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RESEARCH ARTICLE

Measuring the impact of renewable energy, public health expenditure, logistics, and environmental performance on sustainable economic growth

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Abstract

The study aims to examine the potential relationship between public health expenditures, logistics performance indices, renewable energy, and ecological sustainability in Association of Southeast Asian Nations member countries. The study used secondary data, which downloaded from the World Bank website and tested for hypotheses using the structural equation modeling. The results show that the use of renewable energy in logistics operations will improve environmental and economic performance to reduce emissions, whereas environmental performance is negatively correlated with public health expenditures, indicating that greater environmental sustainability can improve human health and economic growth. The results also show that increased public health spending and poor environmental performance undermine economic growth in low efficiency and low labor productivity, thus reducing the speed of economic activity. On the other hand, the use of renewable energy in logistics cannot only improve the sustainability of the environment but also create a better national image and provide better export opportunities in environmentally friendly countries to promote sustainable economic growth. The outcomes of this study will help the policy/decision makers to make the proper planning to their investments for achieving sustainable economic growth.

Highlights

- This study examines the underlying relationship among renewable energy, public health expenditure, logistics operations, and eco-environmental sustainability in the panel of ASEAN countries.
- The findings revealed that the usage of renewable energy in logistical operations improves the eco-environmental sustainability.
- The results showed that higher public health expenditure and poor environmental performance harm economic activities in terms of inefficiency and low productivity of labor.
- The usage of renewable energy not only improves the environmental sustainability but also build a better image of the country and attract foreign direct investment inflows and spurring sustainable economic growth with better export opportunities in pro-environmental countries.

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KEYWORDS
environmental degradation, green logistics, public health expenditure, renewable energy, sustainable economic growth

1 | INTRODUCTION

In recent years, theories of green logistics, reverse logistics, recycling logistics, and waste logistics have been continuously improved and developed. The green logistics evaluation system has become the standard for measuring the greening of enterprise logistics operations (Khan, Sharif, Golpîra, & Kumar, 2019; Ramos, Caeiro, Moreno Pires, & Videira, 2018; Khan and Dong, 2017a). The circular economy is an economic model of economic, resource, and environmentally sustainable development. The theory of circular economy can be used to guide the development of green logistics.

In logistics management, the association between renewable energy, logistics infrastructure, environmental performance indicators, and economic growth factors has been deeply explored, but there still exists a gap to be critically discussed on empirical evaluation of renewable energy, environmental, and economic factors so as to assess the best practices of eco-friendly logistics and business operations across the globe. Logistics is one of the critical backbones for global supply chain management (SCM) and improve material handling, information processing, storage of inventory, and freight transport that is required to move goods through the smooth process of a supply chain (Li, Shi, Emrouznejad, & Liang, 2018; Uygun & Dede, 2016).

In the 1990s, logisticians were not widely aware of the idea of global SCM. The bottom line of global SCM is to reduce negative effects from logistics operations and to protect environmental sustainability with higher economic growth (Hussain, Khan, & Ajmal, 2019; Mafakheri & Nasiri, 2014). Changqiong (2005) established an overall evaluation framework for the sustainable development of the logistics industry from the aspects of external support level, development status, development trend, and regional coordination of the logistics industry, and studied the specific evaluation index system. Hong (2005) constructed a green logistics statistical indicator system from the transportation, distribution, warehousing, packaging, distribution processing, and reverse logistics of logistics. Lijun (2008) divided the comprehensive benefits of green logistics into target factors such as economic benefit, social benefit, and ecological benefit. Wenjun (2008) proposed the green logistics evaluation index system from three different levels: enterprise, region, and society based on the theory of circular economy. Undeniably, logistics operations mainly rely on energy consumptions, especially fossil fuel, which emits substantial carbon emissions and also creates a negative effect on environmental sustainability (Rao & Holt, 2005). Recently researchers emphasized the reduction of polluting activities from the global supply chain, which destroying environmental beauty and creating climate change problems more and more complex (Besassi et al., 2015; Zhang et al., 2018).

Several firms use green techniques and procedures as a strategy to boost economic and environmental sustainability, that is, eco-efficient firms use renewable energy resources, recycling, and reduce carbon footprints. Many developing countries have started to implement eco-friendly techniques in their manufacturing and SCM operations (Boonchai & Beeton, 2016; Khan and Dong, 2017; Li, 2014; Xue, Weng, & Yu, 2018). Many manufacturing firms have already adopted partial green practices on supply chain operations to improve firms' operational, economic, and environmental sustainability with higher customer satisfaction and to build a positive image for firms. In a similar line, an empirical study was conducted in China, and the findings concluded that Chinese firms continued struggling to enhance their image through adopting green logistics practices, and many firms shifted their manufacturing and logistics operations into relying on renewable energy/biofuels Zhu, Sarkis, Cordeiro, and Lai (2008). On the other side, Dangelico and Pontrandolfo (2013), their study's results showed that profitability and environmental performance and firm image are not confidently correlated with an increasing level of carbon emissions.

The existing literature has created a green logistics evaluation index and proposed a comprehensive evaluation method, which has effectively promoted the theoretical development and practice of green logistics. Therefore, the purpose of conducting this research is to examine the underlying association among health expenditure, logistics performance, renewable energy, and eco-environmental sustainability in the data set of Association of Southeast Asian Nations (ASEAN) countries. This study has six sections. Section 1 covers the introduction part of the study. Section 2 is based on a literature review related to renewable energy and logistics indicators attempt to find its link with a country's environmental and economic performance. Section 3 includes data sources and methodology. Section 4 covers the analysis part of the research and discussion with previously published materials and/or research papers. Section 5 provides concluding remarks, and the last section provides implications/policies and future work guidance.

