. The evaluation of fifteen selected countries revealed that Northern Europe exhibits the most favourable sustainable development outcomes in the FinTech industry. Finland, Denmark, and the Netherlands occupy the top three positions, followed by North-West and Central Europe. Southern European nations, i.e., Spain, Portugal, and Italy, ranked lowest in evaluating sustainable development within the FinTech industry.

4. The Method of Moments Quantile Regression (MMQR) demonstrated that SDG 8 and SDG 9 have a significant influence on FinTech development, thereby validating their efficacy as indicators of sustainable FinTech advancement. However, the negative values of SDG 4 and the fluctuating impact of SDG 16 on FinTech suggest that these indices need to be improved, with SDG 4 retaining only the "Attainment of higher education (% of the population aged 25–34)" and SDG 16 removing the negatively influencing "Freedom of the press index". The research also showed that SDGs need to integrate the positively impacting components of SDG 7.
5. The final research of the dissertation, a multi-criteria assessment of the sustainable development of the FinTech industry, validated that the indicators of FinTech development, the external environment of FinTech, and Sustainable Development, integrated within the methodology, are suitable for assessing the sustainable development of the FinTech industry at the national level and that energy consumption is a significant factor in this context.
6. The practical significance of the research findings in this dissertation is grounded in three domains: government, business, and society. The methodology and indicator framework presented in the dissertation for quantitatively evaluating the sustainable development of the FinTech industry

at the national level can be readily adapted by national regulators to assess the industry's sustainable development, including its strengths and weaknesses. The research findings can also be helpful for FinTech companies, as they allow for a rational and objective assessment of the sustainable development of the FinTech sector in the selected state. The research findings can also benefit society, FinTech customers, and users, as the sustainable development of the FinTech sector promotes digital financial inclusion within society. The practical implications of this dissertation's results include advancing sustainable development within the FinTech industry, enhancing digital financial inclusion, achieving the Sustainable Development Goals, and promoting global sustainable economic development.

References

Adjasi, C., Hamilton, C., & Lensink, R. (2023). Fintech and financial inclusion in developing countries. In T. Walker, E. Nikbakht, & M. Kooli (Eds), *The Fintech Disruption: How financial innovation is transforming the banking industry* (pp. 297–328). Palgrave Macmillan Cham. https://doi.org/10.1007/978-3-031-23069-1_12

Afroz, S., & Raghutla, C. (2024). Do various financial resources ensure renewable energy production and environmental protection in OECD countries: modelling for insight? *Environmental Science and Pollution Research*, *31*(48), 58562–58580. https://doi.org/10.1007/s11356-024-34995-z

Anshari, M., Almunawar, M., & Masri, M. (Eds.) Fintech development for financial inclusiveness, *IGI Global*, 1–13. https://doi.org/10.4018/978-1-7998-8447-7.ch001

Arner, D. W., Barberis, J., & Buckley, R. P. (2015). The evolution of fintech: a new post-crisis paradigm. *Georgetown Journal of International Low*, *47*, Article 1271. https://doi.org/10.2139/ssrn.2676553

Arner, D. W. (2016). *Fintech: evolution and regulation* [Presentation]. Melbourne Law School. http://law.unimelb.edu.au/__data/assets/pdf_file/0011/1978256/D-Arner-FinTech-Evolution-Melbourne-June-2016.pdf

Arner, D. W., Barberis, J., & Buckley, R. P. (2016). 150 years of Fintech: an evolutionary analysis. *Jassa*, (3), 22–29.

Arner, D. W., Buckley, R. P., Zetzsche, D. A., & Veidt, R. (2020). Sustainability, fintech and financial inclusion. *European Business Organization Law Review*, *21*(1), 7–35. http://dx.doi.org/10.2139/ssrn.3387359

Arner, D. W., Buckley, R. P., Charamba, K., Sergeev, A., & Zetzsche, D. A. (2021). Bigtech and platform finance: governing fintech 4.0 for sustainable development. University of Hong Kong Faculty of Law. http://dx.doi.org/10.2139/ssrn.3915275

Arner, D., Buckley, R., Charamba, K., Sergeev, A., & Zetzsche, D. (2022). Governing fintech 4.0: bigtech, platform finance, and sustainable development. *Fordham J. Corp. & Fin. L.*, *27*(1).

Ascher, W. L., & Mirovitskaya, N. (2020). *Guide to sustainable development and environmental policy*. Duke University Press. https://doi.org/10.1515/9780822381037

Asif, M., Khan, M. N., Tiwari, S., Wani, S. K., & Alam, F. (2023). The impact of fintech and digital financial services on financial inclusion in india. *Journal of Risk and Financial Management*, *16*(2), Article 122. https://doi.org/10.3390/jrfm16020122

Awais, M., Afzal, A., Firdousi, S., & Hasnaoui, A. (2023). Is fintech the new path to sustainable resource utilisation and economic development? *Resources Policy*, *81*, Article 103309. https://doi.org/10.1016/j.resourpol.2023.103309

Bayar, Y., Gavriletea, M. D., & Păun, D. (2021). Impact of mobile phones and internet use on financial inclusion: empirical evidence from the EU post-communist countries. *Technological and Economic Development of Economy*, *27*(3), 722–741. https://doi.org/10.3846/tede.2021.14508

Baležentis, A., & Žalimaitė, M. (2011). Ekspertinių vertinimų taikymas inovacijų plėtros veiksnių analizėje: Lietuvos inovatyvių įmonių vertinimas. *Management Theory & Studies for Rural Business & Infrastructure Development*, *27*(3). https://research.ebsco.com/linkprocessor/plink?id=565d92ad-7618-3023-96c0-2d723c7de2ac

Barroso, M., & Laborda, J. (2022). Digital transformation and the emergence of the fintech sector: systematic literature review. *Digital Business*, *2*(2), Article 100028. https://doi.org/10.1016/j.digbus.2022.100028

Basiago, A. D. (1998). Economic, social, and environmental sustainability in development theory and urban planning practice. *Environmentalist*, *19*(2), 145–161. https://doi.org/10.1023/A:1006697118620

Bateman, M. (2020). Be careful what you wish for: the spectacular rise of fintech. In Langthaler, M., Obrovsky, M., & Raza, W. (Eds.), Digitalization for development?

Challenges for developing countries, 25–34. https://doi.org/10.60637/2020-oepol20

Bedoui, H. E., & Robbana, A. (2019). Islamic social financing through cryptocurrency. In Billah, M. (Ed.), *Halal cryptocurrency management*, 259–274. https://doi.org/10.1007/978-3-030-10749-9_16

Bersudskaya, V., Celik, A., Forstater, M., He, M., Mitha, A., Singh, A., & Zadek, S. (2020). *People's Money: Harnessing digitalization to finance a sustainable future* (Report). Retrieved from https://sdghub.com/project/peoples-money-harnessing-digitalization-to-finance-a-sustainable-future/

Boitan, I. A., & Barbu, T. C. (2021). EU fintech index: an evaluation of countries' opportunities for fintech growth. In Boitan, I. A., & Marchewka-Bartkowiak, K. (Eds.), *Fostering innovation and competitiveness with FinTech, RegTech, and SupTech*, 1–20. IGI Global. https://doi.org/10.4018/978-1-7998-4390-0.ch001

Boyer, R. H., Peterson, N. D., Arora, P., & Caldwell, K. (2016). Five approaches to social sustainability and an integrated way forward. *Sustainability*, *8*(9), Article 878. https://doi.org/10.3390/su8090878

Boston Consulting Group & QED Investors. (2023, May). *Global Fintech 2023: Reimagining the Future of Finance*. Boston Consulting Group. https://web-assets.bcg.com/66/7e/a36d7eab41e2b4b65c3e687a17f5/bcg-qed-global-fintech-report-2023-reimagining-the-future-of-finance-may-2023.pdf

Buchak, G., Matvos, G., Piskorski, T., & Seru, A. (2018). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of financial economics*, *130*(3), 453–483. https://doi.org/10.1016/j.jfineco.2018.03.011

Bueno, P. C., Vassallo, J. M., & Cheung, K. (2015). Sustainability assessment of transport infrastructure projects: a review of existing tools and methods. *Transport reviews*, *35*(5), 622–649. https://doi.org/10.1080/01441647.2015.1041435

Castilla-Rubio, J. C., Zadek, S., & Robins, N. (2016). *Fintech and sustainable development. Assessing the implications. Summary* (Report). United Nations Environment Programme. Retrieved from http://unepinquiry.org/wp-content/uploads/2016/12/Fintech_and_Sustainable_Development_Assessing_the_Implications_Summary.pdf

Cen, T., & He, R. (2018). Fintech, green finance and sustainable development. *Proceedings of the 2018 International Conference on Management, Economics, Education, Arts and Humanities (MEEAH 2018)*, 222–225. Atlantis Press. https://doi.org/10.2991/meeah-18.2018.40

Chakravorti, B., Chaturvedi, R. S., Filipovic, C., & Brewer, G. (2020). *Digital in the time of covid. Trust in the digital economy and its evolution across 90 economies as the planet paused for a pandemic*. The Fletcher School at Tufts University.

Chen, C. C., Huang, H. H., Takamura, H., Kato, M. P., & Huang, Y. L. (2023). Fintech on the web: an overview. *ACM Transactions on the Web*, *17*(2), 1–3. https://doi.org/10.1145/3572404

Chen, X., & Liu, Z. (2024). Fintech and sustainable resources management: role of trade openness and globalisation in BRICS countries. *Resources Policy*, *90*, Article 104700. https://doi.org/10.1016/j.resourpol.2024.104700

Cheng, M., & Qu, Y. (2023). Does operational risk management benefit from fintech?. *Emerging Markets Finance and Trade*, 1–16. https://doi.org/10.1080/1540496X.2022.2164464

Choudhary, P., Ghosh, C., & Thenmozhi, M. (2025). Impact of fintech and financial inclusion on sustainable development goals: evidence from cross country analysis. *Finance Research Letters*, *72*, Article 106573. https://doi.org/10.1016/j.frl.2024.106573

Combley, R. (Ed.). (2011). *Cambridge business English dictionary*. Cambridge University Press.

Cumming, D., Johan, S., & Reardon, R. (2023). Global fintech trends and their impact on international business: a review. *Multinational Business Review*, *31*(3), 413–436. https://doi.org/10.1108/MBR-05-2023-0077

Čekanavičius, V., & Murauskas, G. (2008). *Statistika ir jos taikymai II. TEV*.

De Ridder, W., Turnpenny, J., Nilsson, M., & Von Raggamby, A. (2007). A framework for tool selection and use in integrated assessment for sustainable development. *Journal of environmental assessment policy and management*, *9*(4), 423–441. https://doi.org/10.1142/S1464333207002883

Dictionary. (n.d.). Fintech. In dictionary.com. Retrieved from https://www.dictionary.com/browse/fintech

Dreher, A. (2006). Does globalization affect growth? Evidence from a new index of globalization. *Applied Economics*, *38*(10), 1091–1110. https://doi.org/10.1080/00036840500392078

Dutta, S., Lanvin, B., Rivera León, L., & Wunsch-Vincent, S. (Eds.). (2023). *Global Innovation Index 2023: Innovation in the face of uncertainty*. WIPO.

Ediagbonya, V., & Tioluwani, C. (2023). The role of fintech in driving financial inclusion in developing and emerging markets: issues, challenges and prospects. *Technological Sustainability*, *2*(1), 100–119. https://doi.org/10.1108/TECHS-10-2021-0017

EY. (2015). *EY FinTech adoption index*.

EY. (2017). *EY FinTech adoption index: The rapid emergence of FinTech*. EY Global Financial Services.

EY. (2019). *Global FinTech adoption index 2019: As FinTech becomes the norm, you need to stand out from the crowd*. EY Global Financial Services.

Ellili, N. O. D. (2022). Is there any association between fintech and sustainability? Evidence from bibliometric review and content analysis. *Journal of Financial Services Marketing, 28*, 748–762. https://doi.org/10.1057/s41264-022-00200-w

Esmaeilpour Moghadam, H., & Karami, A. (2023). Financial inclusion through fintech and women's financial empowerment. *International Journal of Social Economics*. https://doi.org/10.1108/IJSE-04-2022-0246

European Commission. (2018). Fintech action plan: for a more competitive and innovative European financial sector. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0109

European Commission (EC). (2020). *Digital Finance Package: Commission sets out new, ambitious approach to encourage responsible innovation to benefit consumers and businesses* (Press release). https://ec.europa.eu/commission/ presscorner/detail/en/IP_20_1684

European Commission (EC). (2021). *Sustainable Finance and EU Taxonomy: Commission takes further steps to channel money towards sustainable activities* (Press release). https://ec.europa.eu/commission/presscorner/detail/en/ ip_21_1804

Eurostat. (2024). Database. https://ec.europa.eu/eurostat/data/database

Faust, C., Dukes, A. J., & Sokol, D. D. (2023). Fintech and financial inclusion: a review of the empirical literature. *Southern California Law Review*. https://southerncalifornialawreview.com/wp-content/uploads/2023/04/Sokol_Final.pdf

fDi Intelligence. (2019). *FinTech locations of the Future: 2019/20 winners*. https://www.fdiintelligence.com/article/75404

Farahani, M. S., Esfahani, A., Moghaddam, M. N. F., & Ramezani, A. (2022). The impact of fintech and artificial intelligence on covid 19 and sustainable development goals. *International Journal of Innovation in Management, Economics and Social Sciences, 2*(3), 14–31. https://doi.org/10.52547/ijimes.2.3.14

Field A., Miles J., & Field Z. (2012). *Discovering statistics using R*. Sage. https://us.sagepub.com/en-us/nam/discovering-statistics-using-r/book236067

Financial Stability Board. (2019). *FinTech and market structure in financial services: Market developments and potential financial stability implications*. https://www.fsb.org/wp-content/uploads/P140219.pdf

Findexable. (2021). *The global Fintech index 2021*. https://findexable.com/2021-fintech-rankings/

Findexable. (2022). *Fintech in Europe, The Quiet Revolution 2022*. https://findexable.com/2022-fintech-in-europe-the-quiet-revolution/

Folke, C., Biggs, R., Norström, A., Reyers, B., & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society, 21*(3), 41. https://dx.doi.org/10.5751/ES-08748-210341

Fratiloiu, I. (2022). New fintech offerings driving financial inclusion. *ITNOW*, *64*(2), 50–51. https://doi.org/10.1093/itnow/bwac057

Frost, J. (2020). The economic forces driving fintech adoption across countries. In M. R. King & R. W. Nesbitt (Eds.), *The technological revolution in financial services: How banks, FinTechs, and customers win together* (pp. 70–89). University of Toronto Press. https://doi.org/10.3138/9781487533137-006

Gauthier, J. F., Penzel, M., Kuester, S., & Boydell, H. (2022). *The global FinTech ecosystem report: Fintech Edition* (Startup Genome LLC).

