Optimum: Jurnal Ekonomi dan Pembangunan
Vol. 16, No. 1, March 2026, pp. 170-179
DOI:10.12928/optimum.v16i1.15867
ISSN 2613-9464

Macroeconomic determinants on fossil fuel energy consumption in six ASEAN countries

Dwi Silfani [a,1,*], Noni Rozaini [a,2]

[a] Department of Economics, Faculty of Economy, Universitas Negeri Medan, Indonesia
[1]dwisilfani3@gmail.com; [2]nonirozaini@gmail.com;

* corresponding author

ARTICLE INFO

Received : 19-02-2026
Revised : 14-03-2026
Accepted : 20-03-2026
Published : 27-03-2026

Keywords:
Economic Growth
Trade Openness
Government Expenditure
Fossil Fuel Energy Consumption

JEL Classification:
Q33, Q50, Q54

ABSTRACT

ASEAN countries continue to face challenges in reducing their dependence on fossil fuels despite rapid economic growth and the ongoing global energy transition. This study examines how government expenditure, trade openness, and economic growth influence fossil fuel energy consumption in six ASEAN countries. Understanding the macroeconomic dynamics that drive fossil fuel use is critical for achieving international climate targets under the Paris Agreement, particularly as the region is among the fastest-growing in terms of energy demand and serves as a major global industrial base. Using panel data for the period 2001–2024 and a fixed effects model (FEM), the results show that economic growth has a positive but statistically insignificant effect on fossil fuel consumption, while trade openness and government expenditure have positive and statistically significant effects. These variables jointly explain approximately 98.28% of the variation, indicating that trade integration and fiscal expansion play a more dominant role than economic growth alone. These findings suggest that ASEAN's reliance on fossil fuels is closely linked to trade dynamics and fiscal policy. Therefore, for regional economic integration to support the transition toward a sustainable energy system, trade and government spending policies must be aligned with energy efficiency and sustainability objectives.

1. Introduction

Rapid global economic growth accompanied by technological advances has created significant challenges for many countries in maintaining sustainable economic development while improving social welfare. According to Bhattacharyya (2011) emphasize energy plays a fundamental role and is a basic necessity in driving economic activities and development processes, but most countries are still heavily dependent on fossil-based energy sources such as oil, coal, and natural gas. This dependence raises serious concerns because these resources are limited and contribute significantly to environmental degradation and climate change. Within the framework of economic growth theory, the expansion of economic output is usually accompanied by an increase in demand for factors of production, including energy. Therefore, economic expansion tends to increase energy demand, especially in the industrial, manufacturing, and transportation sectors. As a result, high economic growth is often attributed to structural increases in fossil-based energy consumption (Todaro & Smith, 2020). In the context of global efforts to reduce greenhouse gas emissions and accelerate the transition to sustainable energy systems, it is necessary to first understand the significant determinants of fossil fuel consumption, so it is important for policymakers to actively reduce dependency factors.

The ASEAN region shows relatively strong economic growth amid global uncertainty. According to ESC For Asia and the Pacific that the region is likely to achieve a higher trade growth rate than the global average in 2024. The ASEAN economy will grow 4.1% in 2023 and is projected to reach 4.7% in 2025. In line with the report from ASEAN Centre for Enegy (2024) projects that ASEAN's total final energy demand (TFEC) will increase to 746.2 Mtoe and primary energy supply (TPES) will reach 1,219 Mtoe by 2050, with the predominance of fossil energy still significant (Setyono & Kiono, 2021).This trend suggests that ASEAN countries face the potential risk of continued dependence on fossil-based energy, which could hinder the transition to a more sustainable energy system. If this dependence on fossil fuels is not addressed promptly, ASEAN risks not only failing to meet its climate commitments under the Nationally Determined Contributions (NDCs) of the Paris Agreement, but also becoming locked into a long-term carbon-intensive development path. Current large-scale investments in fossil fuel infrastructure may lead to stranded assets in the future as global environmental regulations become increasingly stringent. As a result, countries in the region may lose economic competitiveness in global markets that increasingly prioritize green and sustainable products. This is particularly critical given that ASEAN is one of the fastest-growing regions in terms of energy demand and serves as a key hub in the global manufacturing network.

