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THE ROLE OF GDP PER CAPITA, HDI, AND INDUSTRIAL VALUE ADDED ON CARBON EMISSIONS IN ASEAN-3

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Abstract:
Climate change is becoming an increasingly urgent global challenge, with carbon dioxide (CO_2) emissions being the main contributor to the increase in greenhouse gases in the atmosphere. ASEAN countries face a dilemma between maintaining economic growth and reducing carbon emissions. This study aims to analyze the effect of Gross Domestic Product (GDP), Human Development Index (HDI), and Industrial value added, which is Manufacturing Value Added (MVA), on CO_2 emissions in ASEAN during the period 1990–2023. The approach used is panel data regression analysis with a Fixed Effect (FE) model, based on the results of the Chow and Hausman tests as determinants of the best model. The results show that simultaneously, the three independent variables have a significant effect on CO_2 emissions (Prob F = 0.0031). However, partially, only HDI has a positive and significant effect on carbon emissions ($p = 0.005$), while GDP ($p = 0.166$) and MVA ($p = 0.249$) do not show a significant effect. These findings indicate that increased human development has the potential to increase energy consumption and economic activity, which in turn leads to an increase in carbon emissions. Conversely, economic growth and industrial activity in the three countries were not always followed by an increase in emissions, possibly due to economic transformation towards the service sector and the application of more efficient industrial technologies. Therefore, development policies in the ASEAN region need to emphasize the transition to renewable energy, industrial energy efficiency, and strengthening environmental awareness to support the achievement of net-zero emissions.

Keywords: Carbon emissions, Gross Domestic Product, Human Development Index, Industrial Value Added, ASEAN

INTRODUCTION

Climate change is a serious global threat that has complex impacts on environmental quality. Its main impacts include rising temperatures and sea levels, melting polar ice caps, and global warming (Amanda, 2023). This phenomenon is triggered by increased concentrations of greenhouse gases (GHGs) in the atmosphere, with carbon dioxide (CO_2) as the main contributor (IPCC, 2022). Globally, CO_2 emissions originate mainly from developed and developing countries in Asia, which account for about 80% of the world's anthropogenic emissions. Poku (2016) notes that the top ten emitters in the world are predominantly Asian countries, with two-thirds of total global emissions originating from this region. The International Energy Agency (2017) emphasizes that the main challenge for Southeast Asia is to maintain a balance between economic growth and environmental sustainability. ASEAN countries have implemented renewable energy policies as a follow-up to the Paris Agreement and their respective national strategies. Indonesia, Thailand, and Singapore, as the three largest economies in the region, face a dilemma between pursuing economic growth and protecting the environment (World Bank, 2023).

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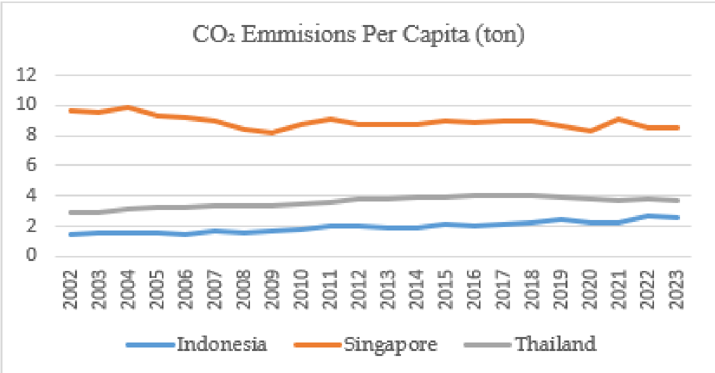

Source: Our World in Data

Figure 1. Increase in CO2 Emissions

The latest data shows the per capita CO_2 emissions in three ASEAN countries. Singapore recorded the highest emissions, namely 9.69 tons in 2002 and 8.51 tons in 2023. Thailand was in the middle range with 2.87 tons in 2002 and 3.69 tons in 2023. Indonesia increased from 1.39 tons in 2002 to 2.61 tons in 2023, while the ASEAN average reached 5.21 tons in 2023 (World Bank, 2023). The COVID-19 pandemic in 2020 caused a sharp decline in global and regional emissions due to mobility restrictions, reduced industrial activity, and decreased fossil fuel consumption (Friedlingstein et al., 2022). However, since 2021, emissions have risen again in line with economic recovery. Some ASEAN countries used this crisis to strengthen social and economic resilience, although the main focus of stimulus remained on short-term recovery (Martinus & Seah, 2021). Post-pandemic, green recovery policies in ASEAN have been integrated into the ASEAN Comprehensive Recovery Framework. However, implementation remains limited, especially in Indonesia, which is still heavily dependent on fossil fuels (Sriwijaya & Devi, 2022). Research by Handayani (2022) shows that with the right policy and technology support, ASEAN has the potential to achieve net-zero emissions in the electricity sector by 2050. A study of the factors determining carbon emissions is important, especially in the post-pandemic era when countries are trying to balance economic recovery with their commitment to net zero.

