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Reassessing the Load Capacity Curve Hypothesis in ASEAN-5: Exploring Energy Intensity, Trade, and Financial Inclusion with Advanced Econometric Techniques

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ABSTRACT

This study investigates how economic growth, energy intensity, financial inclusion, and trade globalization impact the load capacity factor in the ASEAN-5 region. Using data from 2000 to 2022 from reputable databases, the study analyzed the load capacity curve (LCC) hypothesis through comprehensive statistical analysis. Several diagnostic tests, such as cross-sectional dependence, slope homogeneity, unit root, and cointegration, to select a suitable long-run estimation model were conducted. The study utilized the Driscoll-Kraay standard error (DKSE) approach to address identified issues like cross-sectional dependence, heterogeneity, and unit root problems. DKSE estimation showed that the LCC hypothesis was not present in the ASEAN-5 region. It is worth noting that an inverted-U-shaped relationship between per capita income and the load capacity factor was found, emphasizing the complexity of economic dynamics in the region. Furthermore, the analysis revealed a strong correlation between energy intensity and the load capacity factor, with trade globalization having a significant negative effect. Surprisingly, financial inclusion did not show a significant correlation with the load capacity factor, highlighting the intricate role of financial accessibility in economic performance. To enhance the strength of the DKSE estimation, the study also utilized quantile regression analysis, which supported the results of the DKSE approach. The study confirmed that the LCC hypothesis is not applicable in the ASEAN-5 region and offered a more detailed analysis of the varying effects of energy intensity and trade globalization at different levels. Conclusively, this study provides valuable insights into the complex relationships among economic growth, energy intensity, financial inclusion, and trade globalization in the ASEAN-5 region. A thorough analytical approach enhances comprehension of sustainable development and economic resilience in the region, guiding policy decisions and future research efforts.

Keywords: Energy Intensity, Financial Inclusion, Trade Globalization, Load Capacity, ASEAN-5
JEL Classifications: Q43, G21, F14, D24, F15

1. INTRODUCTION

Environmental concerns have been increasingly integrated into economic concepts in response to the pressing need to combat the changes in climate and endorse sustainable economic progress (Raihan et al., 2024). Every nation, whether developing or developed, experiences the effects of excessive emissions of greenhouse gases (GHGs) due to expanding economic activities all over the world. The linkage between the economy and the environment has been long debated since 1991 by Grossman and Kruger, an underlying theory known as the EKC hypothesis (Baloch et al., 2019; Polcyn et al., 2023). Historically, numerous research has prioritized investigating the most significant repercussion of the emission of greenhouse gases (GHGs), more particularly carbon dioxide (CO2) (Voumik et al., 2023; Martial et al., 2023) and more recently, on Ecological Footprint (ECF), proposed by Addai et al., (2022) and Ahmed et al., (2021). Both metrics exclusively address the demand side, overlooking the natural supply aspect, particularly concentrating on CO2 and emphasizing air pollution. This neglects aspects such as soil and water contamination, as highlighted by Borhan et al. (2023) and Pata and Ertugrul (2023). Moreover, ECF primarily focuses on harms caused by human activities without taking into account nature's responses to these impacts. As a fix for this, Siche et al. (2010) suggest using the load capacity factor (LCF), which is found by dividing the supply side component Biocapacity by the demand side one ECF (Pata, 2021; Galli, 2015). LCF is calculated by multiplying biocapacity by EF−1. A measurement of LCF is "Biocapacity * EF−1". Any score below "1" indicates that the population's consumption patterns are negatively impacting the environment. The sustainability limit for the LCF analysis is characterized by a value of "1". An LCF value larger than "1" indicates that the natural resources and environmental conditions currently in place are enough to support human requirements (Fareed et al., 2021). In comparison to biocapacity, ECF, and CO2 alone, LCF provides a more accurate assessment of the environment by including natural resource resilience in addition to the demands of humans on the atmosphere, water, and soil (Adebayo et al., 2024).

It is common practice to utilize GDP as an indicator variable while analyzing the LCF components (Shang et al., 2022; Fareed et al., 2021). A U-shaped association between LCF and income is possible, running counter to the EKC hypothesis that states a U-shaped inversion between income and environment. The reason behind this is the fact that rising incomes might result in the developing stage that disregards the environment, which can lower ecological quality and, consequently, LCF (Pata and Ertugrul, 2023). When a country's GDP rises above a particular threshold, cleaner production technology and heightened environmental consciousness are directed towards an improvement in ecological quality and a decline in LCF. The "load capacity curve" (LCC) hypothesis describes the relationship between LCF and earnings as a U-shaped curve.

With an emphasis on the existence of the LCC curve in five ASEAN nations, this study takes into account Energy Intensity (EI), Global Trade Dynamics (GOB), and Financial Inclusion (FI) as additional factors that determine LCF. There was a correlation between economic production and EI prior to the Industrial Revolution as found by Biesiot and Noorman (1999). Expanded industrial activity due to energy exploitation has increased pollution, which poses a threat to the environment. This alliance has exacerbated this problem. An indicator of a country's energy efficiency, EI measures the quantity of energy required to generate a specific amount of gross domestic product (GDP) (Song et al., 2015). Reduced EI, or the amount of energy usage relative to GDP, is a goal of many countries as they seek ways to maximize efficiency in energy production and consumption. Less energy use means less pollution from manufacturing processes (Lin et al., 2016). Lessening EI is key to effectively managing and regulating environmental challenges (He and Lin, 2019).

The notion of Financial Inclusion (FI) surfaced from research conducted since the start of the 2000s, which suggested that financial exclusion was a primary contributor to income inequality (Chibba, 2009). In order to progress in the field of finance, FI is a crucial part of financial development that fosters institutional advancement and accelerates the economic expansion of recipient nations (Le et al., 2019). In theory, there may be advantageous and adverse outcomes of FI on CO2 production. Le et al. (2020) note that FI facilitates easier access to affordable financial services, which in turn makes investments in green technology more possible for both individuals and businesses. Because of this, green technology can be funded via inclusive financial structures, which can greatly reduce pollution (IPA, 2017). On the flip side, more industrial activity, higher CO2, and faster access to financial resources all contribute to global warming. Zhao et al. (2021) found that an increase in activities could lead to energy poverty, which in turn could detriment environmental circumstances.