2 | LITERATURE REVIEW AND HYPOTHESIS FORMULATION

2.1 | Green energy sources

The association between energy demand and logistics operations is extensively discussed area under the umbrella of the global supply chain (Zaman & Shamsuddin, 2017; Lee & Wu, 2014). Logistics operations mainly depend on fossil fuel consumptions that pollute environmental sustainability and also damage the human lives (Khan et al., 2018),

whereas green logistics operations positively influence on environmental sustainability and play a vital role to promote green products (Zaman et al., 2016; Lu, Lai, & Cheng, 2007; Fotis & Polemis, 2018). They concluded that the global logistics business is a main producer of carbon emissions and greenhouse gases, whereas the usage of biofuels and renewable energy can mitigate the negative effects on the environment. It can be seen from the results that renewable energy improves the environmental beauty and economic health in terms of more excellent export opportunities in pro-environmentalist countries, where environmental policies are strict as compared with developing countries (Nassani, Aldakhil, Abro, & Zaman, 2017). They concluded that between fossil emissions and transportation services, there is a strong positive correlation that deteriorates the sustainable agenda of Brazil, Russia, India, China and South Africa. They also suggest that policies should be determined to help minimize and/or control the environmental degradations through adopting green energy and green vehicles in logistical operations.

In many European countries, including Germany, France, and the Netherlands, regulatory authorities have stringent environmental policies to discourage polluting activities and encourage renewable energy sources and green logistics practices. Bhattacharya, Paramati, Ozturk, and Bhattacharya (2016) researched to find the effect of renewable energy consumption on economic growth. The results show that renewable energy consumption has a positive impact on economic and environmental performance. Anable et al. (2012) believed that transportation activities, including long lead times and traffic congestion, consume more energy to carry out their logistics activities. Iakovou et al. (2010) Waste biomass is inevitably considered a suitable solution to minimize dependence on fossil fuel energy. Bhattacharya et al. (2016) and Khan et al. (2016) recommended that governments and international cooperation agencies must act together to promote the use of renewable energy and green logistics investments to achieve better economic and social environmental sustainability.

Zhu et al. (2008) evaluated the business practices of Chinese firms and found that Chinese companies are fully cooperating with the governmental sustainability agenda. Besides, some firms converted their polluted systems towards eco-efficient systems, which not only benefits firms in terms of positive image building but also encourages customers to "go towards green and buy green products" (Khan and Zhang, 2019). Shahbaz, Solarin, Sbia, and Bibi (2015) considered that energy efficiency promotes economic development through the existence of capital and labor, whereas Kumar, Teichman, and Timpernagel (2012) claimed that renewable energy is expected to support green financial growth may help government agencies foster green technology. Yakovleva et al. (2011) and Qureshi, Rasli, and Zaman (2016) evaluated the association between logistics operations, energy demands, and national scale economic factors. Their findings showed the strong relationship between energy demand, economic indicators, and logistics operations in the developed countries across the globe. The policy to environmental factors and different natural resources is vital to encourage the sustainability agenda (Bozan, 2015). Based on the above discussed literature, the following hypothesis are proposed:

H1a *Renewable energy usage in logistical operations promotes green logistics.*

H1b *Renewable energy usage enhance environmental performance.*

H1c *Renewable energy has a healthy and positive relationship with economic health.*

H1d *Renewable energy consumption is negatively correlated with health expenditure.*

2.2 | The link between logistics indicators, national scale environmental, and economic factors

The logistics industry plays a vital part in the country's economic growth and provides export opportunities to the firms, whereas the polluted logistics system is not only degraded and creates barriers for the firms in terms of export restriction in European and Western countries but it is also harmful to environmental sustainability. European Commission (2011), the report emphasized that the labors working in the logistics and freight industry are beyond 10 million, which is almost 5% of total employment. Zhang et al. (2018) emphasized that the most polluting activities exist in the global SCM, which can destroy environmental beauty and create climate change problems in the region. Besassi et al. (2015) studied the association between logistics performance and transport infrastructure in Spanish regions. The results showed that smooth and superior quality logistics infrastructure would reduce the air pollution and enhance the environmental sustainability with more fabulous economic activities including export flows, value-added industry activities, and manufacturing value-added activities (Aldakhil, Nassani, Awan, Abro, & Zaman, 2018). Khan et al. (2018) did empirical research by using the data from 2007 to 2016. The results demonstrated that improved logistics indicators have positive impacts on the country's economic factors, including value-added manufacturing percentage of gross domestic product (GDP), foreign direct investment (FDI inflows), and trade openness. Besides, poor logistics infrastructure is the main reason for carbon emissions and weak economic growth. They concluded that the logistics industry has the potential to increase and/or decrease the overall economic and environmental performance of the countries. Because the polluted logistics system becomes a trade barrier for several countries at a different level, which restricts trade and export opportunities. On the other side, green logistics infrastructure and vehicles enhance environmental sustainability and also attract foreign investments with better export opportunities around the globe. They suggested that the government should encourage eco-friendly practices for better economic and environmental growth.