Data from the Global Carbon Atlas shows that the industrial, transportation, and deforestation sectors are the main sources of emissions in ASEAN. Indonesia is dominated by deforestation, Singapore by high-tech industry and transportation, while tourism activities dominate Thailand. The increase in CO_2 emissions is a complex phenomenon influenced by various structural and sectoral factors. One of the main factors is the growth of Gross Domestic Product (GDP). Data from the World Bank shows that the increase in GDP in Indonesia, Singapore, and Thailand is accompanied by an increase in carbon emissions. In addition to economic growth, the Human Development Index (HDI) is also closely related to the increase in carbon emissions. Countries with high HDI generally have better education, income, and life expectancy, which encourages high energy consumption. Increased income often implies the use of private vehicles and energy-intensive electronic equipment (Ritchie & Roser, 2020). Economic growth and human development are inseparable from the role of the industrial sector, which is a significant contributor to emissions in the ASEAN region. An increase in industrial added value indicates an increase in industrialization activities that have the potential to increase CO_2 emissions due to high energy requirements and dependence on fossil fuels such as coal and petroleum.

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Previous studies reinforce this relationship. Alam et al. (2016) found a positive correlation between economic growth and increased CO_2 emissions. Muhammad (2023) asserts that increases in GDP per capita and HDI drive energy consumption and economic activity, while Al-Mulali et al. (2015) show the significant contribution of industrialization to carbon emissions in developing countries. The limitation of previous studies lies in their narrow focus on GDP without considering the quality of human development and economic structure. Several studies, such as Shahbaz et al. (2014), which involved HDI, produced mixed findings. This research gap highlights the need for a comprehensive analysis that combines GDP, HDI, and industrial value added simultaneously. Therefore, this study aims to examine the influence of GDP per capita, HDI, and industrial value added on carbon emissions in ASEAN.

Operational Definition

Carbon Emissions (CO_2 Emissions). According to the Intergovernmental Panel on Climate Change (IPCC) (2022), carbon dioxide emissions are the release of CO_2 gas into the atmosphere from the burning of fossil fuels, industrial processes, and land use change. The World Bank (2023) explains that carbon emissions are a key indicator of a country's contribution to global climate change, measured in metric tons per capita per year. Meanwhile, Our World in Data (2023) asserts that carbon emissions per capita describe a country's energy intensity and the efficiency of its energy resource use. Increased carbon emissions are closely related to economic activity, especially in developing countries that still rely on fossil-based energy such as coal and petroleum. Kaya & Yokobori (1997), through Kaya Identity, explain that carbon emissions are determined by four main factors, namely population, GDP per capita, energy intensity, and the carbon intensity of the energy used. In the context of this study, carbon emissions are defined as the amount of carbon dioxide (CO_2) produced from economic and industrial activities in a country, measured in metric tons per capita, and serve as an indicator of environmental pressure due to economic development.

Gross Domestic Product (GDP) per Capita. Gross Domestic Product (GDP) is the total value of final goods and services produced by a country in a given period (Samuelson & Nordhaus, 2010). According to Adam Smith (1776), economic growth occurs due to the accumulation of capital, labor, and increased productivity through the division of labor. Meanwhile, the neoclassical growth model of Solow & Swan (1956) emphasizes that long-term economic growth is determined by capital accumulation, labor force growth, and technological progress. GDP per capita reflects the average income of a country's population, which is obtained by dividing the total GDP by the population. According to the World Bank (2023), this indicator is used to measure a country's economic welfare and productivity. Todaro & Smith (2020) assert that an increase in GDP per capita is a key indicator of economic growth, but in the early stages of development, it is often accompanied by increased exploitation of natural resources and carbon emissions. It is in line with the Environmental Kuznets Curve (EKC) theory proposed by Grossman & Krueger (1991), which states that the relationship between economic growth and environmental degradation is in the form of an inverted U-curve, where in the early stages of development, an increase in GDP causes an increase in carbon emissions, but after reaching a certain income level, emissions tend to decrease due to the adoption of clean technology. According to a report by the Asian Development Bank (2021), most ASEAN countries are still in the early stages of the EKC, where economic growth is still synonymous with increased emissions. Therefore, in this study, GDP per capita is defined as the average income per person per year, which reflects a country's level of economic activity and its potential for increased carbon emissions.