The debate over how globalization addresses environmental issues while fostering economic expansion is a relatively new topic. In the age of globalization, developing and emerging nations are enhancing their domestic economic systems through trade, technological transfer, and financial operations. Consequently, this elevated worldwide economic activity may result in a rise in energy usage and the release of GHG (Odugbesan et al., 2021; Adebayo and Kirikkaleli, 2021). Gygli et al. (2019) enhanced this index by integrating supplementary sub-indices to enhance our understanding of the dynamics of globalization. Because of this, we can differentiate between the various ways in which Trade Globalization (GOB) has affected the environment, which may either boost or mitigate emissions. The relationship involving trade and environmental circumstances is supposed to be a complex interplay of numerous factors. Owing to the scale impact, which occurs when an economy prioritizes increasing production at the expense of decreasing input, trade liberalization can exacerbate environmental issues (Dinda, 2004). Still, emissions are reduced during the composition effect and the technique effect of trade because, first, structural economic shifts encourage cleaner actions, and second, the technique effect causes polluted technology to be replaced with environmentally friendly ones. However, national policies on international trade determine the extent to which trade globalization affects the environment. Undoubtedly, trade globalization has the potential to raise a nation's greenhouse gases and EF while lowering its LCF if that nation serves as a sanctuary for polluters. The environmental impacts of EI, GOB, and FI can be both positive and negative, as has been pointed out throughout this extensive analysis. Therefore, discovering how these factors affect emissions is an important question for the ASEAN-5 nations to answer.

Due to the increasing global population, emerging economies have experienced substantial expansion and have become significant contributors to the world's total output and consumption. As per WDI (2023), the members of ASEAN include over 600 million worldwide consumers, accounting for 9.7% of the worldwide GDP. More specifically, the ASEAN-5 countries—Singapore, Malaysia, the Philippines, and Indonesia—are more economically advanced than other ASEAN nations and are among the most prominent members of the alliance. From 2000 forward, the average yearly growth rate of the ASEAN countries was above 5%, which was significantly higher than the 1.6% growth rate reported by the OECD nations (Zhu et al., 2016). Furthermore, there has been a heightened focus on enhancing FI initiatives in Asia. The objective is to promote the growth of the finance industry, ensure financial stability, and improve public exposure to financial services, particularly within the official financial system (Wardhono et al., 2018; Tufail et al., 2021). Because of their rapid economic development, ASEAN plays a pivotal role in the global demand for energy. The energy demand in this region increased by about 50% between 2000 and the present, as reported by the IEA (2015). Furthermore, between 2013 and 2040, the region's requirement for energy is predicted to upsurge by 80%, doubling its CO_2 emissions. This surge in energy demand and emissions underscores the critical need for a transition to cleaner and more sustainable energy practices to alleviate the environmental consequences linked to economic growth. Achieving a harmonious equilibrium between economic growth and environmental sustainability is imperative. This recognition stems from the imperative need to fulfill the escalating energy requirements of a growing economy while minimizing adverse effects on the environment. The adoption of clean energy practices presents a viable pathway to strike this crucial balance, ensuring that economic development is conducted in an ecologically responsible manner, and safeguarding the well-being of future generations. The utilization of conventional energy sources, notably coal and oil, has significantly contributed to the environmental challenges at hand. The surge conveys a sense of rapid and substantial escalation, highlighting that the present trajectory of energy consumption is unsustainable over the long term. The urgency to address these environmental repercussions promptly arises from the imperative to avert irreversible damage to ecosystems and mitigate the impacts of climate change. To address the environmental consequences associated with this surge in energy demand, a transition to cleaner and more sustainable energy practices is strongly advocated. This entails a departure from reliance on fossil fuels towards embracing renewable energy sources, such as solar, wind, hydro, and geothermal power. These sources are deemed "cleaner" due to their significantly lower emissions of greenhouse gases, thereby reducing the overall environmental footprint. This strategic shift aligns with the imperative of steering away from environmentally detrimental practices, fostering a more sustainable and responsible approach to energy generation. The ASEAN member states are quite economically open, which means that trade globalization is booming there (Phong 2019). The environment may be impacted favorably or unfavorably via this. In order to effectively tackle the problem of deterioration of the environment, it is essential to have a thorough knowledge of the root causes and trends of contamination in these countries.

With the above being said, this study aims to find out if the LCC theory holds for the ASEAN-5 countries. Additionally, this work utilizes the Quantile method for a panel dataset that spans from 1970 to 2017 to examine how the Load Capacity Factor (LCF) for the ASEAN-5 states is impacted by GDP, Energy Intensity (EI), Financial Inclusion (FI), and Trade Globalization (GOB). The present study adds to the growth versus environment literature in several important ways: (1) Using the load capacity factor as a metric for environmental deterioration, this study endeavors to apply it to the example of ASEAN-5 nations. Therefore, the study takes a supply-and-demand approach to environmental problems. (2) Indicators like this take conversations about environmentally responsible practices to a new level. Very few studies have been conducted on how EI, GOB, and FI contribute to environmental deterioration. This work uses the Quantile regression method, which allows for factor analysis at different quantiles, to address these limitations of the existing literature. (3) Using the Driscoll-Kraay standard errors (XTSCC), the study was able to determine the long-run impact of the independent factors on the LCF.

2. LITERATURE REVIEW

In this part, we survey the research that has reviewed the previous literature on how economic progress, energy intensity, monetary inclusion, and trade globalization have affected the sustainability of the environment.

2.1. Nexus between Environment and Economic Growth

In the initial part of the literature review, the present study looks at the ways in which rising GDP causes pollution. The extent of global pollution has increased in tandem with the growth of the economy. From a strategic point of view, the most important question is how to promote both economic growth and environmental safety at the same time. Hence, the correlation between economic progress and environmental degradation has been extensively examined. For Turkey, Pata and Balsalobre-Lorente (2022) used the ARDL method and discovered that GDP growth had a statistically significant negative influence on LCF between the 1965 and 2017 periods. In a similar track, Ni et al. (2022) also found a negative association between LCF and economic expansion by utilizing the CS-ARDL approach for resource-rich nations. Moreover, Xu et al. (2022) also found that GDP per capita lessens the LCF in Brazil from 1970 to 2017. Another study in this field ensured the existence of a U-shaped relationship between ecological state and income for 23 OECD countries. However, using the Dual adjustment method, Akadiri et al. (2022) discovered a positive relationship between GDP growth and LCF in India between 1970 and 2017. The study of Dam and Sarkodie (2023) also found real income causes to improve LCF in the case of Turkey. Using the ARDL method for South Korea, Pata and Kartal (2023) investigated the relationships between both of the factors. This country's environmental conditions improved as a function of rising per capita income, proving both the EKC and LCC hypotheses. While looking at India, Pata and Ertugurl came to a similar conclusion (2023). Dogan and Pata (2022) confirmed the LCC hypothesis that income initially affects ecological conditions but eventually improves them. They identified a U-shaped link between the environment and GDP in G-7 countries, which supports this idea. Conversely, Shahzad et al. (2023) found no evidence of the LCC hypothesis for top tourism countries. For the top ten tourism-based economies, Pata and Tanriover (2023) concluded that there is no U-shaped connection between GDP, GDP2, and the load capacity factor.