There is no doubt that regulatory authorities and customers are creating pressure to let firms think about environmental sustainability. Governments' strict policies are persuading the corporate sector to implement green practices in operations (Khan et al. 2017b; Nicolas, Daniel, Francois d, Frantz, & Hiro, 2018; Alinejad et al., 2018;

Luthra et al., 2015). Meanwhile, the shortage of research on how to integrate the supply chain model makes this task more thought-provoking (Aldakhil et al., 2018). Its findings revealed that green logistics indicators attract FDI inflows, whereas logistics operations mainly rely on fossil fuel, which needs to be shifted towards renewable energy/biofuels for the sake of environmental beauty. Ojala, Kersten, and Lorentz (2013) found that for green products, consumers are willing to pay higher prices, which also motivates firms to adopt greener processes and ecological design in their products. Laari, Töyli, and Ojala (2017), by 2025 due to strict government policies and customer awareness, will grow (Uygun & Dede, 2016), and more than 70% of firms in Finland have adopted green practices in their business and logistical operations. Savita et al. (2012) claimed that green technology would offset the carbon footprints as much as 15% by the end of 2020. They also emphasized that solving environmental issues is not only the responsibility of governmental authorities, but they should be resolved with the collective efforts of governmental bodies, corporate sectors, customer awareness, and policymakers' formation of more effective environmental policies. Thus, the following hypothesis are proposed:

H2a *Green logistics has a positive correlation with economic development.*

H2b *Green logistics mitigate the harmful effects of logistical operations and enhance environmental sustainability.*

2.3 | Environmental, economic, and health performance

Countries' environmental performance reduces the health expenditure and enhances economic activities and besides attracts foreign investors and improves the country's image in the international arena. Hamelinck, Suurs, and Faaij (2005) argued that the industrialization and polluted logistics operations lifted environmental problems, which can be mitigated through the adoption of green practices and implementing strict environmental policies by regulatory authorities. Khan et al. (2017a) study revealed that the environmental performance of firms is directly and positively correlated with firm financial performance and provide an opportunity to build a competitive edge. Charfeddine (2017) conducted empirical research in Qatar, and results confirmed that poor environmental performance is positively correlated with health expenditure, and due to the air and water pollution, human lives are at risk, whereas people are facing different diseases including asthma, lung cancer and heart problems.

Bekhet and Othman (2018) highlighted that rapid global polluted logistics operations result in a 1.4% increment in carbon emissions, which does harm to both environmental sustainability and human health and fauna and flora. In the Asian world, if a governmental authority adopts no appropriate environmental policy, climate change will reduce annual GDP growth as much as 2% to 4% till the end of 2040 (Zoudi, 2016). Khan et al. (2018) emphasized that as a green energy/biofuel is promoted can be promoted. The key advantages of biofuels are the low cost as compared with fossil fuels and to mitigate the horrible effect of climate change and carbon emissions (Zawaydeh, 2017). Boukherroub, Ruiz, Guinet, and Fondrevelle (2015) companies reduce their negative effects of logistical operations through adopting green practices, which enhances the economic and environmental performance and provides opportunities to explore new markets in developed countries. On the basis of above-cited papers, we put forward the following hypotheses:

Hc1 *Greater environmental performance reduces the health expenditure.*

Hc2 *Country environmental performance has a positive correlation with economic growth.*

2.4 | The link between health spending and economic growth

The association between economic development and health expenditure has been widely discussed in literature reviews in the context of African and European countries, but the results were inconclusive, and researchers suggested to conduct more studies. Hashmati (2001) used samples from Organisation for Economic Co-operation and Development countries to assess the link between health spending and economic development in the country. The results show that there is a positive link between health spending and economic development. A study by Kar and Taban (2003) found that there is a negative correlation between public health spending and economic development. Yumuşak and D Yıldırım (2009) used Turkish time series data to draw similar conclusions, confirming a negative correlation between economic development and health spending in Turkey. Empirical research conducted by Oni (2014) explained that a country's labor force productivity, gross capital formulation, and health expenditure are significant in the context of Nigeria. However, the poor health of workers and life expectancy rates are negatively affected by economic growth. Eggoh, Houeninvo, and Sossou (2015); Newhouse (1992) and Hilaire and Gilles (2015) investigated higher health expenditure and poor labor health not only slow down the economic activities but also increase the unemployment rate and create a burden on country economic growth for the long term. Khan et al. (2017a) In general, health expenditures in countries will increase due to poor environmental performance in terms of higher carbon dioxide, greenhouse gas emissions, and nongreen industrialization, which can be controlled by using biofuels in business operations and adopting green practices (Khan et al., 2018). We initiate the given below hypothesis:

H4 *Greater public health expenditure slowdown to the economic development of countries.*

Based on the mentioned hypotheses, the following structural model has been developed and pictured in Figure 1.

3 | METHODOLOGY

Data on all observed variables for the potential construction of this empirical analysis are collected annually from each country in the World Bank database (World Bank Database 2017). Most of the previous impact studies discussed in Section 2 use a defined set of observed variables at the empirical level. However, when it comes to multifacet, hardly direct, measurable issues like logistics performance, economic growth, and environmental degradations, the essence of developing latent constructs using multiple observed indicators becomes relevant. Therefore, we designed a set of latent variables with multiple observations. This prompted the selection of structural equation modeling (SEM) as an appropriate analytical method. According to Kline (2005) and Munim and Schramm (2018), SEM is suitable for a minimum of 100 sample sizes. For this purpose, in this study have pooled the data from seven years (namely, 2007, 2009, 2010, 2012, 2014, 2016, and 2018), generating 541 observations, except for observations with missing values. The definition of constructs is explained in Table 1.

The renewable energy construct is formed with one observed variable, named REC, which covers the consumption of renewable energy of their country's logistical and business operations. The data of renewable energy is based on the percentage of total final energy consumption in their country. Furthermore, the public health expenditure is also formed with one observed variable, named HP, which contains the healthcare goods and services consumed to facilitate patients, including asthma, lung cancers, and outdoor pollution-related diseases affected patients. Khan et al. (2018) highlighted that pollution-related diseases are increasing in emerging economies, which are the primary cause of burning coal and fossil fuel (World Health Organization 2005). They warned that developing countries need to formulate policies to protect their socio-environmental sustainability.

The logistics performance construct consists of four indicators mainly Logistics performance index: Competence and quality of logistics services, Logistics performance index: Ease of arranging competitively priced shipments, Logistics performance index: Quality of trade and transport-related infrastructure, and Logistics performance index: Efficiency of customs clearance process. Previous researchers used LP index data to measure logistics performance in Asian and European economies (Munim and Schramm, 2018; Hair et al, 2006; Lu et al. 2014; Khan et al., 2019).