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Human Development Index (HDI). The Human Development Index (HDI) was first introduced by the United Nations Development Program (UNDP) (1990 as a comprehensive measure to assess human development progress. According to UNDP (1990), the HDI is calculated based on three main dimensions, namely health, measured by life expectancy at birth; education, measured by average years of schooling and expected years of schooling; and decent living standards. Sen (1999) emphasizes that improvements in welfare are not only measured by income, but also by access to education, health, and decent living standards. This idea became the basis for the development of the HDI by the UNDP as a comprehensive measure of quality of life. The World Bank (2023) explains that the HDI provides a comprehensive picture of the quality of life of a society and is often used as an indicator of social development in macroeconomic analysis. Todaro & Smith (2020) emphasize that quality human development plays an important role in promoting sustainable economic growth. However, several studies, such as those conducted by Ritchie & Roser (2020), show that increases in HDI are often positively correlated with increases in carbon emissions in developing countries, as increases in income and education drive higher energy consumption. Conversely, in developed countries with high HDI, increased environmental awareness and efficient technology can reduce carbon emissions. Thus, in this study, HDI is defined as a composite measure of health, education, and income dimensions that describe the quality of life of a society, with a value between 0 and 1, and is used to assess the extent to which human development contributes to changes in carbon emissions in three ASEAN countries.

Industrial Value Added (Manufacturing Value Added). According to the World Bank (2023), industrial value added is the contribution of the manufacturing sector to a country's total Gross Domestic Product (GDP), measured as a percentage of total GDP (% of GDP). Industrial value added reflects the productivity of the manufacturing sector in creating economic value through the transformation of raw materials into finished goods. The Ministry of Industry of the Republic of Indonesia (2023) explains that an increase in industrial value added is a key indicator of the success of a country's industrialization and economic transformation. However, according to the International Energy Agency (2023), the industrial sector is one of the largest contributors to carbon emissions globally due to the use of fossil fuels in the production process. Stern (2004) adds that countries with rapid industrial growth tend to experience increased energy consumption and carbon emissions if they have not adopted low-emission technologies. In the context of ASEAN, Rayhan Ali et al. (2025) show that the positive relationship between industrial value added and carbon emissions remains strong because most industries in the region still rely on conventional energy. Therefore, in this study, industrial value added is defined as the proportion of the manufacturing sector's contribution to a country's total GDP (in percent), which serves as an indicator of the level of industrialization and energy intensity that has the potential to increase carbon emissions.

METHODS

This study uses a quantitative approach. The data used is secondary data obtained from the World Bank and Our World in Data. This study uses carbon emissions (CO_2) per capita as the dependent variable in metric tons of carbon dioxide (MtCO2). The independent variables consist of Gross Domestic Product (GDP) per capita (current US$), Human Development Index (HDI) (score 0–1), and Manufacturing Industry Value Added (% GDP). Variables with the same indicators are found in the study by Shahbaz et al. (2014), which also uses MtCO2 (tons) as the dependent variable, GDP per capita (current US$), and Manufacturing Industry Value Added (%GDP) as independent variables. The study by Al-Mulali et al. (2015) also examined MtCO2 (tons) as the dependent