Gedvilaitė, D. (2019). *The assessment of sustainable development of a countrys' regions* [Doctoral Dissertation]. Technika.

Gibson, R. B. (2006). Beyond the pillars: sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision-making. *Journal of environmental assessment policy and management, 8*(3), 259-280. https://doi.org/10.1142/S1464333206002517

Giglio, F. (2021). Fintech: A literature review. *European Research Studies Journal*, 24(2B), 600–627.

Ginevičius, R. (2009). Socioekonominių sistemų būklės kiekybinio įvertinimo problematika. *Verslas: teorija ir praktika*, *10*(2), 69–83. https://doi.org/10.3846/1648-0627.2009.10.69-83

Ginevičius, R.; Gedvilaitė, D.; Bruzgė, Š. 2015. Assessment of a country's regional eco- nomic development on the basis of estimation of a single process (ESP) method. *Entre- preneurial business and economics review (EBER)*. *3*(2): 141–153. ISSN 2353-883X. https://doi.org/10.15678/EBER.2015.030210

Gygli, S., Haelg, F., Potrafke, N., & Strum, J. E. (2019). The KOF Globalisation Index – revisited. *The Review of International Organizations, 14*, 543–574. https://doi.org/10.1007/s11558-019-09344-2

Gomber, P., Koch, J. A., & Siering, M. (2017). Digital finance and fintech: current research and future research directions. Journal of Business Economics, 87(5), 537–580. https://doi.org/10.1007/s11573-017-0852-x

Gomber, P., Kauffman, R. J., Parker, C., & Weber, B. W. (2018). On the fintech revolution: interpreting the forces of innovation, disruption, and transformation in financial services. *Journal of management information systems*, *35*(1), 220–265. https://doi.org/10.1080/07421222.2018.1440766

Goo, J. J., & Heo, J. Y. (2020). The impact of the regulatory sandbox on the fintech industry, with a discussion on the relation between regulatory sandboxes and open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(2), Article 43. https://doi.org/10.3390/joitmc6020043

Guermazi, I. (2025). Impact of financial technology (fintech) on sustainable growth: key factors, practical cases and empirical review. In M. Shehadeh & K. Hussainey (Eds.), *From Digital Disruption to Dominance*, 211–224. https://doi.org/10.1108/978-1-83549-608-420251010

Gupta, A. (2013). Environment & PEST analysis: an approach to the external business environment. *International Journal of Modern Social Sciences*, *2*(1), 34–43.

Hasan, M., Hoque, A., Abedin, M. Z., & Gasbarro, D. (2024). Fintech and sustainable development: a systematic thematic analysis using human-and machine-generated processing. *International review of financial analysis*, *95*, Article 103473. https://doi.org/10.1016/j.irfa.2024.103473

Hausemer, Ch. (2020, November 10). *Innovating the way to Sustainable Development Goals.* Fintech Talents. https://www.fintechtalents.com/innovating-the-way-to-sustainable-development-goals/

Hieminga, G., Lande, F., & Nijboer, T. (2016). *The FinTech index: Assessing digital and financial inclusion in developing and emerging countries*. ING Economics Department.

Hinson, R., Lensink, R., & Mueller, A. (2019). Transforming agribusiness in developing countries: SDGs and the role of FinTech. *Current Opinion in Environmental Sustainability*, *41*, 1–9. https://doi.org/10.1016/j.cosust.2019.07.002

Hoang, T. G., Nguyen, G. N. T., & Le, D. A. (2022). Developments in financial technologies for achieving the sustainable development goals (SDGs): fintech and SDGs.

In *Disruptive technologies and eco-innovation for sustainable development* (pp. 1–19). IGI Global. https://doi.org/10.4018/978-1-7998-8900-7.ch001

Holmberg, J., & Sandbrook, R. (2019). Sustainable development: what is to be done? In J. Holmberg (Ed.), *Policies for a small planet* (pp. 19–38). Routledge. https://doi.org/10.4324/9780429200465-1

Honecker, F., & Chalmers, D. (2022). Fintech for financial inclusion. In Chen, H.-y., Jenweeranon, P. and Alam, N. (eds.) *Global Perspectives in FinTech: Law, Finance and Technology* (pp. 155–173). Palgrave Macmillan: Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-11954-5_8

Hudaefi, F. A. (2020). How does islamic fintech promote the SDGs? Qualitative evidence from Indonesia. *Qualitative Research in Financial Markets, 12*(4), 353–366. https://doi.org/10.1108/QRFM- 05-2019-0058

Hwang, C. L.; Yoon, K. 1981. *Multiple Attribute Decision Making. Methods and Applications A State-of-the-Art Survey.* Lecture Notes in Economics and Mathematical Systems (Vol. 186). Springer Berlin Heidelberg.

Iftikhar, H., Ullah, A., & Pinglu, C. (2024). From regional integrated development toward sustainable future: evaluating the belt and road initiative's spillover impact between tourism, fintech and inclusive green growth. *Clean Technologies and Environmental Policy*, 1–28. https://doi.org/10.1007/s10098-024-02890-3

International Monetary Fund. (2018). *The Bali FinTech Agenda*. https://www.imf.org/en/Publications/Policy-Papers/Issues/2018/10/11/pp101118-bali-fintech-agenda

International Monetary Fund. (2021). *World Economic Outlook (October 2021)*. https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD

International Monetary Fund. (2023). World Economic Outlook (April 2025). https://www.imf.org/external/datamapper/datasets/WEO

International Monetary Fund. (2024). *IMF Data Portal*. https://data.imf.org/?sk=388dfa60-1d26-4ade-b505-a05a558d9a42&sid=1479329334655

International Monetary Fund. (2024). *What is inclusive growth?* https://www.imf.org/en/Publications/fandd/issues/2024/03/B2B-what-is-inclusive-growth-Ruchir-Agarwal

International Organisation of Securities Commissions. (2017). *IOSCO Research Report on Financial Technologies (FinTech)*. https://www.iosco.org/library/pubdocs/pdf/IOSCOPD554.pdf

Young, D., & Young, J. (2022). Technology adoption: impact of fintech on financial inclusion of low-income households. *International Journal of Electronic Finance*, *11*(3), 202–218. https://doi.org/10.1504/IJEF.2022.124480

Yu, P., Li, C., Sampat, M., & Chen, Z. (2022). How the development of fintech can bolster financial inclusion under an era of disruptive innovation?: case study on

China. In M. Amshari & M. N. Almunawar (Eds.), *FinTech Development for Financial Inclusiveness* (pp. 135–167). IGI Global. https://doi.org/10.4018/978-1-7998-8447-7.ch009

Jie, Y., Rasool, Z., Nassani, A. A., Mattayaphutron, S., & Murad, M. (2024). Sustainable central Asia: impact of fintech, natural resources, renewable energy, and financial inclusion to combat environmental degradation and achieving sustainable development goals. *Resources Policy*, *95*, Article 105138. https://doi.org/10.1016/j.resourpol.2024.105138

Kakar, S. K., Ali, J., Wang, J., Wu, X., Arshed, N., Le Hien, T. T., & Yadav, R. S. (2024). Exploring the impact of industrialization and electricity use on carbon emissions: the role of green fintech in Asian countries using an asymmetric panel quantile ARDL approach. *Journal of Environmental Management*, *370*, Article 122970. https://doi.org/10.1016/j.jenvman.2024.122970

Karakas, C., & Stamegina, C. (2019). Fintech (financial technology) and the European Union: State of play and outlook. EPRS: European Parliamentary Research Service. Belgium. https://coilink.org/20.500.12592/txr31j

Kashif, M., Pinglu, C., Ullah, S., & Zaman, M. (2023). Evaluating the influence of financial technology (fintech) on sustainable finance: a comprehensive global analysis. *Financial Markets and Portfolio Management*, 1–33. https://doi.org/10.1007/s11408-023-00439-w

Keeble, B. R. (1988). The Brundtland report:'Our common future'. *Medicine and war*, *4*(1), 17–25. https://doi.org/10.1080/07488008808408783

Kishor, K., Bansal, S. K., & Kumar, R. (2024). The role of fintech in promoting financial inclusion to achieve sustainable development: an integrated bibliometric analysis and systematic literature review. *Journal of the Knowledge Economy*, 1–29. https://doi.org/10.1007/s13132-024-02168-5

KOF Swiss Economic Institute. (2023). *KOF Globalisation Index 2023*. https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html

KOF Swiss Economics Institute. (2024). KOF Globalisation Index data: https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html

Kong, X., & Xu, T. How fintech affects total factor energy efficiency? – evidence from Chinese cities. *Frontiers in Energy Research*, *11*, Article 1296820. https://doi.org/10.3389/fenrg.2023.1296820

KPMG & CB Insights. (2016). T*he pulse of Fintech, 2015 in Review. Global Analysis of Fintech Venture Funding*. https://assets.kpmg/content/dam/kpmg/pdf/2016/03/the-pulse-of-fintech.pdf

KPMG. (2017). *The Pulse of Fintech Q4 2016. Global analysis of investment in fintech*. https://assets.kpmg/content/dam/kpmg/xx/pdf/2017/02/pulse-of-fintech-q4-2016.pdf

KPMG. (2018). *The Pulse of Fintech Q4 2017. Global analysis of investment in fintech*. https://assets.kpmg/content/dam/kpmg/xx/pdf/2018/02/pulse_of_fintech_q4_2017.pdf

KPMG. (2019). *The Pulse of Fintech 2018. Biannual global analysis of investment in fintech*. https://assets.kpmg/content/dam/kpmg/xx/pdf/2018/07/h1-2018-pulse-of-fintech.pdf

KPMG. (2020). *Pulse of Fintech H2 2019*. https://assets.kpmg/content/dam/kpmg/xx/pdf/2020/02/pulse-of-fintech-h2-2019.pdf

KPMG. (2021). *Pulse of Fintech H2'20*. https://assets.kpmg/content/dam/kpmg/xx/pdf/2021/02/pulse-of-fintech-h2-2020.pdf

KPMG. (2022). *Pulse of FinTech H2'21*. https://assets.kpmg/content/dam/kpmg/xx/pdf/2022/02/pulse-of-fintech-h2-21.pdf

KPMG. (2023). *Pulse of FinTech H2'22*. https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2023/02/pulse-of-fintech-h2-22-web-file.pdf

KPMG. (2024). *Pulse of FinTech H2'23*. https://kpmg.com/xx/en/home/insights/2024/02/pulse-of-fintech-h2-2023-global-insights.html

KPMG. (2025). *Pulse of FinTech H2'24*. https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2025/02/pulse-of-fintech-h2-2024.pdf

Kunskaja, S. (2018). Expert evaluation of the expression of personal competencies in professional activities. *European Journal of Economics and Business Studies*, *4*(2), 197–205. https://doi.org/10.26417/ejes.v4i2.p203-211

Kwong, R., Kwok, M. L. J., & Wong, H. Green *Fintech as a future research direction: a bibliometric analysis on green finance and fintech*. Available at SSRN 4299813. http://dx.doi.org/10.2139/ssrn.4299813

Langthaler, M., Obrovsky, M., & Raza, W. (Eds.), Digitalization for development? Challenges for developing countries, 25–34. https://doi.org/10.60637/2020-oepol20

Legowo, M. B., Subanidja, S., & Sorongan, F. A. (2020, September). Model of sustainable development based on fintech in financial and banking industry: a mixed-method research. In *2020 3rd International conference on computer and informatics engineering (IC2IE)* (pp. 194–199). IEEE. https://doi.org/10.1109/IC2IE50715.2020.9274605

Leong, K., & Sung, A. (2018). Fintech (financial technology): what is it and how to use technologies to create business value in fintech way?. *International Journal of Innovation, Management and Technology*, 9(2), 74–78. https://doi.org/10.18178/ijimt.2018.9.2.791

Libby, R., & Blashfield, R. K. (1978). Performance of a composite as a function of the number of judges. *Organizational behavior and human performance*, *21*(2), 121–129. https://doi.org/10.1016/0030-5073(78)90044-2

Lin, H. H., Hsu, C. C., Wu, P. H., Shen, C. C., & Chen, G. H. (2024). Demystifying the interconnections among natural resources, fintech, green technologies, and sustainable environment in E-7 nations. *Resources Policy*, *90*, Article 104698. https://doi.org/10.1016/j.resourpol.2024.104698

Lisha, L., Mousa, S., Arnone, G., Muda, I., Huerta-Soto, R., & Shiming, Z. (2023). Natural resources, green innovation, fintech, and sustainability: a fresh insight from BRICS. *Resources Policy*, *80*, Article 103119. https://doi.org/10.1016/j.resourpol.2022.103119

Lomachynska, I. A. (2020). Modernization of structure of financial systems with the development of FinTech. In V. O. Boiko, N. I. Verkhoglyadova, O. M. Volska, V. H. Hranovska, *Scientific approaches to modernizing the economic system: Vector of development*, 363–382. Liha-Press. http://catalog.liha-pres.eu/index.php/liha-pres/catalog/view/97/1184/8872-1

Lv, Z., Chen, L., Ali, S. A., Muda, I., Alromaihi, A., & Boltayev, J. Y. (2024). Financial technologies, green technologies and natural resource nexus with sustainable development goals: evidence from resource abundant economies using MMQR estimation. *Resources Policy*, *89*, Article 104649. https://doi.org/10.1016/j.resourpol.2024.104649

Macchiavello, E., & Siri, M. (2022). Sustainable finance and fintech: can technology contribute to achieving environmental goals? A preliminary assessment of 'green fintech' and 'sustainable digital finance'. *European Company and Financial Law Review*, *19*(1), 128174. https://doi.org/10.1515/ecfr-2022-0005

Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics*, *213*(1), 145–173. https://doi.org/10.1016/j.jeconom.2019.04.009

Manyika, J., Lund, S., Singer, M., White, O., & Berry, C. (2016). *Digital finance for all: Powering inclusive growth in emerging economies*. McKinsey Global Institute.

