

Drivers of Carbon Intensity in Indonesia: Unpacking the Effects of FDI, Energy Imports, and Economic Growth

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Abstract: This study provides significant contributions to the literature by comprehensively examining the simultaneous effects of foreign direct investment (FDI), energy imports, and economic growth on carbon intensity in Indonesia during 2000–2022, using data from the World Bank and the International Energy Agency (IEA). By applying multiple linear regression analysis, the results reveal that the model has a coefficient of determination (R^2) of 0.797, indicating that the independent variables simultaneously explain 79.7% of the variation in carbon intensity. Partially, energy imports exert a negative and significant effect on carbon intensity, primarily through the substitution of coal with cleaner fuels such as liquefied natural gas (LNG) and oil, an aspect rarely discussed in previous Indonesian studies. In contrast, FDI demonstrates a positive and significant effect, reflecting the dominance of pollution-intensive sectors and weak environmental governance, while GDP growth shows no significant impact, suggesting that economic expansion alone has not led to improvements in energy efficiency or a transition to low-carbon sources. Overall, these findings highlight the dual role of FDI, the importance of energy imports in shaping emission dynamics, and the urgent need for stricter environmental governance, a more selective FDI policy oriented toward clean technology, and an accelerated energy transition to achieve sustainable and low-carbon economic growth.

Keywords: Carbon Intensity, Energy Import, Foreign Direct Investment, GDP Growth, Energy Transition, Sustainable Development.

Introduction

Global climate change poses a significant challenge for Indonesia, the largest economy in Southeast Asia, as it seeks to balance economic development with environmental sustainability. Carbon intensity, defined as the amount of carbon dioxide (CO_2) emissions per unit of energy consumption, is widely used to assess sustainable development. This indicator is considered more comprehensive than total emissions alone, as it accounts for energy efficiency in production and consumption processes. For developing countries like Indonesia, which still rely heavily on fossil fuels, carbon intensity presents a critical challenge in the transition toward a low-carbon economy.

The relationship between economic growth and environmental degradation is theoretically framed through the Environmental Kuznets Curve (EKC) (Grossman & Krueger, 1995), which posits that emissions rise in the early stages of economic growth and decline after reaching a turning point due to technological transformation and increased environmental awareness. However, empirical evidence from developing countries remains relatively mixed. For developing countries in Southeast Asia, including Indonesia—the region's largest economy—carbon intensity poses a major challenge. Heavy

reliance on fossil fuels, particularly coal and oil, has often linked economic growth with rising emissions. According to the International Energy Agency (IEA), Indonesia's carbon intensity fluctuated during 1990–2022, generally showing an upward trend. Overall, these developments suggest that Indonesia's economic expansion during this period remained heavily dependent on fossil fuels, with each growth phase typically accompanied by significant increases in carbon emissions. Carbon intensity data for 2000–2022 are presented in Figure 1.

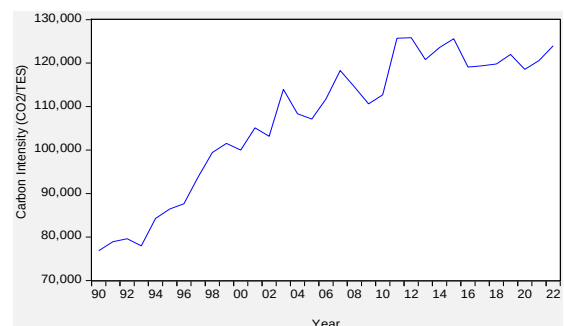


Figure 1. Carbon Intensity Trend in Indonesia (1990–2022)
Source: International Energy Agency (IEA), processed by authors

Between 1990 and 2012, carbon intensity increased from 76.848 to 125.835, followed by a temporary decline, before rising again post-COVID-19 to 123.966 in 2022. This pattern indicates

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that energy efficiency has not been structurally integrated into national economic growth. The trend is further reinforced by limited domestic energy supply, making energy imports—especially oil and coal—crucial, yet simultaneously heightening structural vulnerability to carbon intensity. The observed trends in carbon intensity in Indonesia are strongly influenced by governmental policies as well as prevailing economic conditions and activities. Several factors are suspected to affect carbon intensity, including foreign direct investment (FDI), energy imports, and economic growth. Indonesia's reliance on energy imports highlights the country's structural vulnerability to global energy supply. Rising energy imports indicate that domestic production has not yet met national demand, thereby driving the continued use of fossil fuels, which impacts carbon intensity. The energy dependency theory (Ozturk & Acaravci, 2010) suggests that limited domestic energy supply encourages countries to increase energy imports, which can exacerbate carbon intensity if imports are dominated by fossil fuels. In the context of Indonesia, the growing energy demand driven by economic growth and industrialization has not been fully met by domestic supply, resulting in significant increases in oil and coal imports (IEA, 2021). This situation complicates the transition toward clean energy, as fossil-fuel-based imports tend to increase emissions per unit of energy consumption.