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variable, GDP per capita (current US$), and HDI (score 0-1). In unit regression, variables do not have to be the same because regression looks at relative influence (coefficients) rather than absolute values (Analytics Vidhya, 2021). The data used is panel data, which is a combination of time series and cross-sectional data from three ASEAN member countries, namely Indonesia, Singapore, and Thailand, for the period 1990 to 2023. The selection of countries was based on the criteria of having the highest GDP in ASEAN, as well as the availability of complete and consistent data for the four research variables. The analysis method used is panel data regression analysis with the Fixed Effect Model (FEM) approach using Stata 17. The selection of the best model was carried out through the Chow Test and the Hausman Test. FEM can show the contribution of economic growth (GDP), Human Development Index (HDI), and Industrial Added Value to the increase in CO2 emissions in three ASEAN countries, namely Indonesia, Singapore, and Thailand. Before estimation, the data were tested for stationarity to ensure data stability and prevent spurious regression. After the best model was selected, classical assumption tests were conducted, covering multicollinearity, heteroscedasticity, and autocorrelation. Furthermore, the t-test was used to test the partial effect of each independent variable on carbon emissions, the F-test to test the simultaneous effect, and the coefficient of determination (R^2) test to assess the strength of the model. The econometric model used in this study was formulated as follows:

$$CO2it = \alpha + \beta1X1it + \beta2X2it + \beta2X3it + eit$$

Information:

Y: Carbon Dioxide Emissions (metric tons per capita)
X1: Gross Domestic Product per capita (current US$)
X2: Human Development Index (score 0–1)
X3: Manufacturing Industry Value Added (% of GDP)
I: Country (Indonesia, Singapore, Thailand)
t: Year of observation (1990–2023)
α: Constant
β_1, β_2, β_3: Regression coefficients of each independent variable
ε: Error term

RESULT AND DISCUSSION

This study uses a Fixed Effect (FE) model to analyze the effect of Gross Domestic Product (GDP), Human Development Index (HDI), and Manufacturing Value Added (MVA) on carbon emissions (CO_2) in three countries with an observation period of 34 years (a total of 102 observations). Before estimation, the data were tested for stationarity to ensure data stability and prevent spurious regression. Next, the best model (FEM, CEM, and REM) was selected based on the estimation results, which produced the following output:

Model Selection Test.

Table 1. Chow Test

F-Statistic	18.62
Prob > F	0.0000

Source: Data processed by researchers

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Based on the Chow Test results listed in Table 1, a Prob > F value of 0.0000 was obtained, which is < 0.05. Therefore, it can be concluded that the Pooled OLS model is rejected. Thus, the more appropriate models to use are the Fixed Effect Model (FEM) and the Random Effect Model (REM). To determine which model is most appropriate, further testing was conducted using the Hausman Test.

Table 2. Hausman Test

Prob > chi2	0.0001

Source: Data processed by researchers

Based on the results of the Hausman Test in Table 2, a Chi-Square probability value of 0.0000 < 0.05 was obtained, so it can be concluded that the appropriate model for this study is the fixed effect model (FEM). Because the best model based on the Hausman Test is FEM, there is no need to perform the Lagrange Multiplier Test (LM Test).

Based on the results of the model selection test, the fixed effect model was selected as the best model for estimating all variables in this study. Therefore, the next step is to conduct a classical assumption test. The classical assumption tests used include multicollinearity, heteroscedasticity, and autocorrelation tests (Basuki, 2014).

Classical Assumption Test.

Table 3. Normality Test

Variable	Obs	W	Prob > z
Resid	102	0.93768	0.0000

Source: Data processed by researchers

The normality test was conducted to determine whether the regression model was normally distributed. Based on Pranadipta (2023), if N > 30, the data can be assumed to meet the assumption of normal distribution. The normality test results show a W value of 0.93768 and a probability of 0.0000 ($p < 0.05$), which statistically indicates that the residuals do not follow a normal distribution. When the number of sample observations is large enough, the sampling distribution of the estimator tends to be normal even though the individual residuals are not completely normal. With 102 observations (3 countries × 34 years), large-sample-based inference can be considered valid.

Table 4. Multicollinearity Test

	Y	X1	X2	X3
Y	1.000000	-0.321487	0.586204	-0.278516
X1	-0.321487	1.000000	0.562314	0.487905
X2	0.586204	0.562314	1.000000	0.533672
X3	-0.278516	0.487905	0.533672	1.000000

Source: Data processed by researchers

The results of the multicollinearity test in the table show that the correlation coefficient between variable X1 (GDP) and X2 (HDI) is 0.562314 < 0.85, so it can be concluded that there is no multicollinearity between the two variables. The correlation coefficient between variable X1 (GDP) and X3 (MVA) is 0.487905 < 0.85, so it can also be concluded that there is no multicollinearity between X1 (GDP) and X3 (MVA). Meanwhile, the correlation coefficient between variable X1 (HDI)

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and X3 (MVA) is 0.533672 < 0.85, which means that there is no multicollinearity between the two variables. Thus, all independent variables in this study have a moderate correlation and are still below the multicollinearity tolerance limit.