The data of logistics performance is based on empirical survey data collected by the World Bank regularly. The Logistics Performance Index is measured at the country/region level by requiring local operators to provide feedback on the "friendliness" of the logistics in the country in which they operate. The data scale of the Likert scale ranges from 1 to 5, with 1 representing inferior logistics performance and 5 representing efficient logistics performance.

TABLE 1 Definition of constructs

Variable	Code	Definition
Renewable energy	REC	It is the consumption of renewable energy, and it is used and prompted by the government to maintain environmental sustainability.
Logistics performance	LP	The efficiency of the clearance process has measured LP in order to reduce emissions, competence, and services and quality of trade and transport-related infrastructure to reduce carbon emissions and air pollutions as minimum as possible.
Environmental performance	ENPI	ENPI shows environmental performance, which reflects better environmental sustainability. Environmental performance improvement means a reduction in carbon emissions and greenhouse gases.
Health performance	HP	The higher environmental performance improved to the people's health due to the fresh atmosphere with minimum carbon emission and greenhouse gases.
Economic growth	ECO	Economy growth measured by trade openness and foreign direct investment inflows. These are the leading proxies used for measuring economic health.

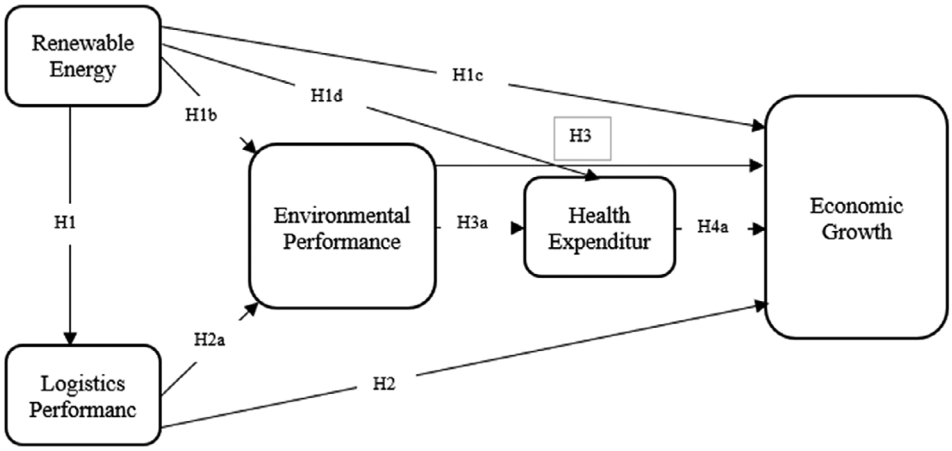


FIGURE 1 Proposed model

Economic growth can be expressed by investment inflows, as used by Khan, Qianli, Song Bo, et al. (2017). However, throughput alone cannot represent the value and intensity of a country's economic growth. Therefore, the underlying structure is based on state-level FDI inflows and trade openness as a percentage of GDP to represent and represent a country's real economic growth. Finally, to measure the environmental performance of ASEAN countries, we have used two observed variables, including total greenhouse gas and CO2 emissions (kt) emits in the atmosphere due to the burning of fossil fuel. The variables defined in Table 1 were used in the empirical analysis in most published research papers' discussion in the literature review, which is also used as encouragement to adopt SEM method for analysis purposes.

The purpose of this study is to draw a link between renewable energy, logistics indicators, public health expenditure, and national scale economic and environmental determinants in the context of ASEAN countries. Unquestionably, global logistical operations are an essential tool to improved economic growth. However, polluted logistical operations also increase health expenditure, and environmental concern is profoundly affected by logistical operations in the absence of renewable energy/biofuels usage in business activities and lack of appropriate environmental policies. For that reason, this study creates a connection between logistics indicators, public health expenditure, renewable energy, and economic and environmental determinants, which motivate green logistics practices across the ASEAN countries (Table A1 shows the list of ASEAN member states).

4 | RESULTS AND DISCUSSIONS

First, the normality of the latent variable has been tested by the Shapiro–Wilk test. Because not all variables are normally distributed, the Satorra–Bentler rescaling method is used for structural equation modeling according to the recommendations of Munim and Scramm (2018). Then perform reliability and reliability statistics for the conceptual model. After verification and reliability checking, the final SEM is proposed.

The logistics performance indices values from 5 to 1, show high logistics performance to low logistics performance, with the panel of ASEAN member states that improve the FDI inflows and trade openness. On the other hand, environmental beauty and human health are significantly compromised by higher CO_2 (carbon emissions) and greenhouse gases, which could be mitigated and reduced by the use of REC. Besides, the greater use of green energy in logistical and business operations may decrease public health expenditure and improve the labor productivity and environmental sustainability, which directly and/or indirectly promotes the economic growth of ASEAN countries. The descriptive analysis of observed variables is present in Table 2.

According to Koufteros (1999), squared multiple correlations, standardized factor loadings, and for an acceptable measurement model, model fit indices are deliberated to be an essential statistical criterion. Table 3 summarizes the statistical criteria for the measurement model. R^2 represents the multiple correlation of the squares, all values are above the recommended 0.50 level. (Munim and Scramm, 2018). Furthermore, all standardized factor loadings are above the suggested value of 0.70 (Bollen, 1989). Furthermore, a good measurement model fit is specified as the Tucker–Lewis index and comparative fit index are both well above the recommended value 0.90.

We have also calculated the reliability of the latent constructs, and reliability is referred to by the value of Cronbach's Alpha, while the two values exceed the required level of 0.70, as recommended by Nunnally (1978). This also confirms the internal consistency of the latent constructs (Garver & Mentzer, 1999). As shown in Table 3, all indicators' z values fulfill the criteria and endorse the convergent validity of each construct with unidimensionality (Anderson & Gerbing, 1988; Munim and Scramm, 2018). Moreover, item reliability is also confirmed, due to all R^2 values above the cutoff value 0.50.

