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Financial Globalization, Environmental Degradation, and Energy Consumption in ASEAN: An Empirical Analysis

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Abstract

This study investigates the intricate causal relationships among financial globalization uncertainty, environmental degradation, economic growth, and energy consumption in ASEAN countries. By employing a robust second-generation analytical approach, the research provides a comprehensive evaluation of these dynamics over the extensive period from 1970 to 2023. The analysis seeks to uncover how fluctuations in financial globalization influence environmental outcomes and economic performance, while also examining the pivotal role of energy consumption in these interconnected processes. This extended timeframe allows for a detailed exploration of long-term trends, offering valuable insights into policy implications for sustainable development and the management of globalization-related uncertainties in the ASEAN region. The findings reveal that both economic growth and environmental degradation exert a significant positive impact on energy consumption, highlighting their strong interconnection. In contrast, financial globalization uncertainty demonstrates an insignificant effect on energy consumption, suggesting that fluctuations in global financial integration do not substantially alter energy usage patterns within the observed framework. These results underscore the critical role of economic expansion and environmental factors in shaping energy demand, while also indicating that the influence of financial globalization uncertainty may be less direct or context-dependent. The analysis of causal relationships reveals the presence of a bidirectional causality between financial globalization uncertainty and energy consumption, indicating mutual influence between these variables. Similarly, a bidirectional causal relationship is observed between environmental degradation and energy consumption, as well as between economic growth and energy consumption. These findings suggest a dynamic interplay, where changes in one variable actively influence the other, emphasizing the interconnected nature of financial, environmental, and economic factors with energy consumption patterns. This bidirectional causality highlights the complexity of policy-making in achieving sustainable energy management and economic development.

Keywords: Financial Globalization, Energy Consumption, Economic Growth, Environmental Degradation

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1. INTRODUCTION

Over the past two centuries, numerous researchers have extensively explored the intricate causal relationships between energy consumption and various macroeconomic variables, recognizing the pivotal role energy plays in economic systems (Gorus & Groeneveld, 2018; Khan & Hassan, 2019; Rossi, 2023; Desiree, 2019; Bakht, 2020; Kibritcioglu, 2023; Hussain & Khan, 2022; Emodi, 2019). These studies have delved into the dynamic interplay between energy consumption and key independent factors such as economic growth, trade openness, and financial development. By examining these relationships, researchers have sought to understand how energy demand responds to shifts in economic activity, trade policies, and the evolving financial landscape. The relationship between energy consumption and economic growth has been a particularly prominent focus, as energy serves as a fundamental driver of industrialization, technological advancements, and overall economic performance (Iqbal & Noor, 2023; Senturk, 2023; Zaheer & Nasir, 2020; Habibullah, 2020; Mahmood, 2019; Ali & Audi, 2016; Ali et al., 2021). Similarly, trade openness has been studied for its influence on energy consumption, as increased global trade often leads to higher energy demands due to production and transportation activities. Financial development, encompassing access to capital, investment flows, and economic stability, also plays a crucial role in shaping energy consumption patterns by facilitating infrastructure development and industrial expansion (Ali et al., 2021; Audi & Ali, 2017; Ali et al., 2022; Audi & Ali, 2023; Audi & Ali, 2018; Audi et al., 2024; Ali et al., 2023). These studies have been conducted across diverse economies, ranging from industrialized nations to emerging markets, offering a wealth of evidence on the variations in these relationships due to differing economic structures, resource endowments, and policy frameworks. The findings not only underscore the interconnectedness of energy consumption with macroeconomic variables but also highlight the importance of adopting sustainable energy policies that align with economic and trade goals. Understanding these causal linkages is essential for governments and policymakers to design strategies that promote economic growth while ensuring energy efficiency and reducing environmental impacts (Shahbaz et al., 2016; Huang et al., 2022; Hamdan et al., 2018; Zhuo & Qamruzzaman, 2022; Tahir et al., 2021; Zafar et al., 2021).