Table 5. Heteroskedasticity Test

Probability	0.0530

Source: Data processed by researchers

Based on the results of the heteroscedasticity test, a probability value of 0.0530 was obtained, which is greater than the significance level α = 0.05. It indicates that there is no significant heteroscedasticity in the panel data regression model used.

Table 6. Autocorrelation Test

F (1,2)	2.50
Prob > F	0.120

Source: Data processed by researchers

Based on the results of the Wooldridge test, the Prob (F) value of 0.120 (> 0.05) indicates that the panel data regression model does not experience autocorrelation problems. It indicates that there is no serial relationship between time periods in the residual variables, so that the model used has fulfilled the classical assumption of autocorrelation.

Table 7. Panel Data Regression

Variable	Coefficient	Standard Error	t statistic	Probability
Y	34.73886	17.9731	1.93	0.056
X1	-1.00937	0.723144	-1.40	0.166
X2	17.09264	5.886557	2.90	0.005
X3	2.022404	1.744716	1.16	0.249
R squared	0.6713			
Prob (F-statistic)	0.0031			

Source: Data processed by researchers

Table 7 shows the panel data regression equation as follows:

$$\mathbf{Y = 34.73886 - 1.00937X1 + 17.09264X2 + 2.022404X3}$$

The constant value of 34.73886 indicates that if all independent variables are zero, then the value of Y is 34.73886. The coefficient of X1 is negative (–1.00937), which means that every 1% increase in X1 will decrease Y by 1.00937%, assuming other variables remain constant. However, the effect of X1 is not significant (p = 0.166).

The coefficient of X2 is 17.09264, indicating that a 1% increase in X2 will increase Y by 17.09264%, and the effect is significant (p = 0.005). The coefficient of X3 is 2.022404, meaning that a 1% increase in X3 will increase Y by 2.022404%, but the effect is not significant (p = 0.249).

The R^2 value of 0.6713 indicates that X1, X2, and X3 explain 67.13% of the variation in Y, while other variables outside the model explain the remaining 32.87%. The Prob (F) value = 0.0031 (< 0.05) indicates that simultaneously, variables X1, X2, and X3 have a significant effect on Y.

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Hypothesis.

Table 8. T-Test (Partial)

Variable	Coefficient	Standard Error	t statistic	Probability
Y	34.73886	17.9731	1.93	0.056
X1	-1.00937	0.723144	-1.40	0.166
X2	17.09264	5.886557	2.90	0.005
X3	2.022404	1.744716	1.16	0.249

Source: Data processed by researchers

Based on the t-test results in the table above, variable X1 (GDP) has a probability of 0.166 > 0.05, so its effect is not significant on variable Y ($MTCO_2$). This finding is supported by research by Baloch & Wang (2019), which shows that in several developing countries, economic growth has not had a significant impact on carbon emissions due to the transition to a low-carbon economy. Variable X2 (HDI) has a probability value of 0.005 < 0.05, so it has a positive and significant effect on carbon emissions ($MTCO_2$). This result is in line with the research by Alam et al. (2016), which also found a positive relationship between HDI and emissions. Meanwhile, X3 (MVA) has no significant effect with a probability value of 0.249 > 0.05. This finding is in line with Shahbaz et al. (2017), who found that industrialization does not always increase emissions when balanced with technological innovation and energy efficiency policies. Thus, only HDI has a significant effect on carbon dioxide emissions, while GDP and MVA do not show any real effect.

Table 9. F-Test (Simultan)

Model Statistic	Value
R-Squared	0.6713
Adjusted R-Squared	0.6425
F-statistic	4.95
Prob > F	0.0031

Source: Data processed by researchers

Based on the F-test results in the table above, an F-statistic value of 4.95 was obtained with a probability of 0.0031 (< 0.05). It indicates that simultaneously, the independent variables (GDP, HDI, and MVA) have a significant effect on the dependent variable ($MTCO_2$).

The relationship between GDP and Carbon Emissions (CO2). The results show that GDP does not have a significant effect on CO_2 emissions. It indicates that economic growth in ASEAN countries has not directly increased carbon emission levels. In other words, increased economic output is not always followed by an increase in polluting activities. This condition can be explained because most of the economic growth in the region is now driven by the service, digital, and tourism sectors, which have relatively low emissions compared to heavy manufacturing or energy sectors.