TABLE 2 Descriptive analysis

Variable	*M*	*SD*	Min	Max	Shapiro–Wilk test
TOP	67.090	42.71050	24.054	202.00	.98**
FDI	2.0895	2.684120	−0.0998	18.300	.98**
REC	51.246	26.15420	3.2624	94.175	.96***
HP	5.1325	2.120550	2.4600	14.140	.97***
LPIQLS	2.3015	0.354552	1.3000	3.1914	.97***
LPICPS	2.2825	0.445150	1.1000	3.3341	.99*
LPIQTTI	2.4921	0.391125	1.2200	3.3742	.98**
LPICUSTOMS	2.4723	0.415215	1.2400	3.3914	.99*
CO_2	0.7948	0.660415	0.0321	2.7003	.97***
TGHG	425,454	827,415.9	1,468.6	2,798,058	.98**

Abbreviations: FDI, foreign direct investment; HP, health performance; LPICPS; Logistics performance index: Ease of arranging competitively priced shipments; LPICUSTOMS; Logistics performance index: Efficiency of customs clearance process; LPIQLS, Logistics performance index: Competence and quality of logistics services; LPIQTTI; Logistics performance index: Quality of trade and transport-related infrastructure; REC, renewable energy construct; TGHG, Total greenhouse gas; TOP Trade openness.
*p < .05; **p < .01; ***p < .001.

TABLE 3 Measurement model results

Latent construct	Observed indicator	Standardized factor loading	Unstandardized factor loading	*Z* value	R^2 (item reliability)
REC	REC	0.23	1.00***	24.61	1.00
LP	LPIQLS	0.16	.92***	24.63	0.87
	LPICPS	0.18	.97***	29.74	0.95
	LPIQTTI	0.15	.85***	18.51	0.76
	LPICUSTOMS	0.21	.98***	30.12	0.89
ENPI	CO_2	0.17	.97***	28.95	0.86
	TGHG	0.22	.97***	28.21	0.87
HP	HP	1.46	.98***	20.28	0.95
ECO	FDI	0.85	.87***	19.23	0.79
	TOP	0.82	.88***	18.29	0.83

Model-fit: $X^2(31) = 81.93$; comparative fit index = 0.98, Tucker–Lewis index = 0.97, Root Mean Square Error of Approximation = 0.09, Standardized Root Mean Square Residual = 0.02.

Abbreviations: ECO, economic growth; ENPI, environmental performance; FDI, foreign direct investment; HP, health performance; LP, logistic performance; LPICPS; Logistics performance index: Ease of arranging competitively priced shipments; LPICUSTOMS; Logistics performance index: Efficiency of customs clearance process; LPIQLS, Logistics performance index: Competence and quality of logistics services; LPIQTTI; Logistics performance index: Quality of trade and transport-related infrastructure; REC, renewable energy construct.

*p < .05; **p < .01; ***p < .001.

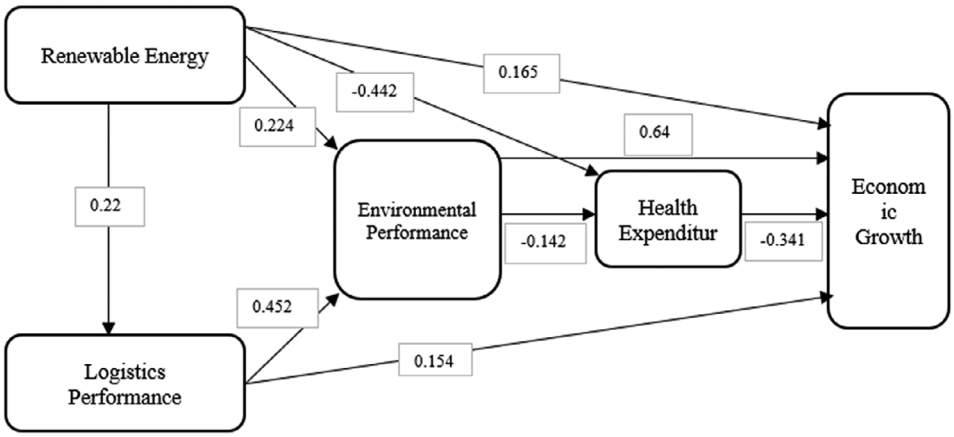


FIGURE 2 Proposed model

After the reliability test and measurement model have confirmed the reliability and validity of constructs, we have proceeded with SEM. Figure 2 showed the regression coefficients with their paths.

All observe variables loadings are above the minimum cutoff level 0.70 and chi-square of 72.85, and the ratio of X2 and degrees of freedom (that is, 72.85/32 = 2.28 < 3) is within the accepted range. The AGFI is 0.99, which confirms that the estimated model predicted 99% of the variances in the observed dataset. Besides, the remaining fit index measures, such as Tucker–Lewis index and comparative fit index values are 0.97 and 0.98, respectively, beyond the minimum cutoff range. Lastly, the Root Mean Square Error of Approximation and Standardized Root Mean Square Residual values are 0.08 and 0.02, which indicates a good fit model.

After ratifying the fitness of the model, we have calculated the hypothesized association between the different latent constructs. Table 4 displays the hypothesized association and its significance.

The findings reveal that renewable energy positively impacts logistics performance, environmental performance, health performance, and economic growth. Logistics performance is positively related to economic growth but is negatively correlated with environmental sustainability/performance. On another side, economic growth and public health expenditure of countries increase due to poor environmental performance with carbon and greenhouse emissions. Moreover, public health expenditure is adversely linked with economic activities, which confirms that higher public health expenditure slows down the economic growth of countries, due to low efficiency and productivity of labors.