ManpowerGroup Talent Solutions. (2020). Total workforce index 2020 global analysis. *ManpowerGroup*. https://www.manpowergroup.com.au/blog/2020/12/total-workforce-index-2020?source=google.com

Mei, S., Peiguang, L., & Xiushan, N. (2018, August). Research on fintech industry development and talent training status. In *2018 13th International Conference on Computer Science & Education* (ICCSE) (pp. 1–4). IEEE. https://doi.org/10.1109/ICCSE.2018.8468796

Mensah, J. (2019). Sustainable development: meaning, history, principles, pillars, and implications for human action: literature review. *Cogent social sciences*, *5*(1), Article 1653531. https://doi.org/10.1080/23311886.2019.1653531

Mention, A. L. (2019). The future of fintech. *Research-Technology Management*, *62*(4), 59–63. https://doi.org/10.1080/08956308.2019.1613123

Merriam-Webster. (n.d.). Fintech. In *Merriam-Webster.com dictionary*. Retrieved February 25, 2025 from https://www.merriam-webster.com/dictionary/fintech

Mhlanga, D. (2022). The role of financial inclusion and fintech in addressing climate-related challenges in the industry 4.0: lessons for sustainable development goals. *Frontiers in Climate*, *4*, Article 949178. https://doi.org/10.3389/fclim.2022.949178

Michael, B. (2020). The fintech dividend: how much money is fintech likely to mobilize for sustainable development? *Global Policy, 12* (5). http://dx.doi.org/10.2139/ssrn.3589224

Milian, E. Z., Spinola, M. D. M., & de Carvalho, M. M. (2019). Fintechs: a literature review and research agenda. *Electronic Commerce Research and Applications*, *34*, Article 100833. https://doi.org/10.1016/j.elerap.2019.100833

Miller, T., Kim, A. B., & Roberts, J. M. (2024). *Index of economic freedom.* The Heritage Foundation.

Moldan, B., Janoušková, S., & Hák, T. (2012). How to understand and measure environmental sustainability: indicators and targets. *Ecological indicators*, *17*, 4–13. https://doi.org/10.1016/j.ecolind.2011.04.033

Mushtaq, R., & Bruneau, C. (2019). Microfinance, financial inclusion and ICT: implications for poverty and inequality. *Technology in Society*, *59*, Article 101154. https://doi.org/10.1016/j.techsoc.2019.101154

National Cyber Security Index. (2024). https://ncsi.ega.ee/ncsi-index/

Ness, B., Urbel-Piirsalu, E., Anderberg, S., & Olsson, L. (2007). Categorising tools for sustainability assessment. *Ecological economics*, *60*(3), 498–508. https://doi.org/10.1016/j.ecolecon.2006.07.023

Nicoletti, B. (2017, February). *The new business model* (Presentation). https://www.cardsinternational.com/wp-content/uploads/sites/3/2017/03/Bernardo-Nicoletti_Transigma.pdf

Nicoletti, B., Nicoletti, W., & Weis. (2017). *Future of fintech*. Palgrave Macmillan. https://doi.org/10.1007/978-3-319-51415-4

Nizam, R., Karim, Z. A., Rahman, A. A., & Sarmidi, T. (2020). Financial inclusiveness and economic growth: new evidence using a threshold regression analysis. *Economic research-Ekonomska istraživanja*, 33(1), 1465–1484. https://doi.org/10.1080/1331677X.2020.1748508

Nkwede, F. (2015). Financial inclusion and economic growth in Africa: insight from Nigeria. *European Journal of Business and Management*, *7*(35), 71–80.

Noreen, U. (2024). Mapping of fintech ecosystem to sustainable development goals (SDGs): Saudi Arabia's landscape. *Sustainability*, *16*(21), Article 9362. https://doi.org/10.3390/su16219362

Oben, R., Seraj, M., & Eyüpoğlu, Ş. Z. (2024). Toward environmental sustainability in Africa: the impact of financial technology, human development, and renewable energy consumption across income groups. *Environmental Quality Management*, *34*(2), Article e22347. https://doi.org/10.1002/tqem.22347

OECD. 2018. Financial Markets, Insurance and Private Pensions: Digitalisation and Finance. https://www.oecd.org/content/dam/oecd/en/publications/reports/2018/01/financial-markets-insurance-and-pensions-2018_9225d1bb/0021e92e-en.pdf

Oxford Advanced Learner's Dictionary. (n.d.). Fintech. In *oxfordlearnersdictionaries.com* by Oxford University Press. Retrieved February 25, 2025 from https://www.oxfordlearnersdictionaries.com/definition/english/fintech?q=fintech

Oxford Dictionary. (n.d.). Fintech. In *oed.com dictionary* by Oxford University Press. Retrieved February 25, 2025 from https://www.oed.com/search/dictionary/?scope=Entries&q=fintech

Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review*, *18*(4), 329–340. https://doi.org/10.1016/j.bir.2017.12.003

Ozili, P. K. (2022). CBDC, fintech and cryptocurrency for financial Inclusion and financial stability. *Digital Policy, Regulation and Governance*, (ahead-of-print). https://doi.org/10.1108/DPRG-04-2022-0033

Podvezko, V. 2011. The comparative analysis of MCDA methods SAW and COPRAS, *Engineering Economics*, 22(2), 134–146. https://doi.org/10.5755/j01.ee.22.2.310

Pope, J., Annandale, D., & Morrison-Saunders, A. (2004). Conceptualising sustainability assessment. *Environmental impact assessment review*, *24*(6), 595–616. https://doi.org/10.1016/j.eiar.2004.03.001

Popescu, A. D. (2022). Understanding fintech and decentralized finance (DeFi) for financial inclusion. In

Portney, K. E. (2015). *Sustainability*. MIT Press.

Portulans Institute. (2020). *The network readiness index 2020: Accelerating digital transformation in a post-COVID global economy.*

Portulans Institute. (2024). *The Network Readiness Index2024*. https://networkreadinessindex.org/countries/#ranking-wrapper

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. *Sustainability science*, *14*, 681–695. https://doi.org/10.1007/s11625-018-0627-5

Ratnawati, K. (2020). The impact of financial inclusion on economic growth, poverty, income inequality, and financial stability in Asia. *The Journal of Asian Finance, Economics, and Business*, *7*(10), 73–85. https://doi.org/10.13106/jafeb.2020.vol7.no10.073

Ren, Y. (2024). Unlocking the green potential through fintech-natural resources, and economic development in resource-rich countries-an MMQR study. *Resources Policy*, *90*, Article 104694. https://doi.org/10.1016/j.resourpol.2024.104694

Ryu, H. S., & Ko, K. S. (2020). Sustainable development of fintech: focused on uncertainty and perceived quality issues. *Sustainability*, *12*(18), Article 7669. https://doi.org/10.3390/ su12187669

Rupeika-Apoga, R., & Thalassinos, E. I. (2020). Ideas for a regulatory definition of fintech. *International Journal of Economics and Business Administration*, *8*(2), 136–154. https://doi.org/10.35808/ijeba/448

Sachs, J. D. (2015). *The age of sustainable development*. Columbia University Press. http://cup.colum-bia.edu/book/theage-of-sustain-able-development/9780231173155

Sachs, J. D., Lafortune, G., Fuller, G., & Drumm, E. (2023). *Sustainable development report 2023: Implementing the SDG Stimulus*. https://s3.amazonaws.com/sustainabledevelopment.report/2023/2023-sustainable-development-report.pdf

Sachs, J. D., Lafortune, G., & Fuller, G. (2024). *Sustainable development report 2024* (No. halshs-04735489). https://s3.amazonaws.com/sustainabledevelopment.report/2024/sustainable-development-report-2024.pdf

Sadigov, S., Vasilyeva, T., & Rubanov, P. (2020, June). Fintech in economic growth: cross-country analysis. 55th International Scientific Conference on Economic and Social Development. In A. Ismayilov, K. Aliyev, & M. Benazic (Eds.), *Economic and social development: Book of Proceedings* (pp. 729–739). Baku, Azerbaijan : 2020. Vol. 1/4.

Sahay, M. R., von Allmen, M. U. E., Lahreche, M. A., Khera, P., Ogawa, M. S., Bazarbash, M., & Beaton, M. K. (2020). *The promise of fintech: Financial inclusion in the post COVID-19 era.* International Monetary Fund.

Saulick, P., Bokhoree, C., & Bekaroo, G. (2023). Business sustainability performance: a systematic literature review on assessment approaches, tools and techniques. *Journal of Cleaner Production*, *408*, Article136837. https://doi.org/10.1016/j.jclepro.2023.136837

Schoenmaker, D. (2017). Investing for the common good: a sustainable finance framework. In S. Gardner (Ed.), *Bruegel essay and lecture series*. Bruegel. https://www.bruegel.org/2017/07/investing-for-the-common-good-a-sustainable-finance-framework/

Schoenmaker, D., & Schramade, W. (2019). *Principles of sustainable finance*. Oxford University Press. Retrieved from https://global. oup.com/academic/product/ principles-of-sustainable-finance-9780198826606

Schoolman, E. D., Guest, J. S., Bush, K. F., & Bell, A. R. (2012). How interdisciplinary is sustainability research? Analyzing the structure of an emerging scientific field. *Sustainability Science*, *7*, 67–80. https://doi.org/10.1007/s11625-011-0139-z

Schueffel, P. (2016). Taming the beast: a scientific definition of fintech. *Journal of Innovation Management*, *4*(4), 32–54. https://doi.org/10.24840/2183-0606_004.004_0004

Scoones, I. (2016). The politics of sustainability and development. *Annual Review of Environment and Resources, 41*, 293–319. https://doi.org/10.1146/annurev-envi-ron-110615-090039

Senyo, P. K., Karanasios, S., Gozman, D., & Baba, M. (2022). Fintech ecosystem practices shaping financial inclusion: the case of mobile money in Ghana. *European Journal of Information Systems*, *31*(1), 112–127. https://doi.org/10.1080/0960085X.2021.1978342

Sgro, J., Smalley, P., & Welch, N. (2019). The fintech opportunity. In *Strengthening the Rules-Based International Order* (pp.11–14). Balsillie School of International Affairs. Retrieved from https:// www.balsillieschool.ca/wp-content/uploads/2020/01/Graduate-Fellows-Anthology-2020.Final_.pdf#page=17

Sharma, D. (2016). Nexus between financial inclusion and economic growth: evidence from the emerging Indian economy. *Journal of Financial Economic Policy*, *8*(1), 13–36. https://doi.org/10.1108/JFEP-01-2015-0004

Shipalana, P. (2019). *Digitising financial services: a tool for financial inclusion in South Africa?* Retrieved rom https://media.africaportal.org/documents/Occasional-Paper-301-shipalana.pdf

Siddiqui, Z., & Rivera, C. A. (2022). Fintech and fintech ecosystem: a review of literature. *Risk Governance & Control: Financial Markets & Institutions*, *12*(1). https://doi.org/10.22495/rgcv12i1p5

Skačkauskienė, I., & Švogžlys, P. (2021). Evaluation of composition suitability of the model for new service development. *Journal of Business Economics and Management*, *22*(4), 847–866. https://doi.org/10.3846/jbem.2021.14589

SolAbility. (2023). *The sustainable competitiveness report* (12th ed.). SolAbility Sustainable Intelligence.

SolAbility. (2024). *Global Sustainable Competitiveness Index 2024* (The GSCI). https://solability.com/the-global-sustainable-competitiveness-index/downloads

Speedtest. (2024). *Speedtest global index 2024*. https://www.speedtest.net/global-index

Tsanis, K., & Stouraitis, V. (2025). How fast-growing industries respond to Black Swans: The case of the FinTech industry in the COVID-19 pandemic. In K. Tsanis, H.C. Webb, A. Kaddour, & O. David-West (Eds.), *The Palgrave Handbook of FinTech in Africa and Middle East: Connecting the Dots of a Rapidly Emerging Ecosystem* (pp.1 –31). Palgrave Macmillan. https://doi.org/10.1007/978-981-97-1998-3_25-2

Sulong, Z., & Bakar, H. O. (2018). The role of financial inclusion on economic growth: Theoretical and empirical literature review analysis. *Journal of Business & Financial Affairs*, *7*(4), 356.

Taghizadeh-Hesary, F., Dong, K., Zhao, C., & Phoumin, H. (2023). Can financial and economic means accelerate renewable energy growth in the climate change era? The case of China. *Economic Analysis and Policy*, *78*, 730–743. https://doi.org/10.1016/j.eap.2023.04.013

Tay, L. Y., Tai, H. T., & Tan, G. S. (2022). Digital financial inclusion: a gateway to sustainable development. *Heliyon*, *8*(6), Article e09766. https://doi.org/10.1016/j.heliyon.2022.e09766

Tidjani, C., & Madouri, A. (2024). Fintech, financial inclusion, and sustainable development in the African region. *Frontiers in Applied Mathematics and Statistics*, *10*, Article 1276218. https://doi.org/10.3389/fams.2024.1276218

Tirmaste, K., Voolma, L., Laidroo, L., Kukk, M. L., & Avarmaa, M. (2019). *FinTech report Estonia 2019*. TalTech School of Business and Governance, Department of Economics and Finance, in co-operation with financeestonia.eu.