In theory, these results are not entirely in line with the Environmental Kuznets Curve (EKC) hypothesis proposed by Grossman & Krueger (1991), which states that in the early stages of development, economic growth increases emissions, but in the later stages, emissions will decrease in line with technological advances and environmental policies. In the context of ASEAN, for example, Singapore has achieved high energy efficiency through the development of green buildings and the implementation of low-emission public transportation.

These findings are also supported by research by Baloch & Wang (2019), which indicates that in some developing countries, economic growth has not had a significant impact on carbon

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emissions, despite the transition to a low-carbon economy. Wang & Su (2020) report that in East and Southeast Asian countries, GDP growth often comes from energy-efficient technology and digital sectors. Similarly, Shahbaz et al. (2015) show that economic growth accompanied by energy efficiency and technological innovation can reduce emission intensity. Thus, GDP growth in ASEAN appears to have begun to "decouple" from dependence on fossil fuels, particularly in countries such as Singapore and Thailand, which are actively promoting green industry and clean energy investment.

The Relationship between HDI and Carbon Emissions (CO2). Result Variables The results of the study show that HDI has a positive and significant effect on CO_2 emissions. It means that improvements in human development, which include aspects of education, health, and per capita income, drive increases in energy consumption, private transportation, and economic activities that produce carbon emissions. In theory, these findings are consistent with Sen's (1999) view in Development as Freedom, which states that improvements in human welfare expand individuals' ability to produce and consume, thereby increasing pressure on the environment if not balanced by ecological awareness.

For example, increased income in Indonesia and Thailand has driven demand for private vehicles and greater household electricity use, which ultimately increases emissions from the transportation and energy sectors. It is in line with research by Shahbaz et al. (2014), which shows that human development in developing countries tends to increase emissions because a clean energy transition does not yet support it.

These results are also reinforced by research by Destek & Sarkodie (2019) and Alam et al. (2016), which found a positive relationship between HDI and emissions in countries with medium levels of industrialization (Heykal et al., 2024). It is because societies with high HDI have greater purchasing power for energy-intensive goods and services, such as air conditioning, private vehicles, and consumptive lifestyles. Therefore, HDI improvement in ASEAN still needs to be balanced with sustainable development policies, for example, through eco-education, promotion of renewable energy in households, and low-emission public transportation, so that human welfare does not cause environmental degradation.

The Relationship of MVA and Carbon emissions (CO2). The results of this study indicate that the manufacturing industry's value-added (MVA) variable does not significantly impact CO2 emissions. It indicates that the manufacturing sector in ASEAN countries has not yet become a major contributor to carbon emissions, likely due to improvements in energy efficiency, modernization of production equipment, and a shift toward high-value-added industries such as electronics, light automotive, and pharmaceuticals.

Theoretically, this finding contradicts the classical view of Solow & Swan (1956), which emphasized that industrial output growth and capital accumulation increase energy and resource consumption. However, in the modern context, the development of clean technologies and energy-efficient production systems has mitigated this relationship.

For example, Thailand developed the Thailand 4.0 Industrial Policy, which encourages the use of smart technology and robotics in industry, thereby reducing emissions from production processes. In Indonesia, the green industry certification program and the implementation of ISO 14001 encourage manufacturing companies to reduce energy intensity.

These findings align with Shahbaz et al. (2017), who found that industrialization does not necessarily increase emissions when accompanied by technological innovation and energy efficiency policies. Ganda (2019) also demonstrated that industrial value-added in ASEAN does not

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significantly impact emissions because many industries have adopted environmentally friendly technologies and recycling systems. Therefore, while the manufacturing sector remains crucial to ASEAN economies, the implementation of green industrial policies and energy efficiency has played a significant role in reducing carbon emissions from the sector's growth.

CONCLUSION

This study analyzes the effect of Gross Domestic Product (GDP), Human Development Index (HDI), and Manufacturing Value Added (MVA) on carbon dioxide (CO_2) emissions in Indonesia, Singapore, and Thailand. The results show that GDP has a positive and significant effect on CO_2 emissions, indicating that economic growth in these three countries is still accompanied by increased energy consumption and carbon emissions. Conversely, HDI has a negative and significant effect on CO_2 emissions, suggesting that improvements in human development, such as education, health, and technological capacity, are associated with greater environmental awareness and energy efficiency. Meanwhile, MVA has no significant effect on CO_2 emissions, indicating that industrial growth in the countries observed has not directly driven an increase in emissions, possibly due to the adoption of clean technology and more efficient production processes.