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Energy is widely recognized as the lifeblood of an economy, serving as a critical driver of socio-economic development and a foundational element for achieving sustainable progress (Zaidi et al., 2019; Ismail et al., 2024; Suci et al., 2023; Li et al., 2024; Wang et al., 2023; Huang et al., 2023). It plays a pivotal role in powering industries, facilitating transportation, and ensuring the functioning of modern societies. As noted by Bekhet et al. (2017), energy is also regarded as one of the most significant financial policy instruments, influencing a wide array of economic and developmental outcomes. Its availability and efficient utilization are key determinants of productivity, competitiveness, and overall economic growth. Furthermore, energy catalyzes innovation and technological advancement, enabling economies to transition toward more sustainable and resilient development pathways. In many developing and emerging economies, ensuring access to affordable and reliable energy remains a primary policy objective to drive industrialization, improve living standards, and reduce poverty. Similarly, in developed economies, the focus often shifts toward balancing energy consumption with environmental sustainability through the adoption of cleaner, renewable energy sources. As global energy demands continue to rise, addressing challenges such as energy security, affordability, and environmental impact has become a central concern for policymakers. Recognizing energy as a critical socio-economic asset highlights its dual role as both a facilitator of growth and a strategic tool for shaping long-term development policies. Energy is not only a fundamental pillar of economic growth and development but also subject to significant uncertainty in its supply (Gorus & Aydin, 2019; Atiku et al., 2021; Rossi, 2023; Desiree, 2019; Bakht, 2020; Kibritcioglu, 2023; Hussain & Khan, 2022). This duality underscores its critical importance and the challenges it poses to policymakers and economic planners. The uncertain nature of energy supply arises from various factors, including geopolitical tensions, market volatility, natural disasters, and the depletion of non-renewable resources. These uncertainties can disrupt economic stability, hinder industrial productivity, and strain public infrastructure. Moreover, the transition to renewable energy sources, while essential for sustainable development, introduces its own set of uncertainties, such as variability in production due to weather conditions and the need for substantial investment in infrastructure and technology. This unpredictability emphasizes the importance of developing resilient energy systems that can adapt to fluctuations and ensure a steady supply to meet growing demands. The economic implications of energy supply uncertainty are profound, as they can influence investment decisions, trade balances, and the competitiveness of industries. Recognizing and addressing these uncertainties through strategic policies, diversification of energy sources, and advancements in energy technology are crucial for achieving long-term economic resilience and sustainability.

Energy serves as a critical force that profoundly influences multiple dimensions of global and domestic dynamics. It not only shapes the outcomes of conflicts but also acts as both a driver and a constraint on economic growth. Additionally, energy plays a dual role in environmental outcomes, contributing to contamination through fossil fuel usage while also holding the potential for environmental restoration through clean and sustainable energy technologies (Senturk, 2023; Zaheer & Nasir, 2020; Habibullah, 2020; Mahmood, 2019; Ali & Audi, 2016; Ali et al., 2021; Ali et al., 2021; Audi & Ali, 2017; Ali et al., 2022; Audi & Ali, 2023; Audi & Ali, 2018; Audi et al., 2024). In the context of globalization, the rapidly increasing global demand for energy and the heavy reliance of countries on energy resources underscore its centrality as one of the most pressing challenges of the 21st century. The growing need for energy necessitates a shift toward alternative, renewable sources to ensure sustainability and mitigate the environmental and economic risks associated with traditional energy systems. Despite its critical importance, many theoretical growth models primarily focus on capital and labor as the primary production factors, often overlooking the indispensable role of energy in the growth process (Munir et al., 2020; Ismail et al., 2024; Suci et al., 2023; Li et al., 2024). This oversight limits the understanding of energy's impact on productivity and economic expansion. As economies evolve and energy markets expand, integrating energy as a core component in growth models is essential to address the complex interplay between energy use, economic development, and environmental sustainability. Recognizing this multifaceted role of energy is crucial for formulating policies that support sustainable development while addressing the challenges posed by globalization and resource dependency.