From a theoretical perspective, economic development, trade openness, and government expenditure are closely related to changing demand for natural resources, including fossil energy (Lunku, 2025). According to Kuznets (1955) on the Environmental Kuznets Curve (EKC) hypothesis suggests that economic expansion in the early stages of development tends to increase environmental pressures, including fossil fuel consumption. Increased production and economic activity require greater energy inputs (Mankiw, 2018). As stated by Krugman et al (2012) and Balassa (1985) that trade openness also encourages industrial growth and export-import activities, which increases energy consumption. Suripto et al (2025) noted that government expenditure has an impact on total energy consumption through public services, infrastructure development, and energy subsidies. However, technological advancements, improved energy efficiency, and structural economic transformation towards less energy-intensive sectors can weaken the direct relationship between economic growth and fossil fuel consumption across countries and time periods. These dynamics highlight the complex interplay between economic activity and fossil energy use, especially the comparison between developed and developing regions such as ASEAN.

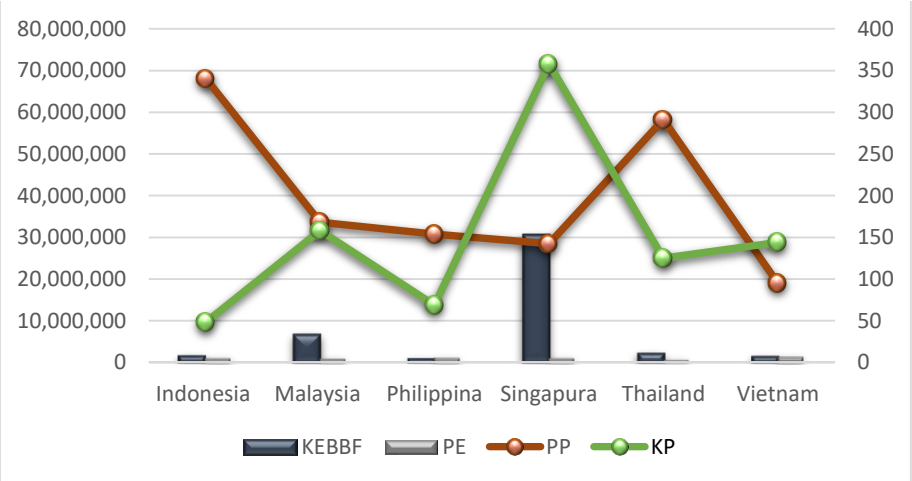

Figure 1. The Pattern of Economic Growth, Trade Openness and Government Expenditure in 6 ASEAN Countries.

Figure 1 shows the overall upward trend, but with a pattern that varies across countries and periods. Singapore records the highest level of fossil energy consumption in the region, reflecting its thriving economic structure characterized by energy-intensive industries and advanced service sectors. Regardless of the impact of the global financial crisis in 2008 and the economic slowdown in 2013, fossil energy consumption in Singapore remains relatively stable and is increasing again, reaching around 179,675 kWh per capita by 2024. In contrast, Vietnam showed the fastest increase among ASEAN developing countries, increasing from 3,665 kWh to 11,322 kWh per capita by 2024, reflecting rapid industrialization and the expansion of its export-oriented manufacturing sector. In the post-pandemic period of 2023–2024, most countries in ASEAN are experiencing a surge in fossil

energy consumption in line with the recovery of economic activities such as production, transportation, and electricity demand, indicating a post-pandemic carbon rebound and continued dependence on fossil-based energy in the region.

Bintariningtyas et al (2024) stated that independent variables move in motion showing dynamics that are in line with changes in energy use. The 2008 crisis led to a slowdown in economic expansion in six ASEAN countries and contracted in the 2020 pandemic, before recovering in the 2023–2024 period, confirming the close link between output expansion and increased energy demand. Consistent with previous research by Setiawan et al (2019), Septyani & Hartati (2024) and Nguyen et al (2023) stated that economic improvement is followed by an increase in the amount of energy used in each country. Meanwhile, in the study Han et al (2022) found complex relationships in developed countries through energy efficiency that allows for increased economic growth without a disproportionate spike in fossil fuel energy consumption. Trade shows very high levels in countries with open economies such as Singapore, but declines during global trade disruptions, while countries with large domestic market bases such as Indonesia show more moderate fluctuations. Some studies have shown conflicting results from Pham & Nguyen (2024) and Koengkan et al (2020) found that trade openness increases fossil fuel consumption, while Siregar & Hasbi (2023), Wang et al (2019) and Mahmood et al (2019) found insignificant or negative effects. These differences underscore the need for further research, especially in ASEAN countries with diverse and interesting economic structures if studied more focused and in-depth.