Tomislav, K. (2018). The concept of sustainable development: from its beginning to the contemporary issues. *Zagreb International Review of Economics & Business*, *21*(1), 67–94. https://doi.org/10.2478/zireb-2018-0005

Uddin, M., Siddik, A. B., Yuhuan, Z., & Naeem, M. A. (2024). Fintech and environmental efficiency: the dual role of foreign direct investment in G20 nations. *Journal of Environmental Management*, *360*, Article 121211. https://doi.org/10.1016/j.jenvman.2024.121211

Udeagha, M. C., & Muchapondwa, E. (2023). Striving for the United Nations (UN) sustainable development goals (SDGs) in BRICS economies: the role of green finance, fintech, and natural resource rent. *Sustainable Development*. https://doi.org/10.1002/sd.2618

Ullah, A., Ullah, S., Pinglu, C., & Khan, S. (2023). Impact of fintech, governance and environmental taxes on energy transition: pre-post covid-19 analysis of belt and road initiative countries. *Resources Policy*, *85*, Article 103734. https://doi.org/10.1016/j.resourpol.2023.103734

United Nations. (2015). *Addis Ababa Action Agenda of the Third International Conference on Financing for Development*. Sustainable Development. https://sustainabledevelopment.un.org/content/documents/2051AAAA_Outcome.pdf

United Nations. (2015). Adoption of the Paris agreement. In *Conference of the Parties to the United Nations Framework Convention on Climate Change.* Paris. https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

United Nations. (2020). *E-participation index 2020*. UN E-Government Knowledgebase. https://publicadministration.un.org/egovkb/en-us/Data/Compare-Countries

UN Capital Development Fund. (2022). *Financial inclusion and the SDGs*. https://www.uncdf.org/financial-inclusion-and-the-sdgs

UN Development Programme. (2024). Human Development Report 2023–24: Breaking the gridlock: Reimagining cooperation in a polarized world. New York. https://doi.org/10.2139/ssrn.4934148

UN Development Programme. (2024). SDG Impact Standards. Glossary. Retrieved February 24, 2025 from http://sdgprivatefinance.undp.org/sites/default/files/resource-documents/20241215%20UNDP%20SDG%20Impact%20Standards%20Glossary%20Dec%202024%20version.pdf

UN Environment Financial Centres for Sustainability (UN Environment FC4S). (2019). *Sustainable Finance and Fintech in Europe.* A study by the UN Environment FC4S European platform in collaboration with Stockholm Green Digital Finance. Retrieved March 9, 2022 from https://stockholmgreenfin.tech/sustainable-fintech

UN E-Government Knowledgebase. (2024). *2024 E-Government Development Index*. https://publicadministration.un.org/egovkb/en-us/Data-Center

UN General Assembly. (2015). *Resolution adopted by the General Assembly on 25 September 2015. 70/1. Transforming our world: the 2030 Agenda for Sustainable*

Development. Retrieved March 9, 2022 from https://www.un.org/ga/search/view_doc.asp?symbol=A/ RES/70/1&Lang=E

UN Global Compact & KPMG International. (2015). *SDG industry matrix. Financial Services.* Retrieved March 9, 2022 from https://d306pr3pise04h.cloudfront.net/docs/issues_doc-%2Fdevelopment%2FSDGMatrix_FinancialSvcs.pdf

UN Secretary-General's Special Advocate for Inclusive Finance for Development, the Better Than Cash Alliance, UN Capital Development Fund & the World Bank. (2018). *Igniting SDG progress through digital financial inclusion*. https://sustainabledevelopment.un.org/content/documents/2655SDG_Compendium_Digital_Financial_Inclusion_September_2018.pdf

U.S. News., & World Report LP. (2023). *Best countries 2023: Global rankings, international news and data insights*. https://www.usnews.com/media/best-countries/2023-overall-rankings.pdf

Valstybinė lietuvių kalbos komisija. (n.d.). *Konsultacijų bankas. Koks yra anglų kalbos termino „sustainable development" lietuviškas atitikmuo?* https://www.vlkk.lt/konsultacijos/3772-sustainable-development-darnus-vystymasis

Van, L. T. H., Vo, A. T., Nguyen, N. T., & Vo, D. H. (2021). Financial inclusion and economic growth: an international evidence. *Emerging Markets Finance and Trade*, *57*(1), 239–263. https://doi.org/10.1080/1540496X.2019.1697672

Van Eck, N. J., & Waltman, L. (2012). VOSviewer manual. *Manual for VOSviewer version*, *1*(0). https://www.vosviewer.com/documentation/Manual_VOSviewer_1.5.2.pdf

Varga, D. (2017). Fintech, the new era of financial services. *Vezetéstudomány-Budapest Management Review*, *48*(11), 22–32. https://doi.org/10.14267/VEZTUD.2017.11.03

Venclovienė, J. (2010). *Statistiniai metodai medicinoje*. *Vytauto Didžiojo universitetas*.

Vlados, C., & Chatzinikolaou, D. (2019). Methodological redirections for an evolutionary approach of the external business environment. *Journal of Management and Sustainability*, *9*(2), 25–46. https://doi.org/10.5539/jms.v9n2p25

Waas, T., Hugé, J., Verbruggen, A., & Wright, T. (2011). Sustainable development: a bird's eye view. *Sustainability*, *3*(10), 1637–-1661. https://doi.org/10.3390/su3101637

Wang, S., Li, J., & Zhao, E. (2024). Exploring the role of financial technologies and digital trade in shaping trade-adjusted resource consumption in E7 countries. *Resources Policy*, *88*, Article 104495. https://doi.org/10.1016/j.resourpol.2023.104495

Wardle, M., & Mainelli, M. (2025). *The Global Financial Centres Index* 37. https://www.longfinance.net/media/documents/GFCI_37_Report_2025.03.20_v1.2.pdf

Walker, J., Pekmezovic, A., & Walker, G. (2019). *Sustainable development goals: harnessing business to achieve the SDGs through finance, technology and law reform*. John Wiley & Sons. https://doi.org/10.1002/9781119541851

Weitzman, M. L. (2002). Sustainability and technical progress. *The Scandinavian Journal of Economics*, *99*(1), 1–13. https://doi.org/10.1111/1467-9442.00043

Williams, H. T., Adegoke, A. J., & Dare, A. (2017). Role of financial inclusion in economic growth and poverty reduction in a developing economy. *Internal Journal of Research in Economics and Social Sciences (IJRESS)*, *7*(5), 265–271.

World Bank. (2020). *Doing business 2020*.

World Bank. (2022). *Financial inclusion*. https://www.worldbank.org/en/topic/financialinclusion/overview#

World Bank. (2024). *DataBank. Global Financial Inclusion*. https://databank.worldbank.org/source/global-financial-inclusion

World Bank. (2025). *Inclusive Digital Financial Services. Glossary*. https://digitalfinance.worldbank.org/glossary

Wójcik, D. (2021). Financial geography I: exploring fintech–maps and concepts. *Progress in Human Geography*, *45*(3), 566–576. https://doi.org/10.1177/0309132520952865

Wuaten, F. M. (2023). The role of sustainable finance and technology at Bank BJB in supporting the "Sustainable Development Goals". *Aptisi Transactions on Technopreneurship (ATT)*, *5*(1Sp), 97–108. https://doi.org/10.34306/att.v5i1Sp.318

Xia, A., & Liu, Q. (2024). Modelling the asymmetric impact of fintech, natural resources, and environmental regulations on ecological footprint in G7 countries. *Resources Policy*, *89*, Article 104552. https://doi.org/10.1016/j.resourpol.2023.104552

Zeng, L., Wong, W. K., Fu, H., Mahmoud, H. A., Cong, P. T., Thuy, D. T. T., & Bach, P. X. (2024). FinTech and sustainable financing for low carbon energy transitions: a biodiversity and natural resource perspective in BRICS economies. *Resources Policy*, *88*, Article 104486. https://doi.org/10.1016/j.resourpol.2023.104486

Zhang, Y. (2023). Impact of green finance and environmental protection on green economic recovery in South Asian economies: mediating role of fintech. *Economic Change and Restructuring*, *56*(3), 2069–2086. https://doi.org/10.1007/s10644-023-09500-0

Zhang, Y., & Cui, X. (2024). Fintech, business regulations, and urbanisation: shaping the landscape of natural resource rent in G10 countries. *Resources Policy*, *89*, Article 104551. https://doi.org/10.1016/j.resourpol.2023.104551

Ziolo, M., Bak, I., & Cheba, K. (2021). The role of sustainable finance in achieving sustainable development goals: does it work?. *Technological and Economic Development of Economy*, *27*(1), 45–70. https://doi.org/10.3846/tede.2020.13863

List of Scientific Publications by the Author on the Topic of the Dissertation

Papers in the Reviewed Scientific Journals

Pauliukevičienė, G., Stankevičienė, J., & Binh, D. (2025). Strategic insights: evaluating SDG 4, SDG 8, SDG 9 and SDG 16 in driving sustainable growth in the global FinTech landscape. *Review of International Business and Strategy*, *35*(1), 27–46. https://doi.org/10.1108/RIBS-02-2024-0019.

Pauliukevičienė, G., & Stankevičienė, J. (2024). Trends in current interfaces between Fintech, sustainable development and methods: A scientific review. *Virtual economics.*, *7*(3), 42–58. https://doi.org/10.34021/ve.2024.07.03(3).

Pauliukevičienė, G., & Stankevičienė, J. (2021). Assessing statistical link between FinTech PEST environment and achievement of SDGs. *Public and Municipal Finance*, *10*(1), 47–66. https://doi.org/10.21511/PMF.10(1).2021.05.

Papers in Other Editions

Pauliukevičienė, G., & Stankevičienė, J. (2024). Trends in current interfaces between fintech, sustainable development and methods: a scientific review. In *International Scientific*

Conference "Emerging trends in economics, culture and humanities (etECH2024)": Abstracts proceedings (pp. 31–32). EKA University of Applied Sciences.https://www.augstskola.lv/upload/2024_ECH2024_Abstracts_proceedings_FINAL.pdf

Pauliukevičienė, G., & Stankevičienė, J. (2022). Assessment of the impact of sustainable development goals indicators on the sustainable development of fintech industry. In 12th International Scientific Conference "Business and Management 2022", Article bm.2022.759. Vilnius Gediminas Technical University. https://doi.org/10.3846/bm.2022.759.

Summary in Lithuanian

Įvadas

Problemos formulavimas

Per pastaruosius 150 metų finansai tapo vienu iš labiausiai globalizuotų, skaitmenizuotų ir reguliuojamų sektorių (Arner et al., 2022), o skaitmenizavimas paskatino finansų technologijų (FinTech) sektoriaus augimą. Nuo 2010 m., o ypač po 2018 m., FinTech sektorius sparčiai auga, o pasaulinės investicijos į FinTech padidėjo nuo 51–74 milijardų JAV dolerių (2014–2017 m.) iki 238,9 milijardų JAV dolerių 2021 m., pažymėtais rekordiniu 7321 sandorių skaičiumi (KPMG & CB In-sights, 2016; KPMG, 2017–2023). Nors FinTech pasiekė 2 procentus pasaulinių finansinių paslaugų pajamų ir buvo prognozuojama, kad iki 2030 m. pasieks 7 procentus šių pajamų (BCG & QED Investors, 2023 m.), dėl pastarojo meto politinių ir ekonominių sukrėtimų pasaulinės investicijos į FinTech sumažėjo iki 95,6 milijardų JAV dolerių ir 4 639 sandorių 2024 m. (KPMG, 2025 m.), todėl kilo susirūpinimas dėl šio sektoriaus plėtros nuoseklumo ir tvarumo. FinTech sektoriaus augimas ir jo potencialas įgalinti pasiekti didelę dalį Jungtinių Tautų darnaus vystymosi tikslų (DVT, angl. *Sustainable Development Goals, SDGs)* ir tokiu būdu reikšmingai prisidėti prie tvariosios ekonomikos plėtros sulaukia vis didesnio mokslininkų susidomėjimo (Hasan et al., 2024; Jie et al., 2024; Kishor et al., 2024; Noreen, 2024; Tidjani & Madouri, 2024; Choudhary et al., 2025; Guermazi, 2025). FinTech sektoriaus plėtra užtikrina finansinę įtrauktį, kuri Pasaulio banko yra apibrėžiama kaip asmenų ir įmonių galimybė už prieinamą kainą gauti ir naudoti jų poreikius atitinkančius finansinius produktus ir paslau-

gas, kurie teikiami atsakingai ir tvariai (Pasaulio bankas, 2022). Nepaisant FinTech sektoriaus plėtros privalumų, išlieka tokie iššūkiai kaip reguliavimo spragos (Ozili, 2018) ir FinTech sektoriaus plėtrai būdinga rizika (Arner et al., 2022). Todėl FinTech tvariosios, t. y. patvarios ir nenutrūkstamos, plėtros užtikrinimas yra labai svarbus siekiant platesnių aplinkosaugos, socialinių ir ekonominių tikslų (Purvis et al., 2019), tačiau vis dar trūksta aiškios apibrėžties ir metodikos, kaip vertinti FinTech sektoriaus tvariąją plėtrą. Todėl disertacijoje nagrinėjama problema – finansų technologijų sektoriaus tvariosios plėtros neapibrėžtumas ir jos vertinimo nebuvimas tiek mokslinėje literatūroje, tiek praktikoje. Disertacijoje siekiama atsakyti, kokiomis teorinėmis ir (ar) metodologinėmis prieigomis, atsižvelgiant į finansų technologijų sektoriaus tvariosios plėtros apibrėžties nekoherentiškumą, galima grįsti finansų technologijų sektoriaus tvariosios plėtros vertinimo metodų tikslingumą, vertinimo rodiklių sąranką ir formuoti vertinimo metodologiją.

Darbo aktualumas

Disertacijos aktualumas grindžiamas globaliais finansinės įtraukties, skaitmeninės finansinės įtraukties ir darnaus ekonomikos vystymosi poreikiais, kuriuos skatina finansų technologijų sektoriaus nuoseklus augimas (Fratiloiu, 2022; Honecker & Chalmers, 2022; Young & Young, 2022; Yu et al., 2022; Ozili, 2022; Popescu, 2022; Senyo et al., 2022; Adjasi et al., 2023; Asif et al., 2023; Ediagbonya & Tioluwani, 2023; Esmaeilpour Moghadam & Karami, 2023; Faust et al., 2023). Tačiau pastarojo dešimtmečio finansų technologijų sektoriaus augimo svyravimo statistika rodo, kad jis yra ypač jautrus išorinės aplinkos pokyčiams, todėl finansų technologijų sektoriaus plėtra nėra nuosekli (KPMG, 2025). O tai parodo tvariosios finansų technologijų sektoriaus plėtros, kuri šiuo metu dar nėra apibrėžta ar vertinama, aktualumą ir poreikį, kadangi susiduriama su gausybe pasaulinių problemų. 2021 m. duomenimis, banko sąskaitas turi tik 76,2 procento pasaulio gyventojų, o mobiliųjų pinigų sąskaitas turi tik 10,24 procento asmenų nuo 15 metų (World Bank, 2025). Skaitmeninių finansinių paslaugų, t. y. finansų technologijų, diegimas šiuo atveju sudaro sąlygas finansiškai atskirtų ir nepakankamai aptarnaujamų gyventojų grupėms teikti įvairias jų poreikius atitinkančias oficialias finansines paslaugas. Jos teikiamos atsakingai, klientams prieinamomis sąnaudomis. Tai yra ypač svarbu turint omenyje, kad kelionė link darnaus vystymosi tikslų, kuriuos pasiekti numatyta 2030 m., yra įpusėta, ir nors padaryta pažanga, išlieka daug iššūkių, o realios galimybės pasiekti šiuos tikslus vis labiau tolsta. Visgi prognozuojama, kad iki 2030 m. finansų technologijų sektoriaus augimas pasieks 7 procentus, o tai yra maždaug 1,5 trilijono JAV dolerių ir sudaro beveik 25 procentus visų bankų vertinimų pasaulyje (BCG ir QED Investors, 2023). Todėl svarbu, kad būtų suprantamai apibrėžtas ir vertinamas finansų technologijų sektoriaus plėtros tvarumas. Disertacijoje ši spraga sprendžiama atliekant empirinius tyrimus, paremtus 2012–2023 m. laikotarpio 15 Europos valstybių 45 rodiklių duomenimis, susijusiais su finansų technologijų plėtra, išorine finansų technologijų aplinka ir darniu vystymusi.