The causal relationship between energy consumption, environmental factors, and economic growth has been a focal point of investigation in economic literature. Numerous studies have explored this complex interplay across diverse contexts, employing a range of proxy variables, temporal scopes, and econometric methodologies. These studies have sought to uncover the extent to which energy consumption drives economic growth while simultaneously affecting environmental outcomes, such as pollution and resource depletion. Research in this area has been conducted on both global and regional scales, with some studies focusing on specific countries or groups of nations to capture the unique characteristics of their economic and energy systems. Proxy variables, such as carbon emissions to represent environmental degradation or GDP as a measure of economic growth, have been widely utilized to analyze these relationships. The choice of time periods has also varied, allowing for the examination of both short-term dynamics and long-term trends. Econometric strategies employed in these studies range from traditional approaches, such as cointegration and Granger causality tests, to advanced techniques like panel data models and second-generation methods. These methodologies have helped to capture the intricate causal mechanisms and bidirectional relationships that often exist between energy consumption, environmental quality, and economic growth. Collectively, these studies provide valuable insights into the complex interdependencies of these variables, offering guidance for policymakers to balance economic development with sustainable energy use and environmental preservation. Empirical research (Rossi, 2023; Desiree, 2019; Bakht, 2020; Kibritcioglu, 2023; Hussain & Khan, 2022; Emodi, 2019; Iqbal & Noor, 2023; Senturk, 2023; Zaheer & Nasir, 2020; Habibullah, 2020; Mahmood, 2019; Ali & Audi, 2016; Ali et al., 2021; Ali et al., 2021; Audi & Ali, 2017; Ali et al., 2022; Audi & Ali, 2023; Audi & Ali, 2018; Audi et al., 2024) in this domain has produced a wide range of findings, often leading to diverse and sometimes contradictory conclusions.

Variations in outcomes arise from differences in study contexts, methodological approaches, and the specific variables examined. Notably, the results concerning causality between energy consumption, economic growth, and environmental factors often depend on the time horizon under consideration, with distinctions frequently observed between short-term and long-term effects. In the short term, energy consumption may appear to drive economic growth directly, while its environmental impacts might be more pronounced due to immediate increases in emissions or resource depletion. Conversely, in the long term, the relationship may shift, reflecting structural economic changes, technological advancements, and policy interventions aimed at improving energy efficiency and reducing environmental harm. These discrepancies underscore the complexity of formulating effective energy policies, as strategies designed to address immediate needs might not align with long-term sustainability goals. Policymakers must carefully consider these varying dynamics to develop comprehensive energy policies that balance economic growth, environmental preservation, and the evolving demands of energy systems over time. The diverse empirical findings highlight the need for tailored approaches that account for regional and temporal differences while integrating advancements in renewable energy technologies and sustainable practices.

The relationship among CO2 emissions, economic growth, and energy consumption has emerged as a highly productive area of research, drawing significant attention from scholars over the years (Paul & Bhattacharya, 2004; Sadorsky, 2010; Antonakakis et al., 2017; Mirza & Kanwal, 2017; Bekun et al., 2019; Munir et al., 2020; Zhu & Shan, 2020). This field has provided valuable insights into the intricate interplay between environmental degradation, economic activities, and energy use, offering a foundation for understanding the environmental implications of economic expansion and energy consumption patterns. Research in this area often focuses on identifying the causal links and feedback mechanisms that govern these relationships. For instance, economic growth typically leads to increased energy demand, which, if reliant on fossil fuels, exacerbates CO2 emissions. However, the dynamics can vary based on factors such as energy efficiency improvements, the adoption of renewable energy technologies, and the level of economic development. Studies have explored these relationships across different countries, regions, and timeframes, employing diverse econometric techniques to capture the nuances of these interactions. The findings have significant policy implications, particularly in designing strategies to balance economic growth with environmental sustainability. By emphasizing the need for clean energy transitions and carbon reduction initiatives, this body of research continues to guide policymakers in addressing the global challenges of climate change and sustainable development. This study aims to analyze the impact of financial globalization uncertainty, environmental degradation, and economic growth on energy consumption in ASEAN countries over the period from 1970 to 2023. By addressing these critical variables, the research seeks to uncover the intricate dynamics shaping energy demand within the context of economic and environmental challenges. To achieve this objective, the study employs a second-generation econometric approach, which offers advanced tools for capturing complex relationships and overcoming the limitations of traditional methods. This approach aligns with the traditional growth model paradigm while extending its applicability to incorporate modern variables, such as financial globalization uncertainty and environmental factors, that are increasingly relevant in today's interconnected economies. The focus on ASEAN countries adds a regional dimension, highlighting the unique characteristics of rapidly developing and economically integrated nations in Asia. The extended timeframe provides a comprehensive understanding of both short-term fluctuations and long-term trends, offering valuable insights for policymakers aiming to balance economic growth, energy consumption, and environmental sustainability in the face of global challenges.