From the fiscal side, government expenditure has increased significantly, especially during the crisis and post-pandemic as an instrument of economic stabilization, which indirectly encourages production activities and energy needs. Research looking at the relationship between government expenditure and fossil fuel energy consumption report findings as diverse as in the study Khan et al (2024) identified positive and significant things, especially in developing countries that still rely on fossil fuels to support economic development. Furthermore Nazlioglu et al (2022) found a negative and significant relationships. Empirical evidence on the effects of economic growth, trade openness, and government expenditure on fossil fuel consumption remains inconsistent.

The study offers three main novelties. First, it specifically focuses on fossil fuel energy consumption in six ASEAN countries, going beyond the aggregate energy analysis commonly examined in previous studies. Second, it integrates economic growth, trade openness, and government expenditure in a single analytical framework, whereas previous research has often investigated these variables separately. Third, this study emphasizes government expenditure as a policy-related variable that is rarely directly related to fossil fuel consumption in the context of ASEAN. More importantly, simultaneous examination of these three variables in the context of ASEAN is rare, even though the region is the global epicenter of rising energy demand. This study contributes to the energy economics literature by providing up-to-date empirical evidence from a diverse and rapidly growing region. In practical terms, these findings offer policy insights for ASEAN governments to better align fiscal and trade policies with the goal of a sustainable energy transition. Therefore, this study aims to examine the impact of economic growth, trade openness, and government expenditure on fossil fuel energy consumption in six ASEAN countries using panel data for the period 2001–2024.

2. Literature Review

2.1 Fossil Fuel Energy Consumption in Six ASEAN Countries

Energy consumption from fossil fuels in the six major ASEAN countries of Indonesia, Malaysia, Singapore, Thailand, the Philippines, and Vietnam has a unique pattern, depending on the shape of their respective economies, the level of development and the policy direction taken. The selection of these six countries is based on the consideration that these countries are the main contributors to the ASEAN economy, both in terms of economic growth, acceleration of industrial activities, and energy use intensity. In addition, around 78% of the increase in energy sector emissions in the ASEAN region comes from Indonesia, Vietnam, Malaysia, and the Philippines whose energy mix structure is still dominated by the use of coal, while Thailand and Singapore are dominated by natural gas. The differences in the characteristics of the energy mix provide relevant structural variations to analyze the linkages between trade openness, fossil energy consumption, and economic dynamics in the ASEAN region. Therefore, the selection of these six countries is considered representative and

strategic in explaining the patterns and differences in responses between countries to economic and energy dynamics (Zhang et al., 2023).

2.2 Macroeconomic Determinants on Fossil Fuel Energy Consumption

Economic growth is a major driver of fossil fuel energy consumption, especially in developing regions. Classical and endogenous growth theories argue that increased economic output requires greater energy inputs for production, transportation, and industrial activities, with fossil fuels (oil, coal, and natural gas) remaining the dominant energy sources. On the other hand, the Environmental Kuznets Curve Hypothesis (EKC) by Kuznets (1955) providing a theoretical framework, explaining that environmental degradation including dependence on fossil fuels increases during the early stages of development before potentially decreasing at already higher income levels with the adoption of cleaner technologies. Empirical evidence strongly supports the existence of positive correlations by research Ritvanen et al (2021) found that economic growth is driven by dominant energy consumption. Karunia et al (2023) shows a long-term relationship that confirms that fossil fuels continue to dominate the energy mix. Furthermore, Umair et al (2024) identified the positive and significant relationship of industrialization to per capita fossil fuel consumption in both the short and long term. Thus, in the context of ASEAN, increased income and economic activity directly translate into increased use of fossil fuels, reflecting the current stage of development of the region where improved energy efficiency has not yet separated growth from large energy demand.

Trade openness significantly affects fossil fuel consumption by expanding economic activities and production. International trade theory, including Ricardo's comparative advantage and Krugman's new theory of trade, explain that openness allows countries to specialize, increasing production volumes as well as trade flows. This expansion directly increases energy demand, particularly fossil fuels, which dominate the trade-supporting power generation, manufacturing, and transportation sectors (Krugman et al., 2012). Research from Hariani et al (2025) explained that trade openness is positively correlated, indicating that international trade activities remain highly dependent on non-renewable energy. Similarly, Cahyono & Hakimah (2019) and Rahmawati & Robertus (2023) found that added value in agriculture and industry, along with trade openness, significantly affects final energy consumption. ASEAN as a global manufacturing hub with open economies such as Singapore, Malaysia, Vietnam, and Thailand, higher trade openness intensifies the use of fossil fuels to support export production, transportation logistics, and related domestic consumption. This creates a structural dependence between trade expansion and fossil energy in the region.