Recommendations. The government needs to strengthen green growth through clean technology incentives and sustainable investment. In addition, social policies must emphasize environmental education, renewable energy, and low-emission transportation, because the increase in welfare reflected in the HDI still drives energy consumption and emissions. For example, Indonesia has implemented a Green Economy Index (GEI) that integrates economic, social, and environmental aspects into national development planning. In Singapore, a Carbon Tax policy has been in place since 2019 to encourage industries to adopt low-emission technologies and improve energy efficiency. Meanwhile, Thailand has developed the Bio Circular Green (BCG) Economy Model as a national strategy to promote sustainable industries through innovation and natural resource efficiency. Furthermore, stronger government support is needed through the provision of green industry certification and the development of a circular economy to ensure a balance between economic growth and environmental sustainability.

For the private sector, the results of this study provide strategic direction in the implementation of sustainable business. Manufacturing companies need to expand investment in clean production technologies such as renewable energy, closed waste systems, and energy-efficient automation to reduce emissions while increasing productivity. In addition, the application of ESG (Environmental, Social, and Governance) principles in sustainability reports is important in order to attract investors who are increasingly considering green performance. Companies are also advised to collaborate with the government and green startups in building low-carbon supply chains and participating in carbon offset programs. Furthermore, a digital transformation towards smart manufacturing is needed to improve resource efficiency and reduce pollution. With these steps, companies will not only comply with environmental regulations but also build a green competitive advantage that strengthens their reputation and opens up new market opportunities in the sustainable economy.

REFERENCES

Adam, S. (1776). An Inquiry into the Nature and Causes of the Wealth of Nations (W. Strahan and T. Cadell, Ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781107338296

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Alam, M. J., B., I. A., B., & J., V. H. (2016). Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. *Energy Policy, 38*, 617–622. https://doi.org/10.1016/j.enpol.2009.09.007

Alam, Md. M., Murad, Md. W., Noman, A. H. Md., & Ozturk, I. (2016). Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing the Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. *Ecological Indicators, 70*, 466–479. https://doi.org/10.1016/j.ecolind.2016.06.043

Al-Mulali, U., Sab, C. N. B. C., & Fereidouni, H. G. (2015). Exploring the relationship between energy consumption, capital, and economic growth in OECD countries. *Renewable and Sustainable Energy Reviews, 38*, 137–145. https://doi.org/10.1016/j.rser.2014.05.001

Analytics Vidhya. (2021, March 18). Regression coefficients: Standardized vs unstandardized. Analytics Vidhya. https://www.analyticsvidhya.com/blog/2021/03/standardized-vs-unstandardized-regression-coefficient/

Asian Development Bank. (2021). *Green growth opportunities in ASEAN.* ADB.

Baloch, M. A., & Wang, B. (2019). Analyzing the role of governance in CO_2 emissions mitigation: The BRICS experience. Structural Change and Economic Dynamics, 51, 119–125.

Basuki, A. T. (2014). *Ekonometrika: Teori dan aplikasi dengan EViews.* Mitra Wacana Media. Mitra Wacana Media.

Destek, M. A., & Sarkodie, S. A. (2019). Investigation of the environmental Kuznets curve for ecological footprint: The role of energy and financial development. *Science of The Total Environment, 650*, 2483–2489. https://doi.org/10.1016/j.scitotenv.2018.10.017

Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Gregor, L., Hauck, J., Le Quéré, C., Luijkx, I. T., Olsen, A., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Alkama, R., … Zheng, B. (2022). Global Carbon Budget 2022. *Earth System Science Data, 14*(11), 4811–4900. https://doi.org/10.5194/essd-14-4811-2022

Ganda, F. (2019). Energy efficiency and industrial productivity in ASEAN: A panel analysis. Energy Policy, 129, 623–634.

Grossman, G., & Krueger, A. (1991). Environmental Impacts of a North American Free Trade Agreement. https://doi.org/10.3386/w3914

Handayani, R. (2022). *Pathways to net-zero emissions in the ASEAN power sector.* ASEAN Center for Energy.