This research examined the relationship between renewable energy usage, logistics performance indicators, environmental sustainability, public health expenditure, and economic growth of ASEAN states members. Overall, the results show that the use of renewable energy in logistics operations will greatly improve environmental sustainability, thereby reducing public health expenditures on low carbon

TABLE 4 Results of the structural model

Hypothesis	SEM regression path	Standardized coefficient	*p* value
H1a	REC → LP	0.221	.000
H1b	REC → ENPI	0.224	.002
H1c	REC → ECO	0.165	.000
H1d	REC → HP	−0.442	.004
H2a	LP → ENPI	0.452	.011
H2b	LP → ECO	0.154	.000
Hc1	ENPI → HP	−0.142	.000
Hc2	ENPI → ECO	0.647	.002
H4	HP → ECO	−0.341	.003

Abbreviations: ECO, economic growth; ENPI, environmental performance; HP, health performance; LP, logistic performance; REC, renewable energy construct; SEM, structural equation modeling.

emissions and greenhouse gases. Higher environmental performance and reductions in public health spending will stimulate economic growth due to the highest efficiency and productivity of the workforce, whereas the use of renewable energy and higher environmental performance in logistics operations will give the country a positive impression. Attract foreign investors. The finding shows that renewable energy usage, logistics indicators, and environmental performance are positively correlated on a 1% confidence level, whereas a 1% increase in renewable energy usage will improve 0.221%, 0.224%, and 0.165% to the green logistical operations environmental performance and economic growth of ASEAN countries respectively (Khan et al., 2018). An empirical study was conducted to discover the impact of renewable energy consumption on logistics performance. They conclude that green energy significantly enhances green logistical operations with better environmental sustainability. Because higher consumption of fossil fuel is a reason for environmental degradation, which also increases trade openness and brings foreign direct investment. Additionally, public health expenditure is reduced due to the adoption of renewable energy in business activities. Undeniably, public health expenditure is increased by burning fossil fuel and using nongreen energy in vehicles and logistical operations. Furthermore, due to poor air quality, different diseases attack human health, including asthma, brain, and lung cancer, which reduce labor efficiency and productivity.

The results show that the logistics operations are positively correlated with economic growth of ASEAN member states on 1% confidence level. The results highlighted that economic growth is mainly based on more excellent and improved logistical operations and infrastructure for business activities, whereas polluted vehicles and business activities destroy environmental sustainability and increase the public health expenditure. Further regulatory authorities should establish strict policies to enforce the firms to use green energy sources and adopt eco-friendly practices to mitigate carbon emissions and climate change problems. Biofuel and green energy should be encouraged by governmental bodies for enhancing environmental beauty and building a positive image of the country. Renewable energy is a crucial source that may promote green logistics operations in ASEAN countries.

In this research paper, two environmental determinants have been used, that is, carbon emissions and greenhouse gas emissions that were significantly influenced by polluted logistical operations. In simple words, due to the more essential polluted logistical operations, the environmental performance of ASEAN countries is reduced. On the other hand, the green logistics business not only contributes to the country's economic growth in terms of foreign direct investment inflows and trade liberalization but also improves environmental performance in terms of low carbon emissions and air pollution, which also reduces the public health expenditure and enhances the labor efficiency and productivity. The green practices such as green energy usage in business operations would be the attractions to foreign direct investment inflows. Many Western countries ban pollutant corporations and impose hefty fines on their polluting vehicles. Also, the polluted logistical system becomes a nontariff barrier for companies and decreases the chances of export to European and Western countries.

The research results revealed that public health expenditure is adversely linked with economic development. In simple words, low efficiency and productivity of labor will decrease the economic growth of countries. The higher carbon emissions increase health expenditure, which is negatively correlated with economic activities. Further, the findings showed that the economic growth of the country is negatively correlated with health expenditure. Logistics infrastructure plays a significant part in economic growth, and fossil fuel emits massive carbon emissions, which increase the public health expenditure. On the other hand, green energy use and green practices implementation in business and logistical operations enhance environmental sustainability and reduce health expenditure without compromising economic growth.

5 | CONCLUSION AND POLICY IMPLICATIONS

This research is to find out the linkages between renewable energy, logistics performance indices, public health expenditure, economic and environmental determinants in a panel of ASEAN member states, from 2007 to 2017. The research employs SEM for evaluating the effect of green energy and logistics performance on public health expenditure economic and environmental factors. The critical contribution of this article includes four possible logistics performance indices: public health expenditure, economic sustainability, and environmental sustainability as regress, under the premises of using renewable energy and eco-friendly practices in global logistics. In the previously published literature, researchers used a primary source of data to estimate the connection between green logistics, firms' financial and environmental performance, whereas this article used time series secondary data of ASEAN countries to measure the hypothesis. The results show that polluted logistical operations have a significant and negative effect on human health and environmental sustainability,

whereas higher carbon emissions increase the public health expenditure, which creates pressure on economic growth in terms of inefficiency and low productivity of labors. On the other hand, green logistical operations and usage of renewable energy in logistics activities reduce the carbon emissions and greenhouse gases with a higher positive image of the country, which attracts foreign direct investment inflows and foreign corporate sectors with more significant export opportunities in environmental-strict-policy countries.

The green logistical activities are well-associated with trade and economic growth, whereas polluted logistical operations will lead to carbon emissions increasing and health expenditure. The global logistics operations and vehicles are mainly dependent on fossil fuels. Hence, the analyst requires comprehensive knowledge of biofuels and green energy sources, which would considerably mitigate the negative effects of logistical operations on environmental beauty and human health. On the other hand, the use of renewable energy in environmental practices and commercial operations has attracted foreign investors, and trade openness has greater ecological sustainability.