Government expenditure, as the main instrument of fiscal policy, has a strategic role in shaping energy consumption patterns. Based on Musgrave's theory of public finance in 1959, the government performs the allocation function through infrastructure development and the provision of public goods (e.g., transportation, industry, energy sector) and the distribution function through energy subsidies. Both mechanisms stimulate energy-intensive economic activities. Infrastructure projects directly consume fossil fuels during construction and operation, while energy subsidies lower the relative price of fossil fuels, encouraging wider consumption across households and industries. In terms of growth stage theory, Rostow underlined this for ASEAN, during the "take-off" and "push to maturity" stages, government-led industrialization and infrastructure development became dominant. This is precisely the situation in ASEAN, where substantial government expenditure on physical infrastructure and energy-intensive industries directly increases fossil fuel consumption. Empirical evidence in research Perwithosuci et al (2024) found that government expenditure in ASEAN has a positive and significant relationship with fossil fuel consumption, noting that subsidy policies aimed at affordability inadvertently drive demand. A study from Haseeb et al (2019) also affirms that increased government expenditure, along with economic growth, has a positive and significant impact on fossil fuel consumption, leading to higher environmental pollution. While Park et al (2021) pointed out that shifting fossil fuel subsidies to renewable energy can have minimal economic impact, the prevailing pattern in ASEAN suggests that fiscal policy remains oriented towards fossil fuel dependence, reinforcing long-term environmental pressures.

3. Method

This study uses secondary panel data that combines time series and cross-sectional observations for six ASEAN countries, namely Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam, during the period 2001-2024. The data was obtained from the World Bank and Our World in Data. Fossil Fuel Energy Consumption, measured in kilowatt-hours (kWh) per capita, is used as a

dependent variable. These independent variables include economic growth (real GDP growth rate, %), trade openness (ratio of exports and imports to GDP), and government expenditure (US$). Panel data analysis is used because it allows for greater variability, increases the degree of freedom, and captures heterogeneity across countries and time dynamics (Gujarati, 2012). Model selection is carried out using the Chow Test and Hausman Test to determine the most appropriate panel data specifications. The results show that the Fixed Effects Model (FEM) is preferred, as it controls for unobserved country-specific characteristics that can affect fossil fuel energy consumption, thus generating more consistent estimates by assuming differences between countries are captured through their interception variations, where each country represents an unknown parameter. Dummy variable estimates are implemented to calculate interception differences, which may arise from variations in other variables while the slope coefficient remains constant across the country. This estimation model is also called the Least Squares Dummy Variable (LSDV) technique. Therefore, the empirical model used in this study is based on Ilyasa et al (2025) formulation as follows:

$$Fos_{it} = \alpha_0 + \beta_1 Growth_{it} + \beta_2 TO_{it} + \beta_3 Gov_{it} + \varepsilon_{it} \quad (1)$$

Where Fos represents the fossil fuel energy consumption, measured in kilowatt-hours (kWh) per capita ; $Growth$ is the economic growth; TO represents trade openness; Gov indicates the government expenditure; ε_{it} is the random error term; α_0 is the constant term; $\beta_1 - \beta_3$ is the coefficient of independent variables; i is the notation for cross-section and t is for time-series. Where the circumstances are indicated and the time period indicated, hypothesis testing is carried out through partial tests (t-tests) and simultaneous tests (F-tests) at a significance level of 5%, as well as evaluation of the determination coefficient (Adjusted) to measure the model's ability to explain variations in dependent variables. In line with the panel data methodological literature, classical assumption testing is focused on multicollinearity and heteroscedasticity tests, given that panel data regression does not strictly require all of the classic OLS tests $i\ t\ R^2$ (Basuki, 2021).

4. Results and Discussion

This section is divided into two main parts, namely the presentation of the results of the estimation and the discussion of each variable based on the empirical tests carried out. The analysis begins with descriptive statistics to provide an overview of the data used in this study. The data set consists of panel data from six ASEAN countries, namely Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam covering the period 2001–2024, (n = 144). Table 1 presents descriptive statistics of all the variables used in the model. Overall, the standard deviation of the variables was relatively small compared to the respective averages, indicating relatively low data variability and suggesting that the datasets were consistent enough for further econometric analysis.