Gaymfi et al.'s (2021) study for E7 nations found no significant influence of economic growth on environmental deterioration for the 1995–2018 time period under the PMG-ARDL approach, the rapid GDP growth of these emerging nations is not a threat to nature, and clarified the presence of EKC with an inverted U-shaped diagram for them. Then, a study conducted by Hassan et al. (2019) delves into the relationship between economic growth, ecological footprint, biological capacity, and human resources. Using data from 1971 to 2014, the ARDL framework estimates that economic development increases the ecological footprint, which in turn contributes to environmental degradation. Aşıcı and Acar (2016) used the panel fixed effects (FE) regression method, there is a negative association between population density and the ecological footprint of domestic output for 116 nations from 2004 to 2008. Chu et al. (2023) conducted a similar experiment, except that they used EF as a stand-in for environmental degradation from 1995 to 2018. Their findings suggest that the rising use of energy in the rapid economic growth is a direct cause of environmental degradation in the E7 countries. Additionally, long-term evidence supports the concept of the environmental Kuznets curve (EKC). Furthermore, a large number of the previous literature focused on the traditional CO2 and EF indicators for environmental sustainability (Nathaniel, 2021; Sharma et al., 2020; Udemba, 2020; Imamoglu, 2018; Wang and Dong, 2019; Alola et al., 2019; Ahmed et al., 2020; Pachiyappan et al., 2021; Sikder et al., 2022; Do and Dinh, 2020; Mohsin et al., 2022). In other words, no clear conclusion is drawn for ASEAN countries, and the evidence suggests that the extent to which environmental issues impact economic development may vary across states.

2.2. Nexus between Energy Intensity and Environment

The second area of investigation is to study the correlation involving energy intensity and pollution levels. Since the turn of the twentieth century, economists have studied the interplay between energy, growth, and environmental impacts. Energy is a key component of manufacturing and has an impact on economic growth (Stern, 1997). In this regard, Shokoohi et al. (2022) examined the correlation between energy consumption and environmental degradation. They used an ARDL approach to illustrate the short- and long-term correlations between energy intensity, ecological footprint, and CO2. Their study found a positive correlation between energy intensity, carbon dioxide emissions, and ecological footprint (EF) in all of the Middle Eastern nations they looked at, indicating that energy intensity is a major contributor to environmental degradation in those regions. Using sophisticated econometric methods, Khan et al. (2022) discovered that among APEC member states, energy intensity correlates favorably with the ecological footprint. Based on a Threshold Autoregressive Model (TAR) analysis for Turkey, energy intensity was determined to be a hindrance to environmental sustainability by Koyuncu et al. (2021). Dogan and Shah (2022) found that using the STIRPAT paradigm, energy intensity significantly impacts environmental sustainability in the UAE in a negative way. In a related vein, Salman et al. (2019) stated that energy intensity increases carbon dioxide (CO2) emissions and hinders the sustainability of the environment in ASEAN countries. They utilized panel quantile regression and CO2 emissions instead of an ecological footprint as their environmental indicator through the two-step system GMM approach for 43 countries in sub-Saharan Africa. Amuakwa-Mensah and Adom (2017) narrated that the integrated as well as separated power concentrations degrade the overall quality of the environment. Using the common correlated effect mean group estimator, the enhanced mean group estimator, and the mean group estimator for the EU-27 nations, Bekun et al. (2019) discovered that energy intensity reduces environmental quality in the studied blocs. Energy intensity positively affects CO_2 emissions in the 44 Belt and Road economies, according to the AMG methodologies and Westerlund-Edgerton panel cointegration procedure applied in the research by Abban et al. (2020). In addition, Umar et al. (2021) showed that the excessive release of carbon is caused by high levels of energy in thirteen African countries when they employed AMG and PMG estimators.

Most of the prior research on load capacity as an indicator of environmentally sustainable environments has concentrated on specific energy consumption rates; however, employing the Fourier autoregressive distributed lag (ARDL) over the United States, Pata et al. (2023) discovered that using biomass energy actually enhances the condition of the environment via nurturing load capacity. The relationship involving LCF and renewable energy consumption has also been the subject of several empirical analyses (Pata et al., 2024; Jiaduo et al., 2023; Huilan et al., 2022; Jin and Huang, 2023; Pata and Samour, 2023; Fareed et al., 2021; Dam and Sarkodie, 2023; Shang et al., 2022).

This literature review portion, there is less evidence of a connection between energy intensity and load capacity. At the same time, there is a noteworthy increase in the usage of CO2 and Energy Efficiency indicators.

2.3. Nexus between Financial Inclusion and Environment

Discussions about financial inclusion's role in perpetuating poverty and underdevelopment began in the year 2000 when research on the subject was conducted (Chibba, 2009). Numerous research has monitored how development and financial depth affect environmental sustainability. However, because financial inclusion statistics and an index are not readily available, there is a severe lack of research that attempts to assess the effect of financial inclusion on ecological sustainability. On the one hand, more people being able to afford financial services means greater production along with economic expansion, which could mean greater greenhouse gas emissions and less care for the environment. An analysis of Turkey's load capacity factor as a function of monetary inclusion was examined by Yurtkuran and Güneysu (2023), where the newly developed ARDL model found out that financial inclusion decreases the load capacity factor. To back this claim, Ozturk and Ullah's (2022) empirical finding demonstrated that digital financial inclusion boosts economic growth but declines environmental quality due to an increase in CO_2 emissions. Financial inclusion and emerging nations' carbon emissions are positively correlated, based on Zhao et al.(2022). Here, Usman et al. (2021) argued that monetary inclusion is a major factor in reversing ecological deterioration by focusing on ecological footprints instead of CO_2 emissions. Based on Yıldırım et al. (2023), the ecological footprint is exaggerated, and pollution levels rise as financial inclusion increases. On the other flip, Musah (2022), Paramati et al. (2021), and Le et al. (2020) put out the argument that financial inclusion exacerbated environmental sustainability issues due to elevated carbon emissions. Following Shabir's (2022) augmented mean group (AMG) result, reducing carbon dioxide emissions is one way that renewable energy usage and financial inclusion significantly enhance environmental sustainability.