There is no doubt that the logistics industry plays a vital role in the country's financial growth, but polluting logistics vehicles emit a large number of carbon emissions, which is the cause of environmental degradation and puts human health in an awkward position. The overall findings of our research drag to the following policies that would promote the renewable energy/green energy and environmental friendly practices in the panel of ASEAN member state, that is,

1. Regulatory bodies should offer tax exemptions and subsidies on green vehicles to use green energy sources and implement green practices in logistical operations, which will significantly improve air quality in terms of low carbon emissions.
2. Foreign direct investment inflows should be increased by green practices to build a positive image of countries, which also attracts foreign n investors.
3. Economic policies should act as an advantage for introducing maximum, liberalize trade policies, foreign direct investment inflows, and enhance logistics services for the deployment of quality gains.
4. Governmental bodies should discourage polluting vehicles and logistical operations by enforcing heavy taxes and import duties with financial fines on nongreen logistical activities. On the other side, the government should offer loans to the corporate sector for adopting renewable energy sources in their logistical operations and buying green vehicles, which will not only reduce health expenditure but will also improve environmental sustainability with better human health.
5. The collaboration between the regulatory authority and logistics industry for enhancing green practices in logistical operations through "certification schemes" may help to promote a sustainable agenda.

Effective logistics management can be an appropriate policy instrument. With the quality of transport-related infrastructure across the ASEAN member states, it would also reinforce the logistics management practices for green business. This study is conducted on a panel of ASEAN member states. The future research should be conducted on Organisation for Economic Co-operation and Development and Brazil, Russia, India, China and South Africa countries and compare the findings to obtain more robust inferences and viability of environmentally friendly logistical operations around the globe.

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REFERENCES

Aldakhil, A. M., Nassani, A. A., Awan, U., Abro, M. M. Q., & Zaman, K. (2018). Determinants of green logistics in BRICS countries: An integrated supply chain model for green business. *Journal of Cleaner Production.*, *195*, 861–868.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modelling in practice: A review and recommended a two-step approach. *Psychological Bulletin*, *103*(3), 411–423.

Bekhet, H. A., & Othman, N. S. (2018). The role of renewable energy to validate dynamic interaction between CO2emissions and GDP toward sustainable development in Malaysia. *Energy Economics*, *72*, 47–61.

Bhattacharya, M., Paramati, S.R., Ozturk I, Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from the top 38 countries. *Appl. Energy 162* (24), 733e741.

Boonchai, C., & Beeton, R. J. (2016). Sustainable development in the Asian century: An inquiry of its understanding in Phuket, Thailand. *Sustainable Development*, *24*(2), 109–123.

Boukherroub, T., Ruiz, A., Guinet, A., & Fondrevelle, J. (2015). An integrated approach for sustainable supply chain planning. *Computers and Operations Research*, *54*, 180e194.

Bozan, K. (2015). The impact of sustainable governance and practices on business performance: An empirical investigation of global firms. *Pratim Datta. Venugopal Gopalakrishna-Remani*, *7*(2), 97–120.

Charfeddine, L. (2017). The impact of energy consumption and economic development on ecological footprint and CO2emissions: Evidence from a Markov switching equilibrium correction model. *Energy Economics*, *65*(May), 355–374.

Dangelico, R.M., Pontrandolfo, P. (2013) Being "green and competitive": The impact of environmental actions and collaborations on firm performance. *Business Strategy and the Environment*. *24*(6), 413–430. https://doi.org/10.1002/bse.1828.

Eggoh J, Houeninvo H, Sossou G-A. (2015). Education, health and economic growth in African countries. *Journal of Economic Development* 2015; *40* (1):93–111.

Fotis, P., & Polemis, M. (2018). Sustainable development, environmental policy and renewable energy use: A dynamic panel data approach. *Sustainable Development*, *26*(6), 726–740.

Garver, M. S., & Mentzer, J. T. (1999). Logistics research methods: Employing structural equation modelling to test for construct validity. *Journal of Business Logistics*, *20*(1), 33–57.

Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. (2006). *Multivariate data analysis*. Pearson Prentice Hall Upper Saddle River. London: Pearson.

Hamelinck, C. N., Suurs, R. A. A., & Faaij, A. P. C. (2005). International bioenergy transport costs and energy balance. *Biomass and Bioenergy*, *29* (2), 114e134.

Hashmati, A. (2001). *On the causality between GDP and health care expenditure in augmented Solow growth model* (p. 2001). Stockholm: Department of Economic Statistics Stockholm School of Economics.

Hilaire, E. J., & Gilles, A. S. (2015). Education, health and economic growth in developing countries. *Journal of Economic Development*, *40*, 93–111.

Hussain, M., Khan, M., & Ajmal, M. (2019). Exploration and assessment of the motivators of social sustainability in healthcare supply chains: Multistake holder's perspective. *Sustainable Development*, *27*(4), 573–586.

Kar, M., & Taban, S. (2003). The impacts of the disaggregated public expenditure on economic growth. *Ankara University Faculty of Political Science.*, *53*(3), 145–169.

Khan, S. A. R., Zaman, K., & Zhang. (2016). The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries. *Renewable and Sustainable Energy Reviews*, *62*(9), 468–477.

Khan, S. A. R., & Dong, Q. (2017a). Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan. *Environmental Science and Pollution Research*, *24* (20), 16829–16844.

Khan, S. A. R., & Zhang, Y. (2019). *Strategic Supply Chain Management*, *Springer International Publishing*. Switzerland AG, ISBN 978-3-030-15058-7. https://doi.org/10.1007/978-3-030-15058-7.

Khan, S. A. R., Qianli, D., Song Bo, W., Zaman, K., & Zhang, Y. (2017). Environmental logistics performance indicators affecting per capita income and sectoral growth: Evidence from a panel of selected global ranked logistics countries. *Environmental Science and Pollution Research*, *24*(2), 1518e1531.