Table 1. Descriptive Statistics

Statistics	Fos	Growth	TO	Gov
Means	36317.99	4.751389	150.3403	39706532
Median	11647.00	5.150000	129.5000	33146667
Maximum	179675.0	14.50000	437.0000	1.100008
Minimum	2418.000	-9.500000	32.00000	2068771.0
Std. Dev.	53367.87	2.960414	103.5506	27484639

Source: data processed

Table 1 shows the average income inequality value in the study area was 0.3363 with a standard deviation of 0.0419. This average value indicates that income inequality is in the moderate category, meaning that income distribution in the study area is not too unequal but still requires attention. Economic growth showed an average of 4.9931 with a standard deviation of 2.5080, indicating moderate economic growth, reflecting relatively stable economic development. However, the standard deviation of 2.5080 indicates fluctuations in economic growth between regions, which can be caused by external factors such as economic policy, investment, and labor market conditions. The average HDI in the study area was 70.3910, indicating that the overall level of human development in the study area is in the medium to high category. The standard deviation of 6.1236 indicates significant variation between regions, indicating differences in levels of well-being, access to healthcare, education, and living standards across regions. Table 2 shows the value of adjusted R-Squared for FEM is 0.983 and means the contribution of economic growth, trade openness and government expenditure to fossil fuel energy consumption of 98.3% and the remaining 1.72% is influenced by

other variables outside the model that were not analyzed in this study and the value of F-statistics is greater than F-table which simultaneously the variables of economic growth, trade openness, and government expenditure have a significant effect on fossil fuel energy consumption in ASEAN.

Table 2. Result of Fixed Effect Model

Variables	Coefficient
C	8.864 (77.758)***
Growth	0.0007 (0.133)
TO	0.003 (4.192)***
Gov	7.940 (11.216)***
Diagnostic Tools	
Adjusted R-Squred	0.983
F-Stat	1026.241

Source: data processed

Table 2 shows in the six ASEAN countries, economic growth no longer automatically leads to a proportionate increase in fossil fuel energy consumption. From an economic perspective, this phenomenon can be explained by structural transformation in the production sector. As the economy grows, the contribution of energy-intensive sectors such as primary extraction and heavy industry is gradually shifting to the relatively more energy-efficient high-value-added manufacturing and services sectors. In Indonesia, Malaysia, and Vietnam, although these countries remain important producers of oil, gas, and coal in the ASEAN region and the framework of the ASEAN Plan of Action for Energy Cooperation (APAEC), recent economic growth has been further supported by the expansion of modern manufacturing, processing industries, and services. Similarly, Singapore, Thailand, and the Philippines show increasing dominance in the services, finance, logistics, and digital economy, which typically result in higher economic output with relatively lower energy intensity. As a result, additional economic output does not necessarily translate into a significant increase in fossil energy consumption. These findings are consistent with Ergun et al (2019) and Ichsan et al (2022) The WHO documented the weakening of the direct link between fossil fuel consumption and economic growth due to improved energy efficiency and structural economic transformation.

On the other hand, trade openness continues to increase fossil energy consumption through the expansion of international production, transportation, and logistics activities. From an economic point of view, greater trade integration increases the scale of production, encourages export-oriented manufacturing, and intensifies the movement of goods across borders, all of which require substantial energy inputs. Indonesia and Vietnam experienced an increase in energy demand in line with the expansion of manufacturing exports and the processing industry. Malaysia and Thailand are showing a similar pattern through the strengthening of the export-oriented electronics and automotive sectors, while Singapore, as a regional trade and logistics hub, needs significant energy to support port operations, international transportation, and distribution networks. The Philippines also showed an increase in energy consumption consistent with the growth of domestic trade and industrial activity. In line with research Juwita et al (2021), Pham & Nguyen (2024), and Rahmawati & Robertus (2023), which indicates that trade openness in developing countries is likely to increase fossil fuel consumption due to the effects of scale from the expansion of production and trade activities.

Significant government expenditure reflects the strong influence of fiscal policy on fossil fuel energy consumption in the ASEAN region. From an economic perspective, public spending can influence energy demand through infrastructure investments, industrial development programs, and energy pricing policies. In many ASEAN countries, government expenditure remains concentrated on physical infrastructure, transportation networks, industrial zones, and public sector operations that require substantial energy inputs. In Indonesia, Vietnam, and the Philippines, state spending directed at infrastructure development, transportation expansion, industrial estates, and energy subsidies directly increased demand for oil, gas, and coal. Malaysia and Thailand are showing similar patterns through public financing of large-scale manufacturing and public services that remain energy-intensive. Meanwhile, Singapore, despite being more advanced and service-oriented, still needs a large supply of energy to operate modern infrastructure, urban transport systems, data centres and

technology-based public facilities. This condition shows the structure of public spending in ASEAN countries remains closely related to fossil energy consumption.