Carbon dioxide emissions have been the subject of a disproportionate number of studies compared to other environmental indicators. For example, Dogan and Turkekul (2016) examined this for US, Ehigiamusoe and Lean (2019) examined a large panel with varying levels of income, Abbasi and Riaz (2016) examined for Pakistani economy, Paramati et al. (2021) examined OECD nations, Odhiambo (2020) examined countries in sub-Saharan Africa (SSA), Germany, France, and the UK's economy by Apergis and Tang (2013), and Maji et al. (2017) examined Malaysia. Despite the abundance of research on carbon dioxide and financial inclusion, the relationship between load capacity factor and financial inclusion has received surprisingly little attention in the literature.

2.4. Nexus between Trade Globalization and Environment

Countless studies have examined the effects of economic globalization on ecological damage and changes in the climate. Trade made it possible for consumers of one nation to transfer the environmental damage brought on by what they consume to other nations (Yunfeng and Laike 2010). However, different studies utilized different indicators of trade while examining the nexus between economy, environment, and trade. In a study spanning from 1990 to 2016, Dauda et al. (2021) examined the connection between trade openness and emissions for several African nations. They found that trade openness negatively impacts environmental quality, supporting the Pollution haven hypothesis. The environmental effects of open trade and export quality in both advanced and developing countries were investigated by Dogan et al. (2020). They discovered that emissions were positively correlated with export quality, but that trade had no discernible effect on emissions. The impact of diversifying exports on the environment was also studied by Liu et al. (2019) using the DKSE technique. According to their research, export diversification is one factor that is causing environmental damage. A similar trade indicator was used by Fareed et al. (2021) to find out its relationship with LCF by utilizing Fourier quantile causality assessment. Recently, the influence of trade globalization on the environment has also caught attention. Using data collected for ASEAN countries between 1985 and 2017, Wang et al. (2020) determined how emissions were affected by trade globalization. According to their research, globalization of trade reduces CO_2 pollution in ASEAN countries. A similar outcome was obtained by Ahmed and Le (2021). Conversely, Kartal and Pata (2023) found that trade globalization raises CO_2 emissions and reduces LCF.

2.5. Literature Gap

The current body of research on the Load Capacity Curve (LCC) theory in ASEAN-5 nations is missing a thorough investigation of the interplay between Load Capacity Factor (LCF), Energy Use Intensity (EI), Trade Globalization (GOB), and Financial Inclusion (FI). Prior research has predominantly concentrated on individual elements of the association amid the environment and economic progress, such as the influence of energy consumption on GDP or the consequences of trade or financial stability, without investigating their interdependencies. In contrast to the EKC theory and indicators such as CO_2 or ecological footprint, the LCC hypothesis and LCF are relatively recent approaches. However, they have the potential to provide more precise and reliable outcomes. The existing research provides fresh perspectives on the concurrent interplay among LCF, EI, GOB, and FI within the ASEAN-5 framework. The variables being studied, especially their collective impact on LCF, have not been thoroughly examined, highlighting the necessity for more research to fill up the existing void in the available literature. The proposed research seeks to rectify these shortcomings and enhance the knowledge of the LCC hypothesis in ASEAN-5 nations. This would provide important perspectives for researchers, policymakers, and practitioners.

3. METHODOLOGY AND DATA

3.1. Data and Variables

This study thoroughly examines the various impacts of economic growth, energy intensity, financial inclusion, and trade globalization on the load capacity factor in the ASEAN-5 region. For this purpose, we gathered thorough datasets from reliable sources. Data on load capacity factor were obtained from the Global Footprint Network (GFN, 2023), and Gross Domestic Product (GDP) data were sourced from the World Development Indicator (WDI, 2023). Data on energy intensity and financial inclusion were extracted from Our World in Data (2022), while trade globalization metrics were sourced from the KOF Globalization Index (KOF, 2022). The variables and their sources are thoroughly described in Table 1, ensuring transparency and making it easier to replicate the study's findings. Through a thorough data collection process, the analysis is reliable and valid, allowing for a detailed examination of the complex relationships between key economic indicators and the load capacity factor in the ASEAN-5 region.

3.2. Theoretical Framework

In the pursuit of environmental balance, the load capacity curve (LCC) hypothesis emerges as a persuasive alternative to the widely recognized Environmental Kuznets Curve (EKC) (Grossman and Krueger, 1991). The LCC proposes a U-shaped correlation between per capita income and the load capacity factor (LCF), which is a reliable measure of ecological sustainability (Pata et al., 2023). This is in direct contrast to the EKC's inverted U-curve. The LCC revolves around the key concept of the LCF. This is determined by biocapacity, which indicates Earth's ability to

Table 1: Variable's name and source

Variables	Description	Logarithmic forms	Units	Sources
LCF	Load Capacity Factor	LLCF	Gha	GFN
GDP	Gross Domestic Product	LGDP	Current US$	WDI
GDP2	Gross Domestic Product Square	LGDP2	Current US$	WDI
ENI	Energy Intensity	LENI	Primary energy consumption per GDP (kWh/$)	Our World in Data
FNI	Financial Inclusion	LFNI	Number of ATM per 10000 individuals	Our World in Data
GOB	Trade Globalization	LTGOB	Overall Measurement	KOF index

provide resources and control waste, compared to the ecological footprint, which represents the demand humans have for these resources (Shahzad et al., 2023). In the early stages of economic growth, there is a focus on industries that require a significant amount of resources and rely heavily on fossil fuels (Gyamfi et al.2021). This leads to a quick increase in the ecological impact. The growth rate of biocapacity is exceeded by this, resulting in a decrease in LCF and subsequent damage to the environment. This initial stage reflects the early phase of the U-curve, where higher income is associated with a decline in sustainability. However, the LCC suggests that there may be a significant shift in the situation as income levels continue to increase. During this transitional period, various significant factors come into play. The rapid progress of technology has brought about cleaner production methods, leading to a significant increase in the use of renewable energy sources (Erdogan, 2024). Additionally, there has been a notable change in consumer preferences, with more people opting for environmentally friendly products. Moreover, the accumulation of wealth allows for the allocation of resources towards initiatives such as pollution control, resource management, and ecological restoration. This combination of factors plays a role in diminishing the ecological impact, ultimately increasing biocapacity. This phase, often referred to as the "right side" of the U-curve, illustrates a situation where higher income is accompanied by improved sustainability. The Load Capacity Curve provides a comprehensive view of the complex interplay between economic growth and environmental sustainability (Tiwari et al., 2023). It highlights the potential for positive change and better ecological results as society progresses economically and simultaneously adopts sustainable practices and innovations.