Khan, S. A. R., Qianli, D., Zhang, Y., & Khan, S. S. (2017b). Impact of the green supply chain on enterprise performance: In the perspective of China. *J. Adv. Mfg. Sys.*, *16*(3), 263e273.

Khan, S. A. R., Sharif, A., Golpîra, H., & Kumar, A. (2019). A green ideology in Asian emerging economies: From environmental policy and sustainable development. *Sustainable Development*, *27*, 1063–1075. https://doi.org/10.1002/sd.1958

Kline, R. B. (2005). *Principles and practice of structural equation modeling*. New York, NY: The Guilford Press.

Koufteros, X. A. (1999). Testing a model of pull production a paradigm for manufacturing research using structural equation modeling. *Journal of Operations Management*, *17*(4), 467–488.

Kumar, S., Teichman, S., & Timpernagel, T. (2012). A green supply chain is a requirement for profitability. *International Journal of Production Research*, *50*(5), 1278–1296.

Laari, S., Töyli, J., & Ojala, L. (2017). Supply chain perspective on competitive strategies and green supply chain management strategies. *Journal of Cleaner Production*, *141*, 1303–1315.

Lee, K. H., & Wu, Y. (2014). Integrating sustainability performance measurement into logistics and supply networks: A multi-methodological approach. *The British Accounting Review*, *46*(4), 361e378.

Li, Y. (2014). Environmental innovation practices and performance: Moderating effect of resource commitment. *Journal of Cleaner Production*, *66*, 450e458.

Li, Y., Shi, X., Emrouznejad, A., & Liang, L. (2018). Environmental performance evaluation of Chinese industrial systems: A network SBM approach. *Journal of the Operational Research Society*, *69*(6), 825–839.

Lu, C.-S., Lai, K.-H., & Cheng, T. E. (2007). Application of structural equation modeling to evaluate the intention of shippers to use internet service in liner shipping. *European Journal of Operational Research*, *180*(2), 845–867.

Mafakheri, F., & Nasiri, F. (2014). Modeling of biomass-to-energy supply chain operations: Applications, challenges and research directions. *Energy Policy*, *67*, 116–126.

Nassani, A. A., Aldakhil, A. M., Abro, M. M. Q., & Zaman, K. (2017). Environmental Kuznets curve among BRICS countries: Spot lightening finance, transport, energy and growth factors. *Journal of Cleaner Production* (2017, *154*, 474–487.

Newhouse, J. P. (1992). Medical care costs: How much welfare loss? *The Journal of Economic Perspectives*, *6*(3), 3–21.

Nicolas, A., Daniel, T., Francois d, C., Frantz, R., & Hiro, T. (2018). An analytical model to investigate the economic and environmental benefits of a supply chain resource-sharing scheme based on collaborative consolidation centres. *Journal of the Operational Research Society*, *69*(12), 1888–1902.

Nunnally, J. C. (1978). *Psychometric theory*, *2nd Edn*. New York: McGraw-Hill.

Ojala, L., Kersten, W., & Lorentz, H. (2013). Transport and logistics developments in the Baltic Sea Region until 2025. *J. East West Bus.*, *19* (1e2), 16–32.

Oni, L. B. (2014). Analysis of the growth impact of health expenditure in Nigeria. *J Econ Finance (JEF).*, *3*(1), 77–84.

Qureshi, M. I., Rasli, A. M., & Zaman, K. (2016). Energy crisis, greenhouse gas emissions and sectoral growth reforms: Repairing the fabricated mosaic. *Journal of Cleaner Production*, *112*, 3657–3666.

Ramos, T. B., Caeiro, S., Moreno Pires, S., & Videira, N. (2018). How are new sustainable development approaches responding to societal challenges? *Sustainable Development*, *26*(2), 117–121.

Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations & Production Management*, *25*(9 and 10), 898–916.

Shahbaz, M., Solarin, S. A., Sbia, R., & Bibi, S. (2015). Does energy intensity contribute to CO 2 emissions? Atrivariate analysis in selected African countries. *Ecological Indicators*, *50*(24), 215–224.

Uygun, Ö., & Dede, A. (2016). Performance evaluation of green supply chain management using integrated fuzzy multi-criteria decision making techniques. *Computers & Industrial Engineering*, *102*, 502–511.

World Bank Database. (2017). https://data.worldbank.org []

World Health Organization. (2005). Make every mother and child count. *The World Health Report*, *2005*, 151–200.

Xue, L., Weng, L., & Yu, H. (2018). Addressing policy challenges in implementing sustainable development goals through an adaptive governance approach: A view from transitional China. *Sustainable Development*, *26*(2), 150–158.

Yumuşak, I. G., & D Yıldırım, C. (2009). An econometric examination over the relation between health expenditure and economic growth. *J Knowl Econ Knowl Manage*, *2009; IV*, *118*, 57–70.

Zaman, K., & Shamsuddin, S. (2017). Green logistics and national scale economic indicators: Evidence from a panel of selected European countries. *Journal of Cleaner Production*, *143*, 51e63.

Zhu, Q., Sarkis, J., Cordeiro, J. J., & Lai, K.-H. (2008). Firm-level correlates of emergent green supply chain management practices in the Chinese context. *Omega*, *36*(4), 577e591.

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APPENDIX A

TABLE A1 List of Association of Southeast Asian Nations countries

S. No.	Country name	Code
1	Brunei Darussalam	BRN
2	Cambodia	KHM
3	Indonesia	IDN
4	Lao People's Democratic Republic	LAO
5	Malaysia	MYS
6	Myanmar	MMR
7	Philippines	PHL
8	Singapore	SGP
9	Thailand	THA
10	Vietnam	VNM