Tyrimo objektas

Disertacinių tyrimų *objektas* yra finansų technologijų sektoriaus tvarioji plėtra.

Darbo tikslas

Disertacijos *tikslas* yra apibrėžti finansų technologijų sektoriaus tvariąją plėtrą valstybės lygmeniu ir pasiūlyti jos vertinimo metodologiją.

Darbo uždaviniai

Darbo tikslui pasiekti buvo sprendžiami šie *uždaviniai*:

1. Atlikti mokslinės literatūros finansų technologijų sektoriaus tvariosios plėtros tema analizę, išgryninti mokslinę problemą finansų technologijų sektoriaus tvariosios plėtros kontekste ir apibrėžti teorinį disertacijos pagrindą.
2. Pasiūlyti finansų technologijų sektoriaus tvariosios plėtros kiekybinio vertinimo valstybės lygmeniu metodologiją.
3. Įvertinti pasiūlytos finansų technologijų sektoriaus tvariosios plėtros vertinimo metodologijos pritaikomumą atliekant empirinius tyrimus pagal pasirinktų valstybių pavyzdį.

Tyrimų metodika

Disertacijos uždaviniams spręsti buvo taikyti šie tyrimo metodai: loginė analizė, sisteminė analizė, lyginamoji analizė, kompleksinė analizė ir modeliavimas. Tuo būdu surinkti duomenys iš mokslinių duomenų bazių, oficialių tarptautinių organizacijų duomenų bazių ir naujausios mokslinės literatūros. Atliekant empirinį tyrimą buvo taikytas ekspertinio vertinimo metodas, konkrečiai – anketinė apklausa, siekiant rodiklių reikšmingumo nustatymo, ir paprastų svorių sudėjimo (SAW) metodas, leidžiantis daugiakriterį sprendimų priėmimą, taip pat taikyti Spearmano ir Kendallo koreliacijos koeficientai statistinei duomenų analizei ir kvantilių regresija pagal momentų metodą (MMQR). Tyrimo rezultatai buvo analizuojami naudojant *VOSviewer, Microsoft Excel* ir R programinę įrangą.

Darbo mokslinis naujumas

Disertacijos mokslinis naujumas grindžiamas trimis aspektais:

1. Išgrynintas finansų technologijų sektoriaus tvariosios plėtros apibrėžimas. Tvariąją finansų technologijų sektoriaus plėtrą siūloma apibrėžti kaip palankioje išorinėje aplinkoje vykstančią nenutrūkstamą finansų technologijų sektoriaus plėtrą, atliepiančią šiuolaikinės visuomenės skaitmeninės finansinės įtraukties poreikius ir nesumažinančią gerovės galimybių ateityje.
2. Pasiūlyta finansų technologijų sektoriaus tvariosios plėtros kiekybinio vertinimo valstybės lygmeniu metodologija, kurioje integruota FinTech, išorinė (PEST) aplinka, darnaus vystymosi tikslai (SDGs) ir energijos suvartojimas.
3. Parengta FinTech sektoriaus tvariosios plėtros kompleksinio vertinimo rodiklių sąranka, apimanti šias grupes: FinTech rodiklius; FinTech politinės, ekonominės, socialinės ir technologinės aplinkos rodiklius; ekonominius, socialinius ir aplinkosauginius tvarumo rodiklius; energijos suvartojimo rodiklius.

Darbo rezultatų praktinė reikšmė

Praktinė darbo reikšmė ir rezultatų nauda grindžiama trimis lygmenimis – valstybės, verslo ir visuomenės. Darbe pasiūlyta finansų technologijų sektoriaus tvariosios plėtros kiekybinio vertinimo metodologija ir rodiklių sąranka valstybės lygmeniu naudinga šiais atžvilgiais:

1. Gali būti lengvai pritaikoma *nacionalinių reguliavimo institucijų*, siekiant įvertinti finansų technologijų sektoriaus tvariąją plėtrą valstybėje bei jos stipriąsias ir silpnąsias dedamąsias dalis.
2. Gali būti naudinga *finansų technologijų sektoriaus įmonėms*, kadangi suteikia galimybę racionaliai ir objektyviai įvertinti finansų technologijų sektoriaus plėtros tvarumą pasirinktoje valstybėje planuojant verslo plėtrą.
3. Gali būti naudinga *visuomenei – finansų technologijų klientams ir naudotojams*, kadangi finansų technologijų sektoriaus tvarioji plėtra skatina visuomenės skaitmeninę finansinę įtrauktį.

Apibendrinant galima teigti, kad šio darbo rezultatų praktinė reikšmė – finansų technologijų sektoriaus tvariosios plėtros, skaitmeninės finansinės įtraukties augimo, darnaus vystymosi tikslų bei pasaulinio darnaus ekonomikos vystymosi skatinimas.

Ginamieji teiginiai

Disertacijoje ginami keturi teiginiai:

1. Finansų technologijų sektoriaus tvarioji plėtra apibrėžtina įvardijant pagrindinius jos veiksnius: palankią išorinę aplinką ir skaitmeninę finansinę įtrauktį.
2. Finansų technologijų sektoriaus tvarioji plėtra vertintina valstybės lygmeniu, suformuojant ir pritaikant tinkamą rodiklių sąranką, įtraukiant finansų technologijų sektoriaus politinės, ekonominės, socialinės ir technologinės aplinkos rodiklius.
3. FinTech plėtros, išorinės FinTech aplinkos ir darniojo vystymosi rodikliai integruojami į metodiką, tinkamą finansų technologijų sektoriaus tvariosios plėtros vertinimui valstybės lygmeniu.
4. Energijos suvartojimas svarbus veiksnys finansų technologijų sektoriaus tvariosios plėtros kontekste.

Darbo rezultatų aprobavimas

Autorė tarptautinėse duomenų bazėse referuojamuose mokslo leidiniuose disertacijos tema yra paskelbusi tris mokslinius straipsnius (vieną – *Web of Science*, visus tris – *Scopus*) (Pauliukevičienė et al., 2025; Pauliukevičienė & Stankevičienė, 2024; Pauliukevičienė & Stankevičienė , 2021).

Autorė dalyvavo dvejose tarptautinėse mokslinėse konferencijose (viena iš jų vyko užsienyje), taigi mokslinių konferencijų darbų leidiniuose disertacijos tema yra paskelbusi du straipsnius (pranešimų tezes) (Pauliukevičienė & Stankevičienė, 2024; Pauliukevičienė & Stankevičienė, 2022):

1. Tarptautinė mokslinė konferencija „Naujos ekonomikos, kultūros ir humanitarinių mokslų tendencijos (*etECH2024*)“, 2024 m. balandžio 25–26 d., Ryga, Latvija.
2. Dvyliktoji tarptautinė mokslinė konferencija „Verslas ir vadyba 2022“, 2022 m. gegužės 12–13 d., Vilnius, Lietuva.

Autorė atliko trijų mėnesių trukmės stažuotę užsienyje, Maltos universitete, nuo 2024 m. balandžio 1 d. iki 2024 m. birželio 30 d.

Tyrimų rezultatai taip pat buvo pristatyti keturiuose doktorantų seminaruose Vilniaus Gedimino technikos universitete (2022 m. gegužės 30 d., 2023 m. gegužės 15 d., 2023 m. spalio 23 d., 2024 m. rugsėjo 9 d.) ir dviejuose seminaruose, kuriuose buvo nagrinėjama disertacijai artima tema, užsienio mokslo centre ir institute:

1. Maltos universiteto Ekonomikos, vadybos ir apskaitos fakultete 2024 m. birželio 6 d., Msidoje, Maltoje.
2. Tarptautiniame kolokviume „Nauji moksliniai-didaktiniai iššūkiai turbulencijos metu 2022“ 2022 m. kovo 7 d., Balstogėje, Lenkijoje.

Disertacijos struktūra

Disertaciją sudaro įvadas, trys skyriai, bendrosios išvados ir tolesnių tyrimų rekomendacijos, literatūros sąrašas, autorės publikacijų sąrašas ir disertacijos santrauka lietuvių kalba. Bendra disertacijos apimtis – 150 puslapių, disertacijoje yra 27 paveikslai, 47 lentelės, 17 sunumeruotų formulių ir 220 literatūros šaltinių.

1. Teoriniai finansų technologijų sektoriaus tvariosios plėtros aspektai

Pirmajame disertacijos skyriuje atliktos loginė, sisteminė, lyginamoji ir kompleksinė mokslinės literatūros šaltinių disertacijos tematika analizės. Atskleistas finansų technologijų sektoriaus augimo potencialas (Arner, 2016; Nicoletti, 2017; Nicoletti et al. 2017; Lomachynska, 2020; Arner et al. 2021; Giglio, 2021) ir parodyta, kad finansų technologijų sektoriaus plėtrai didelę įtaką daro išorinės aplinkos veiksniai (KPMG & CB Insights, 2016; KPMG, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025).

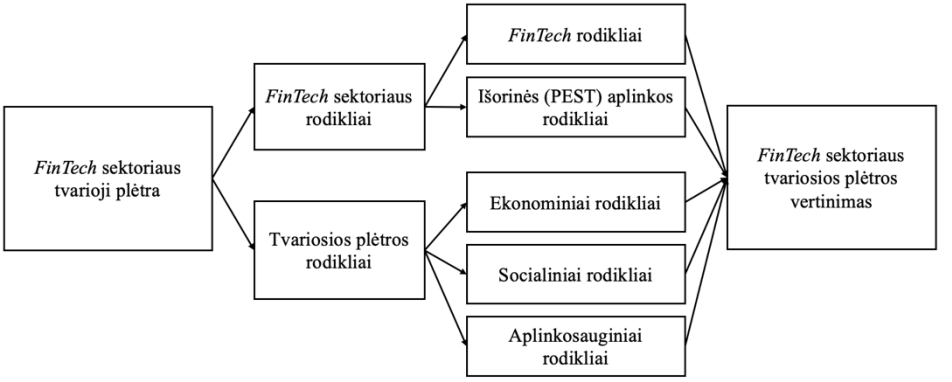
Lyginamoji esamų FinTech indeksų sudedamųjų dalių analizė atskleidė jų ribotumą tikslinės grupės, rodiklių ar aplinkos atžvilgiu (Hieminga et al., 2016; fDi Intelligence, 2019; Boitan & Barbu, 2021; Findexable, 2021; Gauthier et al., 2022; Findexable, 2022; Wardle & Mainelli, 2025). Dėl to siūloma finansų technologijų sektoriaus išorinės aplinkos analizės sistema, pagrįsta PEST analize (Gupta, 2013; Shtal et al., 2018; Tirmaste et al., 2019; Vlados & Chatzinikolaou, 2019).

Atskleista finansų technologijų sektoriaus ir darniojo vystymosi sąsajų svarba (Cen & He, 2018; Sgro et al., 2019; Bersudskaya et al., 2020; Michael, 2020; European Commission, 2021; Ellili, 2022; Farahani et al., 2022), kadangi FinTech sektoriaus plėtra turi teigiamą poveikį skaitmeninės finansinės įtraukties augimui (Hudaefi, 2020; Mhlanga, 2022; Adjasi et al., 2023; Asif et al., 2023; Ediagbonya & Tioluwani, 2023; Esmaeilpour Moghadam & Karami, 2023; Faust et al., 2023). Literatūros apžvalga taip pat parodė, kad finansų technologijų sektoriaus plėtra turi daugiausia sąsajų su darnaus vystymosi tikslais SDG 4, SDG 8, SDG 9, SDG 16 (Bedoui & Robbana, 2019; Hinson et al., 2019; Shipalana, 2019; Walker, 2019; Hoang et al., 2022).

Mokslinės literatūros apie darnaus vystymosi vertinimo metodus analizė parodė, kad šiame kontekste pirmenybė teikiama daugiakriterei sprendimų analizei, reitingavimui ir integruotiems indeksams (Ness et al., 2007; De Ridder et al., 2007; Bueno et al., 2015;

Saulick et al., 2023). Literatūros analizė naudojant *VoSViewer* atskleidė, kad kvantilių regresija pagal momentų metodą (MMQR) yra naujausias finansų technologijų ir darnaus vystymosi sąsajų tyrimo metodas (Lisha et al., 2023; Chen & Liu, 2024; Lin et al., 2024; Lv et al., 2024; Ren, 2024; Wang et al., 2024; Xia & Liu, 2024; Zeng et al., 2024; Zhang & Cui, 2024).

Nors FinTech sektoriaus plėtra priklauso nuo išorinės aplinkos veiksnių palankumo, siekiant apibrėžti finansų technologijų sektoriaus tvariąją plėtrą, svarbu įtraukti darnaus vystymosi vertinimo rodiklius, kurie šiuo metu visuotinai pripažįstami kaip SDG rodikliai. Todėl siūloma finansų technologijų sektoriaus tvariąją plėtrą apibrėžti kaip *palankioje išorinėje aplinkoje vykstančią nenutrūkstamą finansų technologijų (FinTech) sektoriaus plėtrą, atitinkančią šiuolaikinės visuomenės skaitmeninės finansinės įtraukties poreikius ir nepakenkiančią ateities gerovės perspektyvoms*. Remiantis šia apibrėžtimi buvo parengta ir šiame skyriuje pateikiama finansų technologijų sektoriaus tvariosios plėtros vertinimo sistema (S1.1 pav.).