These results are in line with previous research by Park et al (2021) emphasizes the impact of government expenditure on fossil fuel dependence can be reduced through subsidy reform and a gradual shift in public spending towards renewable energy and green infrastructure. From a broader economic perspective, economic growth, trade openness, and government expenditure create interconnected and reinforcing cycles that have an impact on fossil fuel dependence. Economic expansion increases energy demand, trade openness expands the scale of production and logistics activities, and fiscal policies, especially energy subsidies, often keep fossil fuel prices artificially low. This makes energy prices relative, weakens incentives for energy efficiency, and ultimately locks the economy into unsustainable fossil energy consumption patterns. In line with previous research by Sari et al (2024) stated that economic growth, energy subsidies, and trade openness simultaneously affected the consumption of non-renewable energy in Indonesia during 2005–2022. In addition, Yahoo et al (2024) found that fossil fuel subsidies increase energy consumption and CO_2 emissions, while subsidy reductions tend to raise electricity prices and reduce output in energy-intensive sectors due to decreased competitiveness.

5. Conclusion

The results of the linear research with the research objectives formulated in the preliminary part are to analyze the influence of economic growth, trade openness, and government expenditure on fossil fuel energy consumption in six ASEAN countries for the period 2001-2024. The results of the estimation explain that economic growth has a positive but insignificant correlation with fossil energy consumption, while trade openness and government expenditure are positively and significantly correlated, with government expenditure as the most dominant variable. Simultaneously, the three variables were able to explain 98.28% of the variation in fossil energy consumption, confirming that the dynamics of economic activities, international trade integration, and fiscal expansion are the main factors shaping fossil-based energy consumption patterns in the ASEAN region. These findings provide important implications for policy formulation, especially in shaping the composition of public spending and trade strategies to better align with the energy efficiency agenda and transition to more sustainable energy sources.

Although this study makes a strong empirical contribution, some limitations need to be noted, namely in the three main macroeconomic variables and do not include energy transition indicators such as the renewable energy mix, energy intensity, as well as energy subsidies and tax policies. In addition, the scope of the research is only in six ASEAN countries, so generalization to other regions needs to be done. Develop a more dynamic model, expand the period and scope of the country and integrate environmental sustainability variables to deepen understanding of energy system transformation. The practical implication is that governments in the ASEAN region need to direct fiscal and trade policies more strategically so that economic growth does not continue to strengthen dependence on fossil energy, but encourages the acceleration of the energy transition and more sustainable development in the short and long term.

Acknowledgment

The author expresses his appreciation and gratitude to the Department of Economics, Faculty of Economy, Universitas Negeri Medan, for consistent support and various valuable inputs during the research process. The response and academic environment provided by the institution are very helpful in directing and improving the quality of this research.

Declarations

Author contribution	:	Each author has reviewed the final version of the paper and has given full approval for its submission and publication.
Funding statement	:	This research was conducted without financial support from any external funding sources.
Conflict of interest	:	The authors declare no conflict of interest.
Additional information	:	No additional information is available for this paper.

References

ASEAN Centre For Enegy. (2024). *ASEAN Energy Investment 2024*. ASEAN Centre for Energy. Jakarta.

Balassa, B. (1985). Exports, policy choices, and economic growth in developing countries after the 1973 oil shock. *Journal of Development Economics*, *18*(1), 23–35. doi: 10.1016/0304-3878(85)90004-5

Basuki, A.T. (2021). *Analisis Data Panel dalam Penelitian Ekonomi dan Bisnis*. PT Rajagrafindo Persada. Yogyakarta.

Bhattacharyya, SC (2011). *Energy Economy*. Springer London Dordrecht Heidelberg.