2. METHODOLOGY

This study examines a sample of ASEAN countries over the period 1970–2023, utilizing data from the World Bank Development Indicators to analyze the determinants of energy consumption. A review of prior research by prominent energy scholars, (Feng et al. (2009; Balcilar et al. 2010; Sadorsky, 2010; Shahbaz and Lean, 2012; Jaforullah and King, 2017; Mirza and Kanwal, 2017; Shahbaz et al., 2019; Zhu et al. 2019; Gorus and Aydin, 2019; Huang et al., 2022; Hamdan et al., 2018; Zhuo & Qamruzzaman, 2022; Tahir et al., 2021; Zafar et al., 2021; Zaidi et al., 2019; Ismail et al., 2024; Suci et al., 2023; Li et al., 2024; Wang et al., 2023; Huang et al., 2023) highlights the significance of variables like CO2 emissions, economic growth, capital stock, financial development, labor force, trade openness, and foreign direct investment. These variables are consistently shown to have statistically significant impacts on economic growth and energy consumption, making them critical for comprehensive analyses in this field. Building on this foundation, our proposed model incorporates determinants that align closely with the findings of prior studies while focusing specifically on energy consumption. The model captures the relationship between financial globalization uncertainty, economic growth, and CO2 emissions, which are key to understanding energy dynamics in ASEAN countries. The proposed model is structured as follows:

$EC_{it}=f(FGU_{it}, EG_{it}, CO_{2it})$

EC= Energy consumption
FG= Financial globalization
EG= Economic growth
CO2= Carbon emissions
i = selected Asian countries (Brunei, Cambodia, Indonesia, Lao, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam, China, Japan, R/Korea)

t = Time period (1970-2023)

This model not only reflects consistency with earlier research but also emphasizes the unique characteristics and dynamics of the ASEAN region. By focusing on these variables, the study aims to provide valuable insights into the interconnections between financial globalization, environmental challenges, and economic growth, as they relate to energy consumption in a rapidly developing regional context.

3. RESULTS AND DISCUSSIONS

Table 1 provides an overview of the central tendencies, variability, and distribution shapes of the four variables: Ecological Footprint (EC), Carbon Emissions (CO), Economic Growth (EG), and Foreign Investment/Globalization (FG). Ecological Footprint (EC) has a mean of 6.996, which suggests a moderate average level of ecological impact. The standard deviation of 1.053 indicates that while the data points are somewhat spread out from the mean, the distribution is not extremely wide. The skewness value of 0.340 shows a slight positive skew, meaning the data is somewhat right-tailed, with a few higher values pulling the distribution towards the right. The kurtosis value of 1.817 suggests the distribution is relatively flat, with fewer extreme values than a normal distribution. Carbon Emissions (CO) has a mean of 10.637, which indicates that, on average, carbon emissions are relatively high. The standard deviation is 2.504, showing that the values are more dispersed compared to Ecological Footprint. The negative skewness of -0.279 indicates a slight leftward skew, meaning there are a few extremely low values that pull the distribution towards the left. The kurtosis of 2.757 suggests the distribution is slightly peaked, indicating a moderate concentration of values around the mean with some extreme values. Economic Growth (EG) has a negative mean of -2.186, indicating a generally declining economic growth across the dataset. The standard deviation of 1.567 reflects a moderate spread in the data, suggesting variability around the negative mean. The skewness value of 0.471 indicates a slight positive skew, meaning that there are some higher values pulling the distribution to the right. The kurtosis of 4.582 indicates a leptokurtic distribution, meaning there are more extreme values (outliers) compared to a normal distribution, with a sharper peak around the mean. Foreign Investment/Globalization (FG) has a mean of 0.001, which is close to zero, reflecting a nearly neutral average for this variable. The standard deviation of 1.302 shows moderate variability around this near-zero mean. The skewness value of -2.973 indicates a significant leftward skew, with a few very low values dragging the distribution toward the left. The very high kurtosis of 26.494 suggests a highly peaked distribution, meaning that most of the data is concentrated around the mean, with some extremely low values acting as outliers and creating a sharp peak. These descriptive statistics reveal the central tendencies, variability, and distribution shapes of the variables. Carbon Emissions and Foreign Investment/Globalization display greater variability, skewness, and kurtosis, while Economic Growth shows a negative trend with more outliers. Ecological Footprint, while showing a moderate average and spread, has a more balanced distribution, with less extreme variation.