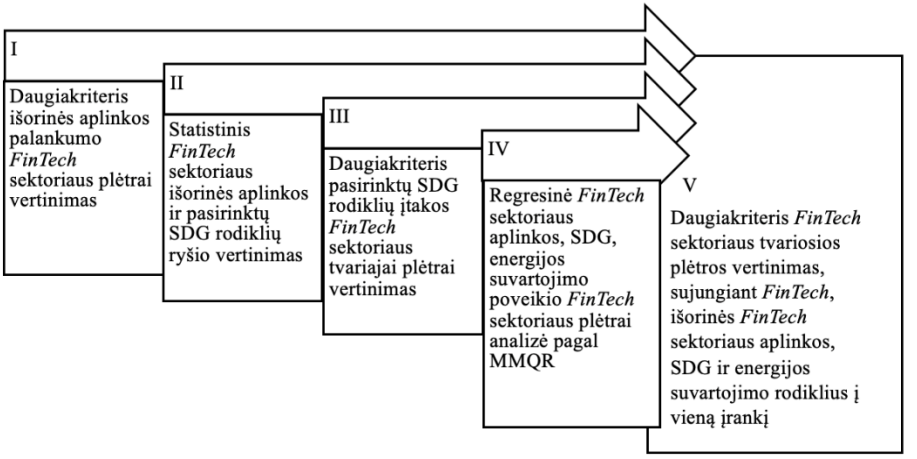


S1.1 pav. Finansų technologijų sektoriaus tvariosios plėtros vertinimo sistema (parengta autorės)

Remiantis šia sistema parengta finansų technologijų sektoriaus tvariosios plėtros kiekybinio vertinimo metodologija.

2. Finansų technologijų sektoriaus tvariosios plėtros vertinimo metodologija

Antrajame darbo skyriuje pateikta autorės parengta disertacijos empirinių tyrimų seka. Disertaciją sudaro penki empiriniai tyrimai, atlikti taikant tris skirtingus metodus: tris daugiakriterius vertinimus, vieną statistinį vertinimą ir vieną taikomosios regresijos vertinimą (S2.1 pav.).



S2.1 pav. Disertacijos empirinių tyrimų seka (parengta autorės)

Empiriniai tyrimai atlikti taikant daugiakriterio sprendimų priėmimo paprastųjų svorių sudėjimo (angl. *SAW - Simple Additive Weighting*) metodą pasitelkus ekspertinį vertinimą (anketinę apklausą), statistinį duomenų vertinimą taikant Spearmano ir Kendallo koreliacijos koeficientus bei kvantilių regresiją pagal momentų metodą (MMQR).

Daugiakriterio vertinimo procesą disertacijos kontekste sudaro rodiklių parinkimas remiantis mokslinės literatūros analizės rezultatais, duomenų rinkimas ir apdorojimas standartizuojant ir išreiškiant procentais, ekspertinis vertinimas naudojant klausimyną, rodiklių reikšmingumo nustatymas, ekspertinio vertinimo suderinamumo skaičiavimas, rodiklių reikšmių normalizavimas, daugiakriteris vertinimas taikant SAW metodą bei tyrimo rezultatų pristatymas ir interpretavimas (Hwang & Yoon, 1981; Ginevičius, 2009; Podvezko, 2011; Ginevičius et al., 2015; Gedvilaitė, 2019).

Atliekant visus tris daugiakriterius vertinimus dalyvavo verslo, viešojo sektoriaus ir mokslo atstovai ekspertai, kuriems buvo keliami tokie reikalavimai: (1) kiekybinių socialinių ar informatikos mokslų (finansų, ekonomikos ar susijusios srities) srities išsilavinimas, pageidautina – magistro arba daktaro laipsnis; (2) mažiausiai 3 metų praktinė patirtis įvairiuose finansų technologijų srities sektoriuose (viešajame, privačiajame, pelno nesiekiančiame, mokslinių tyrimų); (3) gilus darnaus vystymosi supratimas, įskaitant žinias apie darnaus vystymosi tikslus, atitinkamus rodiklius ir poveikį finansų technologijų sektoriui; (4) bent 3–5 recenzuotos publikacijos arba dalyvavimas projektuose, susijusiuose su finansų technologijų arba darniu vystymusi. Buvo prašoma atitikti bent 3 iš 4 ekspertams keliamų reikalavimų. Ekspertų apklausa buvo vykdoma elektroniniu būdu, užtikrinant konfidencialumą. Atliekant pirmąjį daugiakriterį vertinimą dalyvavo 8 ekspertai (3 verslo, 3 viešojo sektoriaus ir 2 mokslo atstovai), antrąjį – 30 ekspertų, suskirstytų į tris atskiras grupes (12 verslo, 10 mokslo ir 8 viešojo sektoriaus atstovai), siekiant įvertinti įvairių grupių nuomonių skirtumus, o trečiojo daugiakriterio vertinimo dalyviai buvo

9 ekspertai (4 verslo, 3 viešojo sektoriaus ir 2 mokslo atstovai). Atliekant kiekvieną vertinimą dalis ekspertų buvo kviečiami naujai, dalis apklausiami pakartotinai. Vertinimo apklausoje dalyvavo tiek Lietuvos, tiek užsienio ekspertai.

Statistinio vertinimo procesą disertacijos kontekste sudaro duomenų rinkimas (Ziolo et al., 2021) ir apdorojimas, koreliacijos koeficientų skaičiavimas pagal Spearmano formulę, koreliacijos koeficientų skaičiavimas pagal Kendallo formulę, rezultatų reikšmingumo nustatymas pagal Studento formulę, tyrimo rezultatų pristatymas, palyginimas ir interpretavimas (Čekanavičius & Murauskas, 2008; Vencloviene, 2010; Field at al., 2012).

Regresinės analizės procesą disertacijos kontekste sudaro momentų sąlygų apibrėžimas, momentų funkcijos sudarymas, momentų sąlygų imties analogo skaičiavimas, apibendrintojo momentų metodo (GMM) tikslo funkcijos minimizavimas ir kvantilių regresijos (MMQR) koeficientų gavimas (Koenker & Hallock, 2001; Koenker, 2005; Greene, 2018; Machado & Silva, 2019).

Disertacijos empirinių tyrimų rodiklių sąranką sudaro FinTech rodikliai; išorinės politinės, ekonominės, socialinės ir technologinės (PEST) aplinkos rodikliai; ekonominiai, socialiniai ir aplinkos tvarumo (SDG) rodikliai; energijos suvartojimas (Eurostat, 2024; IMF, 2024; KOF, 2024; Portulans Institute, 2024; Sachs et al., 2024; SolAbility, 2024; UN E-Government Knowledgebase, 2024; World Bank, 2024).

3. Finansų technologijų sektoriaus tvariosios plėtros vertinimas

Trečiajame skyriuje pritaikyta autorės antrajame skyriuje pasiūlyta finansų technologijų sektoriaus tvariosios plėtros kiekybinio vertinimo valstybės lygmeniu metodologija, siekiant įvertinti jos pritaikomumą atliekant empirinius tyrimus pagal pasirinktų valstybių pavyzdį. Atsižvelgiant į tai, kad disertacijos metodologijos pagrindą sudaro penki empiriniai tyrimai, apsiribota 15 valstybių, priklausančių keturiems skirtingiems Europos regionams (Jungtinės Tautos, 1999) duomenimis, t. y. Rytų Europos (Lenkija), Šiaurės Europos (Danija, Estija, Suomija, Latvija, Lietuva, Švedija ir Jungtinė Karalystė), Pietų Europos (Italija, Portugalija ir Ispanija) ir Vakarų Europos (Austrija, Prancūzija, Vokietija ir Nyderlandai), siekiant įvertinti ir regioninius finansų technologijų sektoriaus tvariosios plėtros skirtumus. Pasirinktos valstybės taip pat atspindi tris esmines finansų rinkas, t. y. mažesnį potencialą turinčias nedideles šalis (angl. *Frontier Market*), kurių akcijų rinka nelikvidi, sudaryta iš mažai prekiaujamų akcijų (Estija, Latvija, Lietuva), besivystančią šalį (Lenkija), kuri turi tam tikrų išsivysčiusios rinkos požymių, bet nevisiškai atitinka jos standartus (angl. *Emerging Market*), ir išsivysčiusias šalis (Austrija, Danija, Suomija, Prancūzija, Vokietija, Italija, Nyderlandai, Portugalija, Ispanija, Švedija, Jungtinė Karalystė), kurių ekonomika ir kapitalo rinkos yra labiausiai pažengusios į priekį (angl. *Developed Market*).

Pirmuoju disertacijos empiriniu tyrimu atliktas daugiakriteris išorinės aplinkos palankumo finansų technologijų sektoriaus plėtrai vertinimas, taikant SAW metodą. Remiantis šio tyrimo rezultatais, nustatyti pagrindiniai politinės, ekonominės, socialinės ir technologinės (PEST) aplinkos veiksniai, darantys teigiamą įtaką finansų technologijų sektoriaus plėtrai. Tyrimas atskleidė, kad FinTech sektoriaus plėtrai palankiausi politinės aplinkos veiksniai yra atvirumas verslui ir verslo pradžios reguliavimo sąlygos valstybėje,

palankiausi ekonominės aplinkos veiksniai – šalies ir miestų konkurencingumas finansų technologijų sektoriaus kontekste, palankiausi socialinės aplinkos veiksniai – talentų prieinamumas, intelektinis kapitalas ir inovacijų skatinimo palaikymas, palankiausi technologinės aplinkos veiksniai – skaitmeninimas ir telekomunikacijų infrastruktūra. Taip pat nustatyta, kad didžiausia svarba teikiama technologinei finansų technologijų sektoriaus aplinkai, mažiausia – socialinei. FinTech politinės, ekonominės, socialinės ir technologinės aplinkos, kaip atskirų aplinkų, vertinimo pasirinktose Europos valstybėse rezultatai parodė, kad palankiausia politinė ir ekonominė aplinka finansų technologijų sektoriaus plėtrai 2020 m. buvo Šiaurės Europoje, įskaitant Baltijos šalis, o palankiausia socialinė ir technologinė aplinka finansų technologijų sektoriaus plėtrai buvo Šiaurės ir Vakarų Europoje. Remiantis bendru 15 Europos valstybių FinTech sektoriaus PEST aplinkos vertinimu, palankiausia aplinka 2020 m. nustatyta Skandinavijos šalyse (Danijoje, Švedijoje, Suomijoje), Nyderlanduose ir Jungtinėje Karalystėje. Mažiausiai finansų technologijų sektoriaus plėtrai palanki PEST aplinka nustatyta Lenkijoje, Portugalijoje ir Italijoje.

Antruoju disertacijos empiriniu tyrimu atliktas statistinis finansų technologijų sektoriaus išorinės PEST aplinkos ir pasirinktų darnaus vystymosi tikslų (SDG) rodiklių ryšio vertinimas, remiantis Spearmano ir Kendallo ranginės koreliacijos koeficientais. Šio empirinio tyrimo rezultatai parodė, kad egzistuoja statistinis ryšys tarp FinTech sektoriaus PEST aplinkos ir SDG 4, SDG 8, SDG 9, SDG 16 – koreliacijos koeficientas buvo didesnis nei 0,5 pagal abu tyrimo imčiai tinkamus koreliacijos matavimo metodus, t. y. nustatyta, kad finansų technologijų sektoriaus PEST aplinka ir SDG 4, SDG 8, SDG 9, SDG 16 yra priklausomi, o didžiausia tarpusavio priklausomybė yra tarp FinTech sektoriaus PEST aplinkos ir SDG 16 („Taika, teisingumas ir stiprios institucijos“). Šio tyrimo rezultatai taip pat parodė, kad, vertinant koreliaciją tarp PEST ir SDG rodiklių tiek pagal Spearmano, tiek pagal Kendallo ranginės koreliacijos koeficientus, didžiausia koreliacija reikšmė dažnu atveju pasireiškia tarp technologinės finansų technologijų sektoriaus aplinkos ir SDG rodiklių, todėl darytina išvada, kad *technologinė FinTech sektoriaus aplinka yra reikšmingiausia* vertinant skirtingų finansų technologijų aplinkų ir SDG tarpusavio ryšį.