Bintariningtyas, S., Mulyaningsih, T., & Purwaningsih, Y. (2024). Coal mining and MSME: Is it mutually beneficial?. *Nature Environment & Pollution Technology, 23*(2), 855-862. doi: 10.46488/NEPT.2024.v23i02.021

Cahyono, BP., & Hakimah, Y. (2019). The impact of economic development, household expenditure, and trade openness on final energy consumption in Indonesia. *Journal of Global Economics*, *4*(2), 1–16. doi: 10.35908/jeg.v4i2.751

Ergun, S.J., Owusu, P.A., & Rivas, M.F. (2019). Determinants of renewable energy consumption in Africa. *Environmental Science and Pollution Research*, *26*(15), 15390–15405. doi: 10.1007/s11356-019-04567-7

Gujarati, D.N. (2012). *Basics of Econometrics, 5th ed*. New York. MacGraw Hill.

Han, J., Zeeshan, M., Ullah, I., Rehman, A., & Afridi, F. E. A. (2022). Trade openness and the impact of urbanization on the consumption of renewable and non-renewable energy in China. *Environmental Science and Pollution Research*, *29*(27), 41653–41668. doi: 10.1007/s11356-021-18353-x

Hariani, E., Febriyastuti, R. W., & Tamonsang, M. (2022). An analysis of factors that affect CO2 emissions in 5 ASEAN country in 2011-2018. *Optimum: Jurnal Ekonomi Dan Pembangunan, 12*(1), 76-86. doi: 10.12928/optimum.v12i1.5824

Haseeb, M., Kot, S., Hussain, H., & Jermsittiparsert, K. (2019). The impact of economic growth, environmental pollution, and energy consumption on health expenditure and R&D expenditure of ASEAN countries. *Energy, 12*(19), 3598. doi: 10.3390/en12193598

Ichsan, M., Lockwood, M., & Ramadhani, M. (2022). National oil companies and fossil fuel subsidy regimes in transition: The case of Indonesia. *The Extractive Industries and Society, 11*, 101104. doi: 10.1016/j.exis.2022.101104

Ilyasa, W. N., Kurniawan, M. L. A., Lubis, F. R. A., & Salim, A. (2025). The role of credit for poverty alleviation in Indonesia: Evidence from panel data analysis. *IJBE (Integrated Journal of Business and Economics), 9*(2), 203-217. doi: 10.33019/ijbe.v9i2.1101

Juwita, A. H., Suryanto, S., & Samudro, B. R. (2021). The impact of international tourism on economic growth and carbon dioxide emission in ASEAN five country. *Optimum: Jurnal Ekonomi dan Pembangunan, 11*(1), 1-11. doi: 10.12928/optimum.v11i1.3393

Karunia, M. R., Komrulzaman, A., & Tjahjawandita, A. (2023). Energy consumption, financial development, and carbon emissions in Indonesia. *Indonesian Journal of Economics and Development*, *23*(1), 81–91.

Khan, S., Afzal, S., Khan, J., & Khan, Z. (2024). Revisiting the role of renewable energy, government expenditure, exports, and imports, in economic growth: A Panel data analysis from selected Asian countries. *Alternative Economics*, *30*(4), 781–795. doi: 10.37075/EA.2024.4.05

Koengkan, M., Fuinhas, J.A., & Vieira, I. (2020). The reaction of fossil fuel consumption to trade openness in Latin American and Caribbean countries. *Journal of Social Studies*, *22*(45), 142–170. doi: 10.19093/res10861

Krugman, P. R., Obstfeld, M., & Melitz, M. J. (2012). *International Economic Theory & Policy* (Ninth Edit). Pearson Education.

Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review*, *65*(1).

Lunku, H. S. (2025). The criticality of clean energy and ICT invesment in achieving environmental sustainability in the EU member states. *Optimum: Jurnal Ekonomi dan Pembangunan, 15*(2), 207-221. doi: 10.12928/optimum.v15i2.12981

Mahmood, H., Maalel, N., & Zarrad, O. (2019). Trade openness and CO2 emissions: Evidence from Tunisia. *Sustainability (Switzerland), 11*(12). doi: 10.3390/su11123295

Mankiw, N. G. (2018). *Introduction to Macroeconomics*, *Ed.7*. Washington. Worth Publisher.