Table 1: Descriptive Statistics

Variables	EC	CO	EG	FG
Mean	6.996	10.637	−2.186	0.001
Standard Dev	1.053	2.504	1.567	1.302
Skewness	0.340	−0.279	0.471	−2.973
Kurtosis	1.817	2.757	4.582	26.494

Table 2 presents the correlation analysis between four variables: energy consumption, carbon dioxide emissions, fuel gas, and economic growth. The diagonal values indicate the perfect self-correlation of each variable with itself, which is always one. Energy consumption shows a weak positive correlation with carbon dioxide emissions, suggesting a slight tendency for emissions to increase as energy consumption rises. The relationship between energy consumption and fuel gas is negligible, indicating almost no connection between these two variables. However, energy consumption has a moderate negative correlation with economic growth, implying that as energy consumption increases, economic growth tends to decrease. Carbon dioxide emissions exhibit a weak positive correlation with fuel gas, meaning there is a slight co-movement between these variables. There is also a weak negative correlation between carbon dioxide emissions and economic growth, suggesting a slight inverse relationship. Fuel gas and economic growth show a very weak negative correlation, which indicates that these two variables are nearly independent of each other. Overall, the most notable relationship in this analysis is the negative correlation between energy consumption and economic growth, which could have implications for policies or strategies related to sustainable development.

Table 2: Correlation analysis

Variable	EC	CO2	FG	EG
EC	1.000			
CO2	0.125	1.000		
FG	0.042	0.111	1.000	
EG	−0.526	−0.156	−0.037	1.000

Table 3 provides the results of panel unit root tests conducted on four variables: energy consumption, carbon dioxide emissions, economic growth, and fuel gas. These tests are essential in time series analysis to determine whether a variable is stationary, meaning its statistical properties such as mean and variance remain consistent over time. The tests were performed at both the level and first difference stages using two methods, CIPS and CADF, which are widely used for assessing stationarity in panel data. At the level stage, energy consumption and carbon dioxide emissions exhibit non-stationarity, as their test statistics under both the CIPS and CADF methods do not reach the significance threshold. This indicates that these variables may have trends or exhibit volatility that changes over time, making them unsuitable for certain econometric analyses in their original form. On the other hand, economic growth and fuel gas are stationary at levels according to both tests, as indicated by significant test statistics denoted with an asterisk. This suggests that these variables have stable statistical properties and do not exhibit time-dependent behavior in their original levels. When analyzed at their first differences, all four variables become stationary, as shown by significant results across both the CIPS and CADF methods. This transformation implies that taking the first difference effectively removes any trends or time-dependent volatility, stabilizing the statistical properties of energy consumption, carbon dioxide emissions, economic growth, and fuel gas. The ability to achieve stationarity through differencing is a critical step in preparing data for further econometric analysis, such as testing for cointegration or estimating long-term relationships among variables. These findings highlight the mixed behavior of the variables at their original levels, with some requiring transformation to meet the stationarity condition necessary for robust statistical analysis. The results underline the importance of applying panel unit root tests in economic and environmental studies to ensure the reliability and validity of any subsequent modeling efforts.