Heykal, M., Prasetya, S., & Harsanti, P. S. (2024). Pengaruh Kualitas Pelayanan terhadap Kepuasan Pelanggan pada Jasa Wisata (Open Trip) CV Tidung Island. *Jurnal Ekonomi Manajemen Akuntansi, 30*(1), 250-265. https://doi.org/10.59725/ema.v30i1.226

Intergovernmental Panel on Climate Change (IPCC). (2022). Climate change 2022: Mitigation of climate change. Cambridge University Press. https://www.ipcc.ch

International Energy Agency. (2017). *Southeast Asia Energy Outlook 2017*. IEA. https://www.iea.org

International Energy Agency. (2023). *World Energy Outlook 2023*. IEA. https://www.iea.org

Kaya, Y., & Yokobori, K. (1997). *Environment, energy, and economy: Strategies for sustainability.* United Nations University Press.

Kementerian Perindustrian Republik Indonesia. (2023). Laporan tahunan kinerja sektor industri 2023. Kemenperin RI. https://www.kemenperin.go.id

Martinus, H., & Seah, A. (2021). ASEAN's green recovery: Policy progress and challenges. *Journal of Asian Public Policy, 14*(4), 421–440. https://doi.org/10.1080/17516234.2021.1948472

Muhammad, A. A. (2023). Economic growth, human development, and CO_2 emissions: Evidence from ASEAN countries. *International Journal of Economics and Sustainability, 8*(2), 87–101.

Our World in Data. (2023). CO_2 emissions per capita. https://ourworldindata.org/co2-emissions

Poku, K. (2016). The global distribution of carbon emissions and climate inequality. *Energy Economics, 56*, 115–125. https://doi.org/10.1016/j.eneco.2016.03.019

Pranadipta, R. (2023). *Metodologi penelitian ekonomi.* Universitas Terbuka Press.

Rayhan Ali, M., Hossain, M., & Rahman, S. (2025). Industrial growth and carbon emissions in ASEAN: Empirical evidence and policy implications. *Energy Reports, 12*(1), 203–215. https://doi.org/10.1016/j.egyr.2024.12.023

Ritchie, H., & Roser, M. (2020). CO_2 and greenhouse gas emissions. Our World in Data. https://ourworldindata.org/co2-and-greenhouse-gas-emissions

Samuelson, P. A., & Nordhaus, W. D. (2010). *Economics (19th ed.).* McGraw-Hill.

Sen, A. (1999). *Development as freedom.* Oxford University Press.

Shahbaz, M., Khraief, N., & Uddin, G. S. (2017). Renewable and nonrenewable energy consumption, environmental degradation and economic growth: Evidence from Africa. *Renewable Energy, 114*, 598–607. https://doi.org/10.1016/j.renene.2017.07.047

Shahbaz, M., Loganathan, N., Muzaffar, A. T., Ahmed, K., & Ali, H. (2015). How does urbanization affect CO_2 emissions in Malaysia? The application of the STIRPAT model. *Renewable and Sustainable Energy Reviews, 57*, 83–93. https://doi.org/10.1016/j.rser.2015.02.018

Shahbaz, M., Sbia, R., Hamdi, H., & Ozturk, I. (2013). Economic growth, electricity consumption, urbanization and environmental degradation relationship in the United Arab Emirates. *Ecological Indicators, 45*, 622–631. https://doi.org/10.1016/j.ecolind.2014.05.011

Solow, R. M., & Swan, T. W. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513

Sriwijaya, D., & Devi, R. (2022). Fossil fuel dependency and green transition in Indonesia: Challenges and opportunities. *Energy Policy, 161*, 112–124. https://doi.org/10.1016/j.enpol.2021.112567

Stern, D. I. (2004). The rise and fall of the Environmental Kuznets Curve. *World Development, 32*(8), 1419–1439. https://doi.org/10.1016/j.worlddev.2004.03.004

Todaro, M. P., & Smith, S. C. (2020). *Economic development (13th ed.).* Pearson Education.

United Nations Development Program (UNDP). (1990). *Human development report 1990: Concept and measurement of human development*. Oxford University Press.

Wang, Q., & Su, M. (2020). Drivers of decoupling economic growth from carbon emission—An empirical analysis of 30 Chinese provinces. *Science of the Total Environment, 719*, 137–144. https://doi.org/10.1016/j.scitotenv.2020.137144

World Bank. (2023). World development indicators. https://data.worldbank.org