To clarify the study stated earlier, we have formulated the following Equation (1) for LCC theory:

$$\text{Load Capacity Factor} = f\,(GDP, GDP^2, X_t) \tag{1}$$

Equation (1) incorporates GDP and GDP^2 as variables representing income, with X_t signifying additional factors impacting the Load Capacity Factor. By introducing additional influential factors such as Energy Intensity, Financial Inclusion, and Trade Globalization, Equation (2) is formulated to account for a more comprehensive understanding of the factors influencing the Load Capacity Factor.

$$LCF = f\,(GDP, GDP^2, ENI, FNI, GOB) \tag{2}$$

In Equation (2), LCF represents the Load Capacity Factor, ENI stands for Energy Intensity, FNI denotes Financial Inclusion, and GOB stands for Globalization. The econometric version of this equation is expressed in Equation (3).

$$LCF_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 ENI_{it} + \beta_4 FNI_{it} + \beta_5 GOB_{it} \tag{3}$$

The equation (3) exhibits the logarithmic values of the variables. Logarithmic variables provide a wide range of advantages when it comes to data analysis. It helps in converting complex relationships into simpler linear forms, making it easier to understand and draw statistical conclusions. Logarithmic scales are useful for compressing large ranges, which helps to deal with heteroscedasticity and accommodate data with different magnitudes. This transformation is highly valuable in financial and scientific analyses as it effectively stabilizes variance.

$$LLCF_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it}^2 + \beta_3 LENI_{it} + \beta_4 LFNI_{it} + \beta_5 LGOB_{it} \tag{4}$$

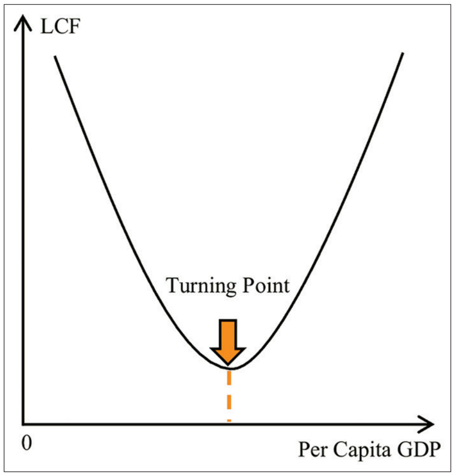
The LCC provides valuable insight into the intricate connection between economic growth and environmental sustainability. This analysis offers a more comprehensive perspective compared to the EKC, acknowledging the possibility of environmental progress even after reaching a certain level of income. Additional research and thorough data analysis are essential for validating the LCC and effectively informing sustainable development policies. The graphical representation of LCC is shown in Figure 1.

3.3. Econometric Approach

3.3.1. Driscoll Kraay standard error

By incorporating financial inclusion, trade globalization, and energy intensity into the model with GDP, the present analysis made use of a more reliable approach as linear regression with Driscoll–Kraay standard errors (XTSCC) to determine their long-term consequences on load capacity factor (Driscoll and Kraay, 1998). This technique is considered to be optimal whenever the dataset contains heteroscedasticity, serial correlations, and CSD, which is typically in panel data as the reason for its nonparametric nature flexibility. Furthermore, distinct nations' economic development may be interconnected if both the cross-section and the time series dimensions are substantial. Therefore, it's possible to make inaccurate statistical conclusions if we ignore heteroscedasticity, serial correlations, and cross-sectional dependences (Qiu et al., 2019). The standard error estimates are resistant to generic kinds of cross-sectional as well as temporal dependency when using the XTSCC approaches, which help to prevent first-order autocorrelation, heteroscedasticity, and cross-sectional dependence concerns (Hoechle, 2007). In regression, Driscoll–Kraay uses pooled ordinary least squares, weighted least squares, or fixed effects to estimate the coefficients. Heteroscedasticity, autocorrelation up to a certain lag, and

Figure 1: Relationship between per capita income and load capacity factor



potential panel correlation are all assumptions made about the error structure. The mathematical form of the Driscoll–Kraay standard error is shown in equation (5):

$$Y_{it} = \rho_0 + Z_{it}^{*}\tau + \varepsilon_{it} \quad (5)$$

The variables i and t represent countries and times, respectively, in this study, independent variables are represented by Z∗.

3.3.2. Quantile regression

This study employs a panel quantile regression model to examine how the load capacity factor in ASEAN countries is influenced by factors such as GDP per capita, energy intensity in the production process, financial inclusion, and globalization in trade. Koenker and Bassett Jr. (1978) were the first to suggest it, and since then, it has become standard practice for research parameters and model estimates. In place of the more conventional conditional mean regression, this model allows us to look at the environmental degradation drivers at various quantile levels. As suggested by Silva et al. (2016) as well as Salman et al. (2019), the presumptions of the OLS method—zero mean, normal, and identical distribution of random disturbance—are unreliable for social and economic metrics due to the high likelihood of verity in the dataset and its spikes or tails. Because real-world data is seldom regularly distributed and frequently contains outliers, conventional regression methods produce inconsistent and useless findings. Many researchers began employing quantile regression as a means to sidestep these issues. Panel quantile regression is based on the hypothesis that each quantile may be predicted by fitting the dependent variable's conditional distribution to the independent variable's regression (Kapetanios et al., 2011; Lin et al., 2018). Here is a possible theoretical basis for the panel quantile regression model:

$$Y_i = x_i\,\alpha_{\varnothing} + \pi_{\varnothing i} \quad (6)$$

$$Q_{Yi} = (\varnothing / x_i) = xi\alpha_i \quad (7)$$

Here, ∅ signifies the quantile; Y indicates the explained factor while X represents the metrics of explanatory factors and $\alpha_{\varnothing}$ is the vector of parameter to be estimated of ∅th quantile. The following model was used to examine how the investigated explanatory factors affected the factor under investigation:

$$Q_\tau\left(LLCF_{it}\right) = \beta_{0\tau} + \beta_{1\tau}\mathrm{LGDP}_{it} + \beta_{2\tau}\mathrm{LGDP}_{it}^{2} + \beta_{3\tau}\mathrm{LENI}_{it} + \beta_{4\tau}\mathrm{LFNI}_{it} + \beta_{5\tau}\mathrm{LGOB}_{it} + \mu_{it} \quad (8)$$

Where i is the individual country's fixed effect, and t represents the period of the fixed effect refer; Q_τ and $\beta_{o\tau}$ refers to regression parameter the τth quantile of the explained variable; β_1-β_5 are the regressors' specifications for τth quantile's regression moreover, μ_{it} the stochastic error term.