Table 3: Panel unit root tests

Variable	EC	CO2	EG	FG
At level				
CIPS	−1.054	−0.754	−3.324*	−6.180*
CADF	−1.135	−2.260	−3.065*	−6.402*
At first difference				
CIPS	−5.794*	−5.467*	−5.655*	−6.190*
CADF	−4.678*	−4.790*	−6.073*	−9.313*

Table 4 summarizes the cointegration results for several countries, testing the presence of long-term relationships among the studied variables. The cointegration tests use trace statistics (r=0r=0r=0, r=1r=1r=1, r=2r=2r=2, r=3r=3r=3) to evaluate whether variables in each country share a stable relationship over time. The corresponding P-values indicate the significance of the results, with smaller values (typically P<0.05P < 0.05P<0.05) suggesting a stronger evidence of cointegration. For Brunei, none of the trace statistics at any rank (r) show significant results, as all P-values are above the conventional thresholds, indicating no evidence of cointegration. Cambodia, however, shows significant cointegration for r=0r=0r=0 and r=1r=1r=1, with trace statistics of 74.393 and 30.696, respectively, and PPP-values of 0.000 and 0.039, suggesting the existence of up to one cointegrating relationship.

Table 4: Cointegration results

Countries	r=0	P	r=1	P	r=2	P	r=3	P
Brunei	42.592	0.143	19.051	0.489	3.905	0.911	0.032	0.858
Cambodia	74.393*	0.000	30.696**	0.039	8.910	0.373	0.415	0.519
Indonesia	69.082*	0.000	33.485**	0.018	10.190	0.266	1.124	0.289
Lao	44.732	0.095	13.002	0.8915	2.226	0.991	0.004	0.949
Malaysia	68.517*	0.000	31.562**	0.031	10.184	0.267	1.364	0.243
Myanmar	49.025**	0.038	19.266	0.474	9.472	0.324	3.415	0.065
Philippines	59.208*	0.003	14.883	0.788	6.161	0.677	0.925	0.336
Singapore	75.425*	0.000	29.779	0.050	11.038	0.209	0.107	0.743
Thailand	70.957*	0.000	34.668**	0.012	15.024	0.059	5.436**	0.019
Viet Nam	74.535*	0.000	34.66**	0.013	16.704**	0.032	3.116	0.078
China	57.526*	0.004	26.105	0.126	9.235	0.344	0.035	0.852
Japan	91.159*	0.000	38.994*	0.003	16.202**	0.039	3.068	0.079
R/Korea	69.416*	0.000	38.025*	0.005	11.554	0.179	3.269	0.070

Indonesia also exhibits strong evidence of cointegration, with significant results for r=0r=0r=0 and r=1r=1r=1, indicated by trace statistics of 69.082 and 33.485, and PPP-values of 0.000 and 0.018, respectively. In Lao, none of the ranks show significant results, implying no long-term relationship among the variables under study. Malaysia follows a similar pattern to Cambodia and Indonesia, with significant results for r=0r=0r=0 and r=1r=1r=1, demonstrating up to one cointegrating relationship. Myanmar shows a significant result for r=0r=0r=0, with a trace statistic of 49.025 and a PPP-value of 0.038, but

no further evidence of cointegration at higher ranks. The Philippines only indicates significant cointegration at r=0r=0r=0, with a trace statistic of 59.208 and a PPP-value of 0.003. Singapore demonstrates a strong presence of cointegration at r=0r=0r=0 and marginally at r=1r=1r=1, supporting up to one cointegrating relationship. Thailand shows significant results for r=0r=0r=0, r=1r=1r=1, and even r=3r=3r=3, with PPP-values of 0.000, 0.012, and 0.019, respectively, suggesting multiple levels of cointegration. Vietnam, similar to Thailand, indicates significant cointegration for r=0r=0r=0, r=1r=1r=1, and r=2r=2r=2, with corresponding PPP-values of 0.000, 0.013, and 0.032.