Meanwhile, economic growth (GDP growth) remains a key determinant of development trajectories. According to the Environmental Kuznets Curve (EKC) hypothesis, emissions initially rise during early stages of economic growth but decline as income levels and environmental awareness increase (Grossman & Krueger, 1995). In addition to economic growth, FDI is regarded as a significant factor influencing emissions in a country. While FDI plays an important role in enhancing the economic growth of recipient countries, particularly developing countries, multiple studies confirm its positive impact on economic performance (Septia, 2024a; Septiani, 2024b; Marjanać & Grujić, 2022; Gökçeli et al., 2022; Fazaalloh, 2024; Rao et al., 2023; Khan et al., 2022; Gligorić et al., 2017). Despite its contribution to economic growth, FDI's environmental impact remains debated. The Pollution Haven Hypothesis (PHH) posits that FDI increases emissions by relocating pollution-intensive industries to countries with lax environmental regulations (Cole & Elliott, 2005); Lestari et al. (2025), whereas the Pollution Halo Hypothesis emphasizes FDI's potential to reduce emissions through the transfer of clean technologies (Eskeland & Harrison, 2003; Porter & van der Linde, 1995).

Empirical evidence in Indonesia is mixed: Saraswati et al. (2022) found that Foreign direct investment (FDI) increases energy intensity in the manufacturing sector, while Sari (2022) indicates that FDI can reduce CO₂ emissions in the long run. This complexity becomes more pronounced when external factors such as energy imports are considered, as studies by Zhou et al. (2018) and Saraswati et al. (2022) suggest that Foreign direct investment (FDI) can increase carbon intensity. Based on data from the World Bank and the International Energy Agency (IEA), total Foreign direct investment (FDI) flows, energy imports, and GDP growth in Indonesia exhibit year-to-year fluctuations (see Figure 1).

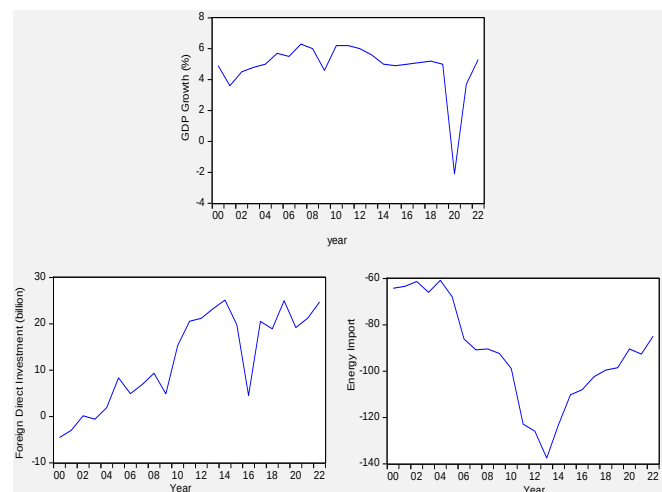


Figure 2. Trends of GDP Growth, Foreign Direct Investment, and Energy Imports in Indonesia (2000–2022)
Source: World Bank and International Energy Agency (IEA), processed by the authors

This phenomenon highlights that the transition toward a cleaner energy mix and improvements in energy efficiency have not yet been structurally realized. The high carbon intensity also indicates that economic growth, measured by Gross Domestic Product (GDP), has not been fully accompanied by gains in energy efficiency. This underscores both academic and practical urgency to empirically examine the relationships between macroeconomic factors—such as economic growth, foreign direct investment (FDI), and energy import dependency—and carbon intensity in Indonesia. Such analysis is critical not only to enrich the scientific literature on the nexus between economic development and environmental sustainability in developing countries, but also to provide evidence-based guidance for formulating effective green energy transition strategies.

Moreover, several international studies have highlighted the relevance of these factors. For instance, Apergis & Payne (2010) found that fossil energy consumption increases carbon emissions, while Paziienza (2019) demonstrated that FDI can reduce emissions through technology transfer. Shahbaz et al. (2019) reported that in Southeast Asia, economic growth drives emissions upward, but renewable energy policies can mitigate carbon intensity. At the national level, most studies still focus on total emissions rather than carbon intensity, and the role of energy imports remains relatively underexplored despite its importance given Indonesia's reliance on imported fossil fuels. Academically, this study contributes to the literature on sustainable development in developing countries, particularly regarding carbon intensity dynamics. Practically, the findings are expected to inform policy design for energy transition and decarbonization in Indonesia, ensuring that economic growth aligns with environmental sustainability.