4. FINDINGS

4.1. Overview of Data

Prior to carrying out the main data analysis, we present the summary statistics in Table 2, where each variable (after the logarithm) contains 125 observations from 1990 to 2018. According to Table 2's summary figures, the ASEAN nation's load capacity is roughly −1.07 gha. The mean value of financial inclusion is 3.54. This suggests that in ASEAN countries, there are typically four ATMs for every 10,000 persons. In a similar vein, the data description reveals that, in general, the GDP growth rate of ASEAN states is 9%. In terms of mean, minimum, and maximum values, the data description shows that LLCF is at the bottom and LGDP2 is at the top. The mean statistics for every variable are constant in this case. Based on the standard deviation, it may be concluded that there are no unstable variables.

4.2. Cross-Sectional Dependence Test

Because the shock in one country can affect other nations in the same regional area when using panel estimates, it is important to check for cross-sectional dependence before deciding if the variables are stationary (Shah, 2020). The decision to use first- or second-generation modeling for data processing is made at this crucial point. In this respect, the current investigation makes use of the CSD test proposed by Pesaran (2007). Table 3 shows that

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
id	125	3	1.42	1	5
T	125	2010	7.24	1998	2022
LLCF	125	−1.068	1.026	−3.327	−0.028
LGDP	125	8.798	1.104	7.483	11.118
LGDP2	125	78.606	20.513	55.99	123.606
LENI	125	0.253	0.504	−0.562	1.181
LFNI	124	3.539	0.723	2.147	4.769
LTOB	125	4.253	0.347	3.279	4.599

Table 3: Cross-sectional dependence test

Pesaran (2004) CSD test	
Variable	Test statistics
LLCF	9.12***
LGDP	15.58***
LGDP	15.57***
LENI	4.48***
LFNI	14.09***
LTOB	4.61***

***P<0.01, **P<0.05, *P<0.1

research variables LLCF, LGDP, LGDP2, LENI, LFNI, and LTOB reject the null hypothesis of cross-sectional independence as the countries included in the study have strong political, social, and economic ties to one another.

4.3. Slope Homogeneity Test

Findings from the slope homogeneity test of the Pesaran and Yamagata (2008) technique are shown in Table 4, confirming that this model experiences the heterogeneity issue. This points to the fact that the model's coefficients are diverse as well as that their slope varies among countries. This analysis supports the null hypothesis at the 1% level of significance. Whenever the pertinent factor is made to fit with the uniformity presumption, it might result in erroneous inferences.

4.4. Second Generation Panel Unit Root Test

The next step in the evaluation of board information is to examine the stationarity of the factors. The study conducted second-generation unit root tests using the CIPS methodology. Table 5 displays the outcomes of these unit root tests, indicating that certain variables such as LGDP, LGDP2, and LFNI are stationary at the first difference (I (1)), while the remaining variables are stationary at the level, (I (0)). Based on this, we can deduce that each of the factors that were examined are likely integrated at I(0) or I(1), while none of them are integrated at I(2). After confirming the stationarity of our variables, we can proceed to examine if the variables exhibit cointegration across longer periods.

This study utilized the CADF second-generation unit root test to analyze the data, with the results summarized in Table 6. The findings indicate that LENI and LFNI exhibit significance at this level and are integrated at order zero or I(0). On the other hand, variables such as LCO_2, LGDP, $LGDP^2$, and LTGOB did not demonstrate significance at the level but became significant after undergoing the first differencing. Consequently, all variables examined in this study are either I(0) or I(1), indicating no instances of I(2) variables and no presence of unit root problems.

4.5. Panel Cointegration Test

Table 7 displays the outcomes of three distinct panel cointegration tests conducted by Kao (1999), Pedroni (2001), and Westerlund (2005). Results from the residual cointegration tests conducted by Kao et al. (1999), as well as Pedroni (2004), support the alternative hypothesis of long-term cointegration at 1% and 5% significance levels, respectively, suggesting that LLCF and other explanatory variables have an equilibrium connection over time. Additionally, the long-term relationship is further defined by the Westerlund (2007) test. Results from this test corroborate those from the other two (Table 5). Overall, the results show that the null hypothesis—that there is no integration among the variables under study—was rejected in this work. It would lend credence to the idea that the variables of interest are cointegrated.

4.6. Driscoll Kraay Standard Error

Now, this study attempts to determine the degree to which the study variables were intrinsically cointegrated; this research moved on to the long-run estimate phase after analyzing the pre-estimation results. To remove autocorrelation, heteroscedasticity, and cross-sectional correlation from the panel data, we examine the impact of some explanatory variables on LLCF using a fixed effects model with Driscoll-Kraay standard errors. In light of what Table 8 shows, the coefficient of economy booms by 1%, then the load capacity factor increases by 4.77%, while LGDP2 depicts a negative association with LLCF. That is, economic expansion initially enhances the load capacity of the environment while later it fosters the deterioration by a 0.31% rate, and both are statistically significant. Additionally, the study findings demonstrate that

Table 4: Slope homogeneity test

Slope homogeneity tests	Δ statistic	P-value
Δ test	6.300***	0.000
Δ_{adj} test	7.425***	0.000

***P<0.01, **P<0.05, *P<0.1

Table 5: CIPS unit root test

Variables (in the log)	Level		First difference		Order
	Without trend	With trend	Without trend	With trend	
Cross-Sectionally Augmented IPS (CIPS)					
LLCF	−2.372**	−2.311	−4.543***	−4.512***	I (0)
LGDP	−2.11	−2.217	−4.489***	−4.756***	I (1)
$LGDP^2$	−2.147	−2.254	−4.428***	−4.638***	I (1)
LENI	−2.449**	−2.270	−3.538***	−3.866***	I (0)
LFNI	−1.967	−1.797	−2.882***	−2.915**	I (1)
LTGOB	−2.417**	−2.437	4.987***	−5.354***	I (0)