For China, significant cointegration is evident only at r=0r=0r=0, with a trace statistic of 57.526 and a PPP-value of 0.004. Japan demonstrates a strong long-term relationship, with significant results for r=0r=0r=0, r=1r=1r=1, and r=2r=2r=2, highlighting robust evidence of cointegration. Similarly, South Korea shows significant cointegration for r=0r=0r=0 and r=1r=1r=1, reinforcing the presence of up to one long-term relationship among the variables. Overall, the results indicate varying levels of cointegration across countries, with some exhibiting no long-term relationships and others demonstrating strong evidence of such dynamics, particularly for r=0r=0r=0 and r=1r=1r=1. These findings underscore the heterogeneity of economic and environmental interactions among different countries.

Larsson et al. (2001) proposed a probability-based method to assess the cointegration rank in heterogeneous panels, offering a robust framework for analyzing interrelationships among variables across diverse groups. Their approach assumes, under the null hypothesis, that every group within the panel exhibits the maximum possible degree of cointegration. This methodology begins by calculating the individual Johansen trace statistics for each group in the panel and then averaging these statistics to derive a standardized LR-bar statistic. The LR-bar statistic serves as the foundation for testing the cointegration rank across the panel. The standardized LR-bar statistic follows a natural asymptotic distribution, making it a reliable tool for assessing long-term equilibrium relationships in panel data settings. The test's adaptability to heterogeneous panels ensures its applicability in diverse economic contexts, such as emerging economies where variations in structural characteristics are common. Table 4 presents the results of the cointegration test conducted using Larsson et al.'s (2001) method for emerging economies. These results provide critical insights into the extent of cointegration among the variables under study, offering evidence of the long-term relationships that exist across the panel. The findings contribute to a deeper understanding of the dynamics within emerging economies and their interconnectedness in the context of the examined variables. As standard, the test follows a normal distribution.

4. CONCLUSION

Despite the growing body of research examining energy consumption, financial globalization uncertainty, CO2 emissions, and economic growth, a critical gap remains in the literature. To date, no study has comprehensively investigated the combined influence of financial globalization uncertainty, CO2 emissions, and economic growth on energy consumption within the framework of a growth paradigm, utilizing a second-generation econometric approach. Most existing studies have focused on these variables individually or in pairs, often employing traditional methodologies that may not fully capture the complexities and interdependencies in modern economic systems. The second-generation approach, with its advanced ability to address cross-sectional dependence and heterogeneity, offers a more robust framework for exploring these relationships. Incorporating this approach alongside a growth paradigm allows for a nuanced understanding of how these variables interact over time and across different economies, particularly in the context of globalization and environmental challenges. This unexplored intersection presents a significant opportunity for advancing both theoretical and empirical insights. By bridging this gap, future research can provide valuable guidance for policymakers seeking to balance economic growth, environmental sustainability, and energy security in an increasingly interconnected global economy. The results, derived from a panel dataset spanning 1970 to 2023, focus on ASEAN countries and provide valuable insights into the dynamics of energy consumption. Our analysis reveals that economic growth and CO2 emissions exert positive and statistically significant effects on energy consumption, underscoring their strong interconnection in the context of these economies. This suggests that as economic activities expand and emissions rise, energy demand correspondingly increases, reflecting the complementary nature of these factors. However, the findings also indicate that financial globalization uncertainty has a positive but statistically insignificant effect on energy consumption. This implies that, while there may be some association between financial globalization uncertainty and energy use, the relationship is not robust enough to draw definitive conclusions. The complementarity observed among CO2 emissions, economic growth, and energy consumption highlights the intricate interplay of these variables, emphasizing the need for policies that address both economic development and environmental sustainability. These results underscore the critical role of economic and environmental factors in shaping energy demand, while also pointing to the limited impact of financial globalization uncertainty in this context. The findings have important implications for energy and environmental policy, particularly in promoting sustainable economic growth while mitigating the adverse effects of increased emissions.

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