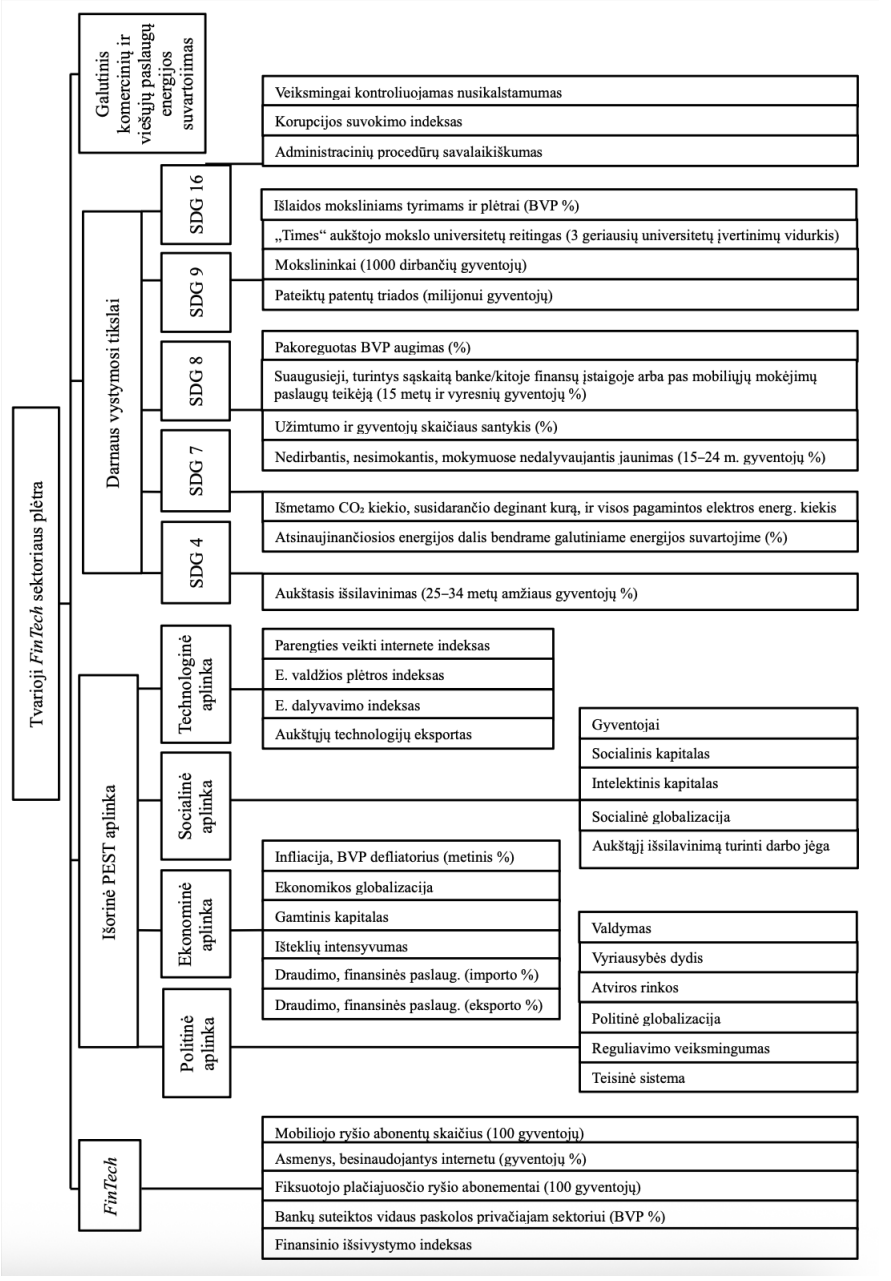
Trečiuoju disertacijos empiriniu tyrimu atliktas daugiakriteris pasirinktų SDG 4, SDG 8, SDG 9, SDG 16 rodiklių svarbos finansų technologijų sektoriaus tvariajai plėtrai vertinimas taikant SAW metodą. Nustatyta, kad didžiausią reikšmę tvariajai FinTech sektoriaus plėtrai turi SDG 9 „Pramonė, inovacijos ir infrastruktūra“, po jo eina SDG 4 „Kokybiškas išsilavinimas“, SDG 8 „Deramas darbas ir ekonominis augimas“ ir SDG 16 „Taika ir teisingumas, stiprios institucijos“. Tai patvirtino visų trijų – verslo, visuomenės ir mokslo – ekspertų grupių apklausos rezultatai. Įvertinus kiekvieno iš SDG pavienių rodiklių svarbą, nustatyta, kad (1) *neribota visuomenės prieiga prie finansų technologijų, arba kitaip tariant – finansinė įtrauktis, yra svarbiausias veiksnys siekiant tvariosios finansų technologijų sektoriaus plėtros*, o bendrosios vidaus išlaidos moksliniams tyrimams ir eksperimentinei plėtrai (MTEP) bei kiti bendrieji šalies ekonominiai rodikliai šiuo atveju atlieka tik antraeilį vaidmenį; (2) esamos darbo jėgos išsilavinimas yra svarbesnis siekiant tvariosios FinTech sektoriaus plėtros nei penkiolikmečių moksleivių matematikos rezultatai ir pasiekimai, o tai yra paradoksalu ir netikėta, nes moksleiviai – būsimoji finansų technologijų sektoriaus darbo jėga. Todėl apibendrinant galima teigti, kad *pagrin-*

diniai veiksniai, darantys įtaką tvariajai FinTech sektoriaus plėtrai, yra neribota visuomenės prieiga prie finansų technologijų (mobilieji įrenginiai ir internetas) ir išsilavinę darbingo amžiaus gyventojai. 15 Europos valstybių daugiakriterio vertinimo rezultatai parodė, kad geriausi darnaus vystymosi rodikliai, susiję su finansų technologijų sektoriumi, yra Šiaurės Europoje (Suomijoje, Danijoje, Švedijoje) bei Nyderlanduose, o prasčiausi – Pietų Europos valstybėse (Ispanijoje, Portugalijoje ir Italijoje).

Ketvirtuoju disertacijos empiriniu tyrimu, pasitelkus kvantilių regresijos momentų metodą (MMQR), atlikta taikomoji regresinė išorinės PEST aplinkos, SDG ir energijos suvartojimo poveikio finansų technologijų plėtrai analizė, apimanti tų pačių 15 Europos valstybių 2012–2023 m. laikotarpio 45 FinTech, politinių, ekonominių, socialinių, technologinių ir tvarumo rodiklių duomenis. MMQR analizės rezultatai patvirtino, kad išorinės FinTech makroekonominės aplinkos gerinimas ir pasirinktų darnaus vystymosi tikslų rodiklių siekimas daro teigiamą įtaką finansų technologijų plėtrai. Taip pat tyrimo rezultatai parodė, kad tiek pagrįstas energijos suvartojimas, tiek atsinaujinančiųjų energijos išteklių augimas yra reikšmingi finansų technologijų augimo veiksniai. MMQR rezultatai atskleidė stabilų teigiamą SDG 7, SDG 8 ir SDG 9, nenuoseklų SDG 16 poveikį ir neigiamą SDG 4 poveikį tvariajai finansų technologijų sektoriaus plėtrai. Atlikus išsamesnę SDG 4 ir SDG 16 rodiklių analizę, išskirti teigiami ir neigiami rodikliai, darantys įtaką tvariajai FinTech sektoriaus plėtrai: nustatytas stabilus teigiamas 25–34 metų amžiaus asmenų aukštojo mokslo pasiekimų, veiksmingos nusikalstamumo kontrolės, administracinių procedūrų savalaikiškumo poveikis ir neigiamas 15 metų amžiaus asmenų rašymo, gamtos mokslų ir ypač matematikos įgūdžių bei spaudos laisvės indekso poveikis. Todėl šiuos aspektus apimantys 4 rodikliai pašalinti iš tvariosios finansų technologijų sektoriaus plėtros rodiklių sąrankos.

Penktuoju ir paskutiniuoju disertacijos empiriniu tyrimu atliktas daugiakriteris finansų technologijų sektoriaus tvariosios plėtros vertinimas, sujungiant 41 FinTech, išorinės PEST aplinkos, SDG ir energijos suvartojimo rodiklius į vieną įrankį ir siekiant įvertinti pasiūlytos FinTech sektoriaus tvariosios plėtros vertinimo metodologijos ir rodiklių sąrankos pritaikomumą (S3.1 pav.).

Tyrimo rezultatai parodė, kad tvariosios FinTech plėtros kontekste reguliavimo veiksmingumas ir atviros rinkos yra dominuojantys veiksniai vertinant finansų technologijų sektoriaus politinę aplinką, išteklių intensyvumas yra pagrindinis veiksnys vertinant finansų technologijų sektoriaus ekonominę aplinką , intelektinis kapitalas ir socialinė globalizacija yra svarbiausi finansų technologijų sektoriaus socialinės aplinkos veiksniai, o svarbiausi finansų technologijų sektoriaus technologinės aplinkos veiksniai – e. dalyvavimo indeksas ir e. valdžios plėtros indeksas. Įvertinus abiejų atsinaujinančiosios energijos rodiklių (SDG 7) svarbą nustatyta, kad ji gana panaši. Kalbant apie SDG 8, nustatyta, kad svarbiausias rodiklis, susijęs su tvariąja finansų technologijų sektoriaus plėtra, yra finansinė įtrauktis – suaugusieji, turintys sąskaitą banke ar kitoje finansų arba mobiliųjų mokėjimų paslaugų teikėjo įstaigoje (15 metų ir vyresni gyventojai %). Kaip SDG 9 pagrindinis rodiklis nurodytos išlaidos moksliniams tyrimams ir plėtrai (BVP %), o SDG 16 – administracinių procedūrų savalaikiškumas.



S3.1 pav. Finansų technologijų sektoriaus tvariosios plėtros kompleksinio vertinimo rodiklių sąranka (parengta autorės)

Atlikus pagrindinių finansų technologijų sektoriaus tvariosios plėtros rodiklių grupių (t. y. FinTech, PEST ir SDG) ir jų atitinkamų komponentų svarbos vertinimą nustatyta, kad FinTech rodiklių grupėje didžiausia svarba suteikiama finansinio išsivystymo indeksui (FDI), o tai atskleidė, kad finansų įstaigų ir finansų rinkų gylis, prieinamumas ir veiksmingumas turi didžiausią reikšmę tvariajai finansų technologijų sektoriaus plėtrai. Kalbant apie FinTech finansinės įtraukties rodiklius, interneto naudotojams priskiriamas gerokai didesnis svoris nei fiksuotojo plačiajuosčio ryšio ir mobiliojo korinio ryšio abonentams. Įvertinus išorinę PEST aplinką nustatyta, kad technologinė ir ekonominė aplinka laikomos svarbiausiomis finansų technologijų sektoriaus tvariajai plėtrai. Įvertinus darnaus vystymosi tikslų svarbą, nustatyti reikšmingiausi SDG 9 ir SDG 16, t. y. „Pramonė, inovacijos ir infrastruktūra“ ir „Taika ir teisingumas, stiprios institucijos“.

Atlikus daugiakriterį 15 Europos valstybių vertinimą nustatyta, kad 2012–2023 metų laikotarpiu pagal FinTech plėtrą nuosekliai pirmauja Jungtinė Karalystė, Danija ir Švedija, nors ir nepastebimas didesnis šio sektoriaus augimas. Taip pat nustatyta, kad daugumoje valstybių FinTech rezultatai laikui bėgant stabiliai gerėja, ypač nuo 2020–2022 m. Įvertinus išorinę PEST aplinką nustatyta, kad palankiausią PEST aplinką tvariajai finansų technologijų plėtrai turi Jungtinė Karalystė, po jos eina Nyderlandai, Danija ir Švedija, o prasčiausia išorinė aplinka tvariajai finansų technologijų sektoriaus plėtrai nustatyta Lenkijoje, Latvijoje, Portugalijoje ir Lietuvoje. Įvertinus SDG 12 metų rezultatus tvariosios finansų technologijų plėtros kontekste nustatyta, kad šioje srityje lyderiauja Švedija ir Danija, o Italijos rezultatai prasčiausi. Įvertinus energijos suvartojimą, sietiną su finansų technologijų sektoriaus plėtros tvarumu, nustatyta, kad daugiausia energijos suvartojama Vokietijoje, nors nuo 2017 m. stengiamasi šią padėtį gerinti ir pamažu daroma pažanga. Prancūzija, Jungtinė Karalystė ir Italija taip pat suvartoja daug energijos, tačiau jų padėtis nepagerėjo. Visose kitose šalyse energijos suvartojama daug mažiau, o padėtis išlieka stabili. Atlikus galutinį tvariosios finansų technologijų sektoriaus plėtros vertinimą nustatyta, kad Danija, Švedija, Suomija ir Nyderlandai turi aukščiausius FinTech sektoriaus plėtros tvarumo rezultatus, tuo tarpu Austrija, Estija ir Jungtinė Karalystė netikėtai atsiliko. Italijoje, Vokietijoje, Lenkijoje ir Prancūzijoje nustatyta mažiausiai tvari finansų technologijų sektoriaus plėtra, o tai, be abejo, iš dalies lemia energijos suvartojimo kiekis. Apibendrinant pažymėtina, kad galutiniai tyrimo rezultatai atskleidė bendrą tvarumo didėjimo tendenciją, nors situaciją dar galima gerinti.

Bendrosios išvados

1. Išsami literatūros analizė pirmajame disertacijos skyriuje išgrynino mokslinių tyrimų problemą – finansų technologijų sektoriaus tvariosios plėtros neapibrėžtumą ir finansų technologijų sektoriaus tvariosios plėtros vertinimo trūkumą tiek mokslinėje literatūroje, tiek praktikoje. Pirmajame skyriuje pateikta literatūros analizė taip pat atskleidė spartų finansų technologijų sektoriaus plėtros augimą pastarąjį dešimtmetį, tolimesnės plėtros potencialą ir tvariosios plėtros svarbą pasauliniame kontekste, siekiant visiškos skaitmeninės finansinės įtraukties visuomenėje. Atskleista, kad finansų technologijų sektoriaus plėtra priklauso nuo išorinės aplinkos veiksnių palankumo, o siekiant apibrėžti finansų technologijų sektoriaus tvariąją plėtrą, svarbu įtraukti tvarumo vertinimo rodiklius, kurie šiuo

metu visuotinai pripažįstami kaip darnaus vystymosi tikslų rodikliai. Taigi pirmajame disertacijos skyriuje pasiūlytas FinTech sektoriaus tvariosios plėtros apibrėžimas: finansų technologijų sektoriaus tvarioji plėtra – tai palankioje išorinėje aplinkoje vykstanti nenutrūkstama finansų technologijų sektoriaus plėtra, atliepianti šiuolaikinės visuomenės skaitmeninės finansinės įtraukties poreikius ir nesumažinanti gerovės galimybių ateityje. Taip pat pasiūlyta šiuo apibrėžimu paremta finansų technologijų sektoriaus tvariosios plėtros vertinimo sistema.