***P<0.01, **P<0.05, *P<0.1

Table 6: CADF unit root test

	CADF test					
Variable	At Level			1st differences		
	T-bar	Z-t-tilde-bar	P value	T-bar	Z-t-tilde-bar	P value
LLCF	−2.08	−0.737	0.23	−3.567	−4.166	0
LGDP	−1.458	0.697	0.757	−3.377	−3.727	0
$LGDP^2$	−1.48	0.645	0.74	−3.388	−3.753	0
LENI	−2.783	−2.358	0.009	−2.94	−2.721	0.003
LFNI	−2.214	−1.047	0.0147	−2.369	−1.405	0.08
LTGOB	−1.653	0.247	0.598	−3.691	−4.452	0

the recently suggested LCC theory seems invalid for selected ASEAN nations. Erdogan (2024), Shahzad et al. (2023), and Bakirtas et al. (2023) also confirmed the invalidation of LCC for African countries, top tourism-based nations, and Bangladesh and Indonesia sequentially. According to the outcome presented in Table 8, energy intensity exhibits a positive association with the load capacity factor. Every one percent rise in power intensity within the ASEAN countries would foster sustainability by a 0.95% rate at a 1% significance level. This result seems to be in sync with the prior studies of Jin and Huang (2023), where they reveal that the increasing use of energy escalates the LCF in the long and short term due to the higher proportion of renewable energy in total share. However, it is out of line with previous studies of Pata and Lorente (2023) and Shokoohi et al. (2022), who narrated that energy intensity is one of the important sources of environmental degradation. As far as LCF is concerned, financial inclusion has no effect on environmental quality over the long run. The regression coefficient of LFNI on LLCF is 0.0429 but doesn't pass the significance test at any significance level. The insignificant contribution of financial inclusion in ASEAN countries in maintaining environmental sustainability implies that it does not provide environmental benefits. This result is inconsistent with the findings of Yurtkuran and Güneysu (2023) and Shen et al. (2023), who found significant negative and positive impacts of financial inclusion on the environmental sustainability indicator LCF. On the other spectrum, trade globalization reduces the load capacity factor, suggesting that if trade globalization increases by 1%, then LLCF decreases by 0.8821%. This outcome is contradicted by Awosusi et al. (2023), who concluded that trade globalization aggravated environmental sustainability by enriching the load capacity indicator.

Table 7: Panel cointegration test

Kao Cointegration test		Pedroni Cointegration	
Estimator	**Statistics**	**Estimator**	**Statistic**
Modified Dickey-Fuller	−2.2170***	Modified Variance Ratio	2.3401***
Dickey-Fuller	−1.9328**	Philips Perron	1.0257**
ADF	−2.2577**	ADF	−0.2710
	Westerlund Cointegration		
	Estimator	Statistics	
	Variance Ratio	−1.5614**	

***P<0.01, **P<0.05, *P<0.1

Table 8: Driscoll kraay standard error

Driskoll Kraay fixed effect results				
Dependent variable: LLCF				
Independent Variables	**Coefficient**	**Drisc/ Kraay Std. Dev**	**t-Statistics**	**Probability**
LGDP	4.7723	0.4809	9.92	0
$LGDP^2$	−0.312	0.0242	−12.84	0
LENI	0.9562	0.0864	11.06	0
LFNI	0.0429	0.4498	0.96	0.349
LTGOB	−0.8821	0.0987	−8.93	0
$F_{Statistics}$=180.90		Probability=0.0000		
R-squared=0.9436		Root- MSE=0.2487		
Number of Observations=125		Number of Groups=5		

4.7. Quantile Regression Approach

By examining the panel QR findings in Table 9, we can confirm that the model in equation () is robust. It appears that the load capacity factor and independent factors have reestablished their long-term equilibrium relationship, as this outcome is consistent across all quantiles (0.05, 0.25, 0.50, 0.75, and 0.90) in ASEAN countries. The robustness result outcome showed that the logarithmic GDP has a significant positive relation with LLCF. In the lower quantile, which is 8.18; in the middle, 6.136; and in the higher quantile, it stands at 4.36. Such a declining rate indicates that the effects of economic growth on environmental sustainability are getting lower throughout the higher quantile; the LGDP2 coefficients also show a declining trend but with negative values as −0.51, −0.44, −0.38, −0.30, −0.29 across the lower to higher quantile. Hence, the quantile regression also claimed the invalidity of the LCC hypothesis for ASEAN countries, which is robust to the DK findings. Secondly, the Load capacity factor is found to be significantly enhanced as energy consumption GDP per capita rises, as shown in Table 9. But here, the coefficients are 0.92, 0.93, and 0.98 from 0.05 to 0.5^{th} quantile and 1.23 and 1.3 in 0.75^{th} and 0.90^{th} quantile sequentially. Therefore, LENI also has an increasing trend till the lower quantile. These significant positive findings suggest that the conclusions reached by the Driscoll-Krray Standard error test are monotonic. However, financial

Table 9: Quantile regression approach

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
	Q0.05	**Q0.25**	**Q0.50**	**Q0.75**	**Q0.90**
LGDP	8.175***	7.120***	6.136***	4.602***	4.363***
	(0.950)	(0.955)	(0.752)	(1.043)	(1.132)
$LGDP^2$	−0.504***	−0.438***	−0.381***	−0.303***	−0.287***
	(0.0483)	(0.0485)	(0.0382)	(0.0530)	(0.0575)
LENI	0.915***	0.933***	0.983***	1.228***	1.301***
	(0.159)	(0.159)	(0.125)	(0.174)	(0.189)
LFNI	−0.00365	−0.0334	−0.0232	−0.0213	−0.0991
	(0.0838)	(0.0842)	(0.0663)	(0.0920)	(0.0999)
LTOB	−0.980***	−0.938***	−1.008***	−0.996***	−0.937***
	(0.145)	(0.146)	(0.115)	(0.159)	(0.173)
Constant	−29.82***	−25.58***	−21.01***	−13.58***	−12.57**
	(4.363)	(4.383)	(3.452)	(4.789)	(5.198)
Observations	125	125	125	125	125