Nazlioglu, S., Kassouri, Y., Kucukkaplan, I., & Soytas, U. (2022). Convergence of oil consumption: A historical perspective with a new concept. *Energy Policy*, *168* (January), 113150. doi: 10.1016/j.enpol.2022.113150

Nguyen, T.A., Le, P.H., Nguyen, H.D., Luong, T.T., & Ngo, M.T. (2023). The effect of environmental accounting information disclosure on the financial performance of listed Vietnamese industrial companies: The role of leverage and big 4 moderation. *CTU Journal of Innovation and Sustainable Development*, *15*(2), 126–138. doi: 10.22144/ctu.jen.2023.027

Park, K., Lee, Y., & Han, J. (2021). An economic perspective on ending fossil fuel subsidies and moving towards a low-carbon society. *Sustainability (Switzerland), 13*(3), 1–17. doi: 10.3390/su13031217

Perwithosuci, W., Anas, M., Hidayah, N., Putri, R. N., & Hadibasyir, H. Z. (2025). Environmental quality, economic growth and population density: A panel study in Indonesia. *Optimum: Jurnal Ekonomi dan Pembangunan, 15*(1), 154-163. doi: 10.12928/optimum.v15i1.12559

Pham, D.T., & Nguyen, H.T. (2024). The effects of trade openness on environmental quality: Evidence from developing countries. *Journal of Applied Economics*, *27*(1). doi: 10.1080/15140326.2024.2339610

Rahmawati, A., & Robertus, M. H. (2023). The effect of electricity consumption, economic growth, industrialization, and trade openness on co2 emissions in Indonesia 1983-2019. *Journal of Diponegoro Economics*, *12*(3), 13–21. doi: 10.14710/djoe.39536

Ritvanen, J., Myöhänen, K., Pitkäoja, A., & Hyppänen, T. (2021). Industrial-scale absorption-enhanced gasification process modeling: One-dimensional simulation for the operation of a combined reactor system. *Energy*, *226*, 120387. doi: 10.1016/j.energy.2021.120387

Sari, I. T., Putri, Ye, & Selvia, N. (2024). The effect of the number of motor vehicles, number of population, energy subsidies, and trade openness on non-renewable energy consumption and economic growth in Indonesia. *Indonesian Journal of Education Research*, *4*(3), 1067–1075. doi: 10.31004/irje.v4i3.880

Septyani, D., & Hartati, S. (2024). Fossil energy consumption on economic growth. *Journal of Economics, Business and Accounting (COSTING), 7*(5), 1491–1498. doi: 10.31539/costing.v7i5.11780

Setiawan, A., Tua, D. P., & Husin, M. E. (2019). The impact of fossil fuel consumption on Indonesia's gross domestic product and the reciprocal relationship between the two. *Journal of Mineral and Coal Technology*, *15*(3), 213–223. doi: 10.30556/jtmb.Vol15.No3.2019.931

Setyono, A. E., & Kiono, B. F. T. (2021). From fossil fuels to renewable energy: A portrait of Indonesia's oil and gas sector 2020–2050. *Journal of New and Renewable Energy*, *2*(3), 154–162. doi: 10.14710/jebt.2021.11157

Siregar, S. W., & Hasbi. (2023). Analysis of the influence of trade openness, energy consumption, and economic growth on carbon emissions in D-8 countries. *Journal of Master of Sharia Economics*, *2*(1), 61–77.

Suripto, S., Salim, A., Kurniawan, M. L. A., Khasanah, U., & Athfal, A. A. (2025). Unveiling regional growth patterns spatial heterogeneity and infrastructure quality under a bayesian framework in Central Java. *Eko-Regional: Jurnal Pembangunan Ekonomi Wilayah, 20*(2), 214-234.

Todaro, M.P., & Smith, SC (2020). *Economic Development* (13th Ed). Pearson Education.

Umair, M., Yousuf, M. U., Cheema, A. R., & Ul-Haq, J. (2024). Assessing the environmental consequences of fossil fuel consumption in newly industrialized countries. *International Journal of Energy Sector Management, 19*(4), 1027-1044. doi: 10.1108/IJESM-08-2024-0036

Wang, S., Yuan, Y., & Wang, H. (2019). Corruption, hidden economy, and environmental pollution: A spatial econometric analysis based on Chinese provincial panel data. *International Journal of Environmental and Public Health Research*, *16*(16), 1–23. doi: 10.3390/ijerph16162871

Yahoo, M., Salleh, N. H. M., Chatri, F., & Lin, M. (2024). Rationalization of fossil fuel subsidies and renewable energy initiatives in Malaysia: Results of the CGE analysis. *Journal of Economics Malaysia*, *58*(3). doi: 10.17576/JEM-2024-5803-5

Zhang, M., Li, X., Pai, C. H., Ding, H., & Zhang, X. (2023). Green credit and fossil fuel resource efficiency: Advancing sustainability in Asia. *Resources Policy*, *86*(Part B), 104204. doi: 10.1016/j.resourpol.2023.104204