2. Antroje disertacijos dalyje pristatyti duomenys ir metodologija, skirti finansų technologijų sektoriaus tvariajai plėtrai vertinti, pagrįsta pirmajame skyriuje pasiūlyta finansų technologijų sektoriaus tvariosios plėtros kiekybinio vertinimo sistema, integruojanti FinTech, išorinę (PEST) aplinką ir darnaus vystymosi tikslus (SDGs). Remiantis pagrindiniais išorinės aplinkos ir darnaus vystymosi veiksniais, lemiančiais finansų technologijų sektoriaus tvariąją plėtrą, parengta ir pateikta disertacijos empirinių tyrimų seka, kurią sudaro 5 empiriniai tyrimai, atlikti taikant 3 skirtingus metodus: 3 daugiakriterius vertinimus, 1 statistinį vertinimą, 1 taikomąją regresinę analizę. Remiantis atliktais mokslinės literatūros tyrimais, pasirinkti tinkamiausi metodai: daugiakriteris sprendimų priėmimo metodas SAW (*Simple Additive Weighting*); Kendallo ir Spearmano koreliacijos koeficientai; kvantilių regresija pagal momentų metodą (MMQR). Siekiant integruotai įvertinti finansų technologijų sektoriaus tvariosios plėtros galimybes, buvo parengtas rodiklių rinkinys, kurį sudaro šios grupės: FinTech rodikliai; FinTech politinės, ekonominės, socialinės ir technologinės aplinkos rodikliai; ekonominiai, socialiniai ir aplinkosaugos tvarumo rodikliai bei energijos suvartojimo duomenys.
3. Trečiojoje disertacijos dalyje, atlikus empirinius tyrimus pasirinktose šalyse, buvo įvertintas pasiūlytos metodologijos pritaikomumas finansų technologijų sektoriaus tvariajai plėtrai vertinti. Įvertinus FinTech PEST aplinką paaiškėjo, kad Šiaurės Europos, ypač Baltijos, šalys, turi palankiausias politines ir ekonomines sąlygas FinTech sektoriaus plėtrai, o Šiaurės ir Vakarų Europoje yra palankiausios socialinės ir technologinės sąlygos FinTech sektoriui vystytis. Bendro PEST vertinimo rezultatai parodė, kad palankiausia PEST aplinka FinTech plėtrai yra Danijoje, Švedijoje ir Suomijoje. Bendrosios finansų technologijų PEST aplinkos ir SDG koreliacijos analizės rezultatai atskleidė, kad egzistuoja statistinis ryšys tarp FinTech PEST aplinkos ir SDG 4, SDG 8, SDG 9, SDG 16, o tai rodo, kad jie yra tarpusavyje susiję, didžiausiai priklausomybei esant tarp FinTech PEST aplinkos ir SDG 16. Įvertinus keturių pasirinktų SDG svarbą nustatyta, kad didžiausią reikšmę finansų technologijų sektoriaus plėtrai turi SDG 9, po jo eina SDG 4, SDG 8 ir SDG 16. Tai patvirtino visų trijų grupių – viešojo, privataus sektorių ir mokslo – ekspertų apklausos rezultatai. Įvertinus kiekvieno SDG kiekvieno rodiklio reikšmę, paaiškėjo du svarbūs rezultatai: neribota visuomenės prieiga prie finansų technologijų, kitaip tariant, finansinė įtrauktis, yra svarbiausias veiksnys siekiant tvariosios finansų technologijų sektoriaus plėtros, o bendrosios vidaus išlaidos moksliniams tyrimams ir eksperimentinei plėtrai (MTEP) bei kiti bendrieji šalies ekonominiai rodikliai šiuo atveju atlieka tik antraeilį vaidmenį; finansų technologijų sektoriaus tvariajai

plėtrai yra svarbesnis dabartinės darbo jėgos mokymas nei jaunosios kartos įgūdžiai ir užimtumas. Todėl pagrindiniai veiksniai, darantys įtaką tvariajai finansų technologijų sektoriaus plėtrai, yra neribota visuomenės prieiga prie FinTech (mobilieji įrenginiai ir internetas) ir išsilavinę darbingo amžiaus gyventojai. 15 pasirinktų šalių vertinimo rezultatai parodė, kad geriausi tvariosios plėtros rezultatai, susiję su finansų technologijų sektoriumi, yra Šiaurės Europoje: Suomija, Danija, Nyderlandai ir Švedija užima pirmąsias tris vietas, po jų eina Šiaurės Vakarų, vėliau – Vidurio Europa, o Pietų Europos šalys – Ispanija, Portugalija ir Italija – užima žemiausias vietas.

4. Kvantilių regresija pagal momentų metodą (MMQR) parodė, kad SDG 8 ir SDG 9 pasižymi ypač palankiu poveikiu finansų technologijų plėtrai, ir patvirtino jų, kaip tvariosios FinTech pažangos rodiklių, naudingumą. Tačiau neigiamos SDG 4 reikšmės ir svyruojantis SDG 16 poveikis FinTech parodė, kad šiuos indeksus reikia patobulinti, SDG 4 paliekant tik „Aukštojo išsilavinimo įgijimas (25–34 metų amžiaus gyventojai %)“, o iš SDG 16 pašalinant neigiamą poveikį darantį „Spaudos laisvės indeksą“. Taip pat tyrimas parodė, kad į SDG reikia integruoti teigiamą poveikį darančius SDG 7 komponentus.
5. Paskutinis darbo tyrimas – daugiakriteris finansų technologijų sektoriaus tvariosios plėtros vertinimas patvirtino, kad FinTech, išorinės PEST aplinkos ir SDG rodikliai, sujungti į metodologiją ir rodiklių sąranką, yra tinkami tvariosios finansų technologijų sektoriaus plėtrai vertinti valstybės lygmeniu, o energijos suvartojimas yra svarbus veiksnys.
6. Šioje disertacijoje pateiktų tyrimų rezultatų praktinė reikšmė grindžiama trimis lygmenimis: valdžios, verslo ir visuomenės. Disertacijoje pristatytą kiekybinio FinTech sektoriaus tvariosios plėtros vertinimo nacionaliniu lygmeniu metodologiją ir rodiklių sąranką gali lengvai pritaikyti nacionalinės reguliavimo institucijos, siekdamos įvertinti sektoriaus plėtros tvarumą, įskaitant jos stipriąsias ir silpnąsias puses. Tyrimo rezultatai taip pat gali būti naudingi FinTech įmonėms, nes leidžia racionaliai ir objektyviai įvertinti FinTech sektoriaus plėtros tvarumą pasirinktoje valstybėje. Tyrimo išvados taip pat gali būti naudingos visuomenei, FinTech klientams ir naudotojams, nes tvarioji FinTech sektoriaus plėtra skatina skaitmeninę finansinę įtrauktį visuomenėje. Šios disertacijos rezultatų praktinė reikšmė apima FinTech sektoriaus tvariosios plėtros skatinimą, skaitmeninės finansinės įtraukties didinimą, darnaus vystymosi tikslų siekimą ir pasaulio darnaus ekonomikos vystymosi skatinimą.

Annexes

Annex A. Explanation of the indicators

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FINTECH:

No.	Indicator	Explanation of the indicator	Source
1.1	Mobile cellular subscriptions (per 100 people)	Subscriptions to a public mobile telephone service that provides access to the PSTN using cellular technology.	World Bank
1.2	Individuals using the Internet (% of the population)	Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV, etc.	World Bank
1.3	Fixed broadband subscriptions (per 100 people)	Fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection) at downstream speeds equal to, or greater than, 256 kbit/s. It includes cable modem, DSL, fibre-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband.	World Bank
1.4	Domestic credit to the private sector by banks (% of GDP)	Financial resources provided to the private sector by other depository corporations (deposit-taking corporations except central banks), such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	World Bank
1.5	Financial Development Index	The depth, access, and efficiency of financial institutions and financial markets.	International Monetary Fund

FINTECH ENVIRONMENT:

No.	Indicator	Explanation of the indicator	Source
2.1 2.2	Governance	Results of core state areas and investments – infrastructure, market	Global Sustainable Competitiveness Index

No.	Indicator	Explanation of the indicator	Source
		and employment structure, the provision of a framework for sustained and sustainable wealth generation.	
	Government size	Government spending, tax burden, and fiscal health.	Index of Economic Freedom
	Open Markets	Trade freedom, investment freedom, and financial freedom.	Index of Economic Freedom
	Political globalisation	Political globalisation characterises the diffusion of government policies and is measured using variables as participation in UN Peacekeeping missions and the number of embassies. The presence of embassies implies that foreigners are acting in their home countries' interest.	KOF Globalisation Index
	Regulatory efficiency	Business freedom, labour freedom, monetary freedom.	Index of Economic Freedom
	Rule of law	Property rights, government integrity, and judicial effectiveness.	Index of Economic Freedom
2.3 2.4	Inflation, GDP deflator (annual %)	Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.	World Bank
	Economic globalisation	Economic globalisation is measured by the actual flows of trade, foreign direct investment and portfolio investment, as well as the restrictions applying to these flows.	KOF Globalisation Index
	Natural capital	The given natural environment includes the availability of resources and the level of depletion of those resources.	Global Sustainable Competitiveness Index
	Resource intensity	The efficiency of using available resources as a measurement of operational competitiveness in a resource-constrained world.	Global Sustainable Competitiveness Index
	Insurance and financial services (% of service imports,	Insurance and financial services cover various types of insurance provided to non-residents by resident	World Bank

No.	Indicator	Explanation of the indicator	Source
	Balance of Payments)	insurance enterprises and vice versa, and financial intermediary and auxiliary services (except those of insurance enterprises and pension funds) exchanged between residents and non-residents.	
	Insurance and financial services (% of service exports, Balance of Payments)	Insurance and financial services cover various types of insurance provided to non-residents by resident insurance enterprises and vice versa, and financial intermediary and auxiliary services (except those of insurance enterprises and pension funds) exchanged between residents and non-residents.	World Bank
2.5 2.6	Population	The total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	World Bank
	Social capital	Health, security, freedom, equality and life satisfaction within a country.	Global Sustainable Competitiveness Index
	Intellectual capital	The capability to generate wealth and jobs through innovation and value-added industries in the globalised markets.	Global Sustainable Competitiveness Index
	Social globalisation	Social globalisation expresses the spread of ideas, information, images and people and includes interpersonal, information and cultural globalisation.	KOF Globalisation Index
	Labour force with advanced education	The percentage of the working-age population with an advanced level of education who are in the labour force. Advanced education comprises short-cycle tertiary education, a bachelor's degree or equivalent education level, a master's degree or equivalent education level, or a doctoral degree or equivalent education level, according to the International Standard Classification of Education 2011 (ISCED 2011).	World Bank

No.	Indicator	Explanation of the indicator	Source
2.7 2.8	Network Readiness	Measures the propensity for countries to exploit the opportunities offered by information and communications technology.	World Economic Forum
	E-Government Development	The state of E-Government Development. Along with an assessment of the website development patterns in a country, it incorporates the access characteristics, such as the infrastructure and educational levels, to reflect how a country uses information technologies to promote access and inclusion of its people.	United Nations
	E-Participation	E-information: enabling participation by providing citizens with public information and access to information without or upon demand; e-consultation: engaging citizens in contributions to and deliberation on public policies and services; e-decision-making: empowering citizens through co-design of policy options and co-production of service components and delivery modalities.	United Nations
	High-technology exports	High-technology exports are products with high R&D intensity, such as in computers, scientific instruments, and electrical machinery.	World Bank

SUSTAINABLE DEVELOPMENT:

No.	Indicator	Explanation of the indicator	Source
3.1 3.2	CO_2 emissions from fuel combustion per total electricity output $MtCO_2/TWh$	A measure of the carbon intensity of energy production, calculated by dividing CO_2 emissions from fuel combustion by electricity output. The data are reported in megatons per billion-kilowatt hours. The long-term objective for this indicator is a value of 0.	Sustainable Development Report

No.	Indicator	Explanation of the indicator	Source
	Renewable energy share in total final energy consumption (%)	The share of renewable energy in the total final energy consumption. Renewable energy includes hydro, solid biofuels, liquid biofuels, biogases, modern biomass, wind, solar, geothermal, tide/wave/oceans and renewable municipal waste. It does not include traditional biomass – local solid biomass resources (e.g., wood, charcoal, dung, agricultural residues) used in low-income households that do not have access to modern cooking fuels or technologies.	Sustainable Development Report
3.1 3.2	Tertiary educational attainment	The percentage of the population aged 25 to 34 who have completed tertiary education.	Sustainable Development Report
3.3 3.4	Adjusted GDP growth (%)	The growth rate of GDP adjusted to income levels (where rich countries are expected to grow less) and expressed relative to the average growth rate of high-income countries. The growth rate over the last 3-year period was calculated.	Sustainable Development Report
	Adults with an account at a bank or other financial institution or with a mobile-money-service provider (% of the population aged 15 or over)	The percentage of adults, 15 years and older, who report having an account (by themselves or with someone else) at a bank or another type of financial institution, or who have personally used a mobile money service within the past 12 months.	Sustainable Development Report
	Employment-to-population ratio (%)	The ratio of the employed to the working age population. Employed people are those aged 15 or older who were in paid employment or self-employed during a specified period. The working-age population refers to people aged 15 to 64.	Sustainable Development Report
	Youth not in employment, education or training (NEET) (%	The percentage of young people who are not in employment, education or training (NEET). Education includes	Sustainable Development Report

No.	Indicator	Explanation of the indicator	Source
	of the population aged 15 to 24)	part-time or full-time education but excludes those in non-formal education and in educational activities of very short duration. Employment is defined according to the ILO Guidelines and covers all those who have been in paid work for at least one hour in the reference week or were temporarily absent from such work.	
3.5 3.6	Expenditure on research and development (% of GDP)	Gross domestic expenditure on scientific research and experimental development (R&D) expressed as a percentage of Gross Domestic Product (GDP).	Sustainable Development Report
	The Times Higher Education Universities Ranking: Average score of top 3 universities (worst 0–100 best)	The average score of the top three universities in each country that are listed in the global top 1,000 universities in the world. For countries with at least one university on the list, only the score of the ranked university was considered.	Sustainable Development Report
	Researchers (per 1,000 employed population)	The number of researchers per thousand employed people. Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of the projects concerned.	Sustainable Development Report
	Triadic patent families filed (per million population)	A triadic patent family is defined as a set of patents registered in various countries (i.e., patent offices) to protect the same invention. Triadic patent families are a set of patents filed at three of these major patent offices: the European Patent Office (EPO), the Japan Patent Office (JPO) and the United States Patent and Trademark Office (USPTO). The number of triadic patent families is "nowcast" for timeliness.	Sustainable Development Report
3.7 3.8	Crime is effectively controlled	Measures whether perpetrators of crimes are effectively apprehended and charged. It also measures whether police, investigators, and prosecutors have adequate resources, are free of	Sustainable Development Report

No.	Indicator	Explanation of the indicator	Source
		corruption, and perform their duties competently.	
	Corruption Perceptions Index	The perceived levels of public sector corruption, on a scale from 0 (highest level of perceived corruption) to 100 (lowest level of perceived corruption). The CPI aggregates data from a number of different sources that provide perceptions of businesspeople and country experts.	Sustainable Development Report
	Timeliness of administrative proceedings	Measures whether administrative proceedings at the national and local levels are conducted without unreasonable delay.	Sustainable Development Report
3.9 3.10	Tertiary educational attainment	The percentage of the population aged 25 to 34 who have completed tertiary education.	Sustainable Development Report

ENERGY CONSUMPTION:

No.	Indicator	Explanation of the indicator	Source
5.1 5.2 5.3	Final energy consumption by other sectors – commercial and public services – energy use	Final energy consumption covers the energy consumption of end-users, such as industry and services. It excludes consumption of the energy sector itself and losses occurring during the transformation and distribution of energy. It also excludes all non-energy use of energy carriers.	Eurostat

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