Standard errors in parentheses

***P<0.01, **P<0.05, *P<0.1

inclusion over time leads to a reduction in load capacity factor by −0.004, −0.03, −0.23, −0.021, and −0.099 rates throughout the lower to higher quantile. Still, all the coefficients over the quantiles are insignificant. Hence, following the DK standard error method robustness test also supports the idea that LFNI has no advantageous impact on the environment. Lastly, the coefficient of LTOB is negative at all the load capacity levels (0.05–0.90), and the effects are significant. So, with the Driscoll-Krray Standard error test, the results panel quantile regression also supports the belief that trade globalization helps to reduce the load capacity factor of selected ASEAN countries.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study explores the intricate interactions between economic growth, energy intensity, financial inclusion, and trade globalization to analyze the load capacity curve (LCC) hypothesis in the ASEAN-5 region. Thorough research was conducted using secondary data collected from reputable sources between 2000 and 2022 to support a detailed analysis. The main goal is to thoroughly examine the LCC hypothesis using a variety of statistical methods. In order to select the right long-term estimation model, the study performed various diagnostic tests. The tests conducted involved assessing cross-sectional dependence, slope homogeneity, unit root, and cointegration. The results showed the existence of cross-sectional dependence, heterogeneity, and unit root problems, leading to the use of the Driscoll-Kraay standard error (DKSE) method. After using the DKSE estimation, it was found that the LCC hypothesis is not applicable to the ASEAN-5 region. The relationship between per capita income and the load capacity factor showed an interesting inverted U-shaped pattern, revealing the intricate economic dynamics in the region. Using the DKSE approach, this study revealed a correlation between energy intensity and the load capacity factor. On the other hand, trade globalization showed a significant adverse correlation. It is interesting to note that financial inclusion did not reveal a strong correlation with the load capacity factor, suggesting a complex relationship between financial accessibility and economic performance. To enhance the strength of the DKSE estimation findings, the study utilized quantile regression analysis. The results of the quantile regression supported the conclusions of the DKSE approach, confirming the rejection of the LCC hypothesis in the ASEAN-5 region. It also confirmed the positive influence of energy intensity and the negative impact of trade globalization on the load capacity factor at various quantiles. Overall, the study offers valuable insights into the complex relationship between economic growth, energy intensity, financial inclusion, trade globalization, and the load capacity factor in the ASEAN-5 region. Using a detailed analytical approach that includes DKSE estimation and quantile regression, this study provides insightful viewpoints that can guide policy decisions and future research in the region's pursuit of sustainable development and economic resilience.

The findings of the research show a U-shaped relationship between GDP growth and the load capacity factor in the ASEAN-5 region, indicating potential environmental degradation and important policy implications. Understanding the negative effects of fast economic growth on environmental sustainability, policymakers are encouraged to implement a comprehensive strategy to harmonies economic progress with environmental conservation. First and foremost, it is important to strengthen environmental regulations and enforcement actions to reduce the negative impacts of GDP growth on the environment. This involves putting in place strict emissions standards, ensuring pollution control measures are followed, and encouraging sustainable resource management practices in various industries. Additionally, it is crucial to prioritize the promotion of sustainable development pathways through fostering green innovation and technology adoption. Supporting renewable energy sources, advocating for energy efficiency initiatives, and encouraging green technologies can contribute to both environmental protection and economic development. Moreover, it is crucial to promote sustainable consumption and production patterns to reduce resource depletion and environmental harm. It includes increasing consumer awareness, advocating for environmentally friendly products, and establishing policies to promote sustainable production practices in businesses. Furthermore, advocating for green finance mechanisms and sustainable investment initiatives can attract funds to environmentally friendly projects and initiatives. We will provide rewards for green investments, create green finance policies, and incorporate environmental factors into financial decision-making.

The research shows a significant positive relationship between energy intensity and the load capacity factor, highlighting an excellent opportunity for policymakers in the ASEAN-5 region to support sustainable development and boost economic growth. In order to effectively utilize this correlation, policymakers should focus on several key policy recommendations. Firstly, substantial investments in energy efficiency measures across various sectors are paramount. By integrating robust energy-saving technologies and enforcing stringent energy efficiency standards, these measures can effectively reduce energy intensity levels without compromising economic productivity. This not only mitigates environmental impacts but also enhances energy security by minimizing waste and optimizing resource utilization.

Moreover, a pivotal aspect of promoting cleaner energy involves a significant increase in investments in renewable energy sources. Championing the utilization of solar, wind, and hydroelectric power not only diversifies the energy mix but also diminishes dependence on fossil fuels. This strategic shift not only contributes to a more sustainable energy landscape but also leads to a substantial reduction in energy intensity levels. By incorporating these cleaner energy sources, we align with global sustainability objectives, fostering innovation and creating employment opportunities within the burgeoning renewable energy industry. Therefore, a comprehensive approach that integrates energy efficiency measures and amplifies investments in renewable sources is essential for achieving a truly sustainable and cleaner energy future. This not only addresses environmental concerns but also propels us towards a more resilient and diversified energy infrastructure, ultimately supporting broader global sustainability goals. Furthermore, it is essential to support capacity-building initiatives and technology transfer programs. By providing businesses and households with the necessary information and tools to embrace energy-efficient practices and clean energy technologies, policymakers can speed up the shift toward a more sustainable energy environment.

Moreover, the study also found a strong positive connection between trade globalization and the load capacity factor. This discovery offers a chance for policymakers in the ASEAN-5 region to leverage international trade advantages and tackle environmental issues. In order to effectively utilize this correlation, policymakers should take into account the following suggestions. First and foremost, policymakers need to focus on sustainable trade practices that boost economic growth and reduce environmental harm. This involves integrating environmental factors into trade agreements, ensuring adherence to international environmental regulations, and supporting green trade projects that focus on sustainable production and transportation practices. Additionally, improving infrastructure and optimizing logistics can boost trade network efficiency and decrease environmental impacts. Enhancing transportation infrastructure, adopting eco-friendly logistics practices, and encouraging various transportation options can reduce emissions from trade activities and improve sustainability. Moreover, promoting innovation and technology transfer in environmentally friendly sectors can boost sustainable trade expansion. Backing research and development projects in renewable energy, clean transportation, and sustainable agriculture can boost competitiveness in global markets and help protect the environment.

The study above is susceptible to potential biases or constraints in data quality and coverage due to its dependence on secondary data sources. Although every attempt was made to procure information from credible sources, discrepancies in reporting standards and variations in data collection methodologies across distinct databases may compromise the precision and dependability of the results. Additionally, causal relationships between variables cannot be established due to the study's exclusive emphasis on correlational analysis. Although statistical methods like quantile regression and DKSE estimation offer insight, they might not comprehensively capture the intricacy of the relationships being examined. Moreover, it is important to note that the scope of the study is limited to the ASEAN-5 region, potentially resulting in an underrepresentation of the dynamic economic and environmental conditions present in all member states. Subsequent investigations may strive to overcome these constraints through the utilization of primary data collection methodologies, the implementation of more rigorous causal inference techniques, and the extension of the analytical geographic scope.

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