Method

This research focuses on Indonesia as the object of study, covering the period from 2000 to 2022. The main objective is to analyze the impact of energy imports, foreign direct investment (FDI), and GDP growth on carbon intensity in Indonesia during the period. The study utilizes annual time series data (2000–2022), with carbon intensity as the dependent variable and energy imports,

FDI, and GDP growth as the independent variables. Data is sourced from official agencies, including the World Bank and the International Energy Agency (IEA). The analysis is conducted using multiple linear regression, with the following details:

$$CARB_INT = \beta_0 + \beta_1 Energy_IMP_t + \beta_2 FDI_t + \beta_3 GDP_GR_t + \varepsilon_t$$

Where :

CARB_INT represents carbon intensity (CO₂/TEST)

Energy_IMP is energy imports (% of energy use)

FDI foreign direct investment (Billion USD)

GDP_GR is GDP growth (%)

β_0 is the intercept

$\beta_1, \beta_2, \beta_3$ are regression coefficients for energy imports, FDI, and GDP growth, respectively

t represents the time period (2000–2022)

ε is Error term

Prior to regression analysis, multicollinearity was tested using Pearson correlation among independent variables. High correlations ($r > 0.8$) indicate potential multicollinearity that may affect coefficient estimates (Gujarati & Porter, 2009; Wooldridge, 2016). Subsequently, the regression model was estimated using Ordinary Least Squares (OLS), and model validity was assessed through the Breusch-Godfrey Serial Correlation LM Test for autocorrelation and White and Breusch-Pagan tests for heteroskedasticity. After confirming classical assumptions, the significance of regression coefficients was tested using the t-test for individual effects and the F-test for overall model significance. Regression results were analyzed to determine the direction and magnitude of each independent variable's effect on carbon intensity, while the R² value was used to evaluate the proportion of variation in carbon intensity explained by the independent variables.

Results and Discussions

The normality test confirms that the dataset used in this study is normally distributed, as indicated by a Jarque-Bera probability of 0.8233, exceeding the 5% significance threshold ($\alpha = 0.05$). These results, presented in Figure 3, validate the suitability of the data for regression analysis.

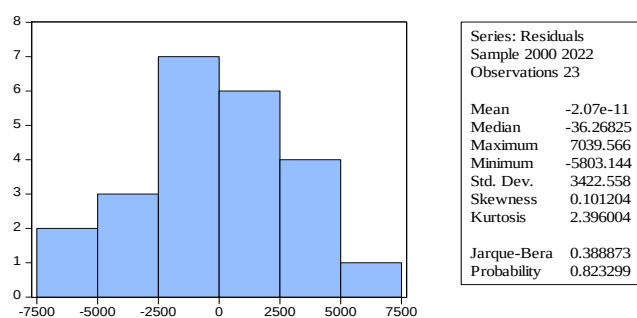


Figure 3. Normality Test Results
Source: Processed research data (2025)

The autocorrelation test shows a Chi-Square probability of 0.0843, exceeding the 5% significance level ($\alpha = 0.05$), indicating that the regression model is free from autocorrelation. Results are presented in Table 1..

Table 1. Autocorrelation Test Results

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	2.329662	Prob. F(2,17)	0.1276
Obs*R-squared	4.947728	Prob. Chi-Square(2)	0.0843

Source: Research data (Processed 2025)

The regression model was also subjected to a heteroskedasticity test. The results indicate no evidence of heteroskedasticity, as shown by the Chi-Square probability of Obs*R-squared = 0.3586. The heteroskedasticity test results are presented in Table 2..

Table 2. Heteroskedasticity Test Results

Heteroskedasticity Test: Breusch-Pagan-Godfrey:			
F-statistic	1.031758	Prob. F(3,19)	0.4009
Obs*R-squared	3.222016	Prob. Chi-Square(3)	0.3586

Source: Research data (Processed 2025)

Finally, a multicollinearity test was conducted to examine the relationships among the independent variables. The results are presented in Table 3

Table 3. Multicollinearity Test Results

Variable	Energy_Import	FDI	GDP_GR
Energy_IMP	1.000000	-0.754883	-0.194076
FDI	-0.754883	1.000000	-0.020118
GDP_GR	-0.194076	-0.020118	1.000000

Source : Research data (Processed, 2025)

Furthermore, the regression results of this study can be seen in Table 4, providing insights into the partial and simultaneous effects of energy imports, foreign direct investment (FDI), and GDP growth on carbon intensity in Indonesia during 2000–2022.

Table 4. Multiple Linear Regression Results

Variable	Coeff.	Std. Error	t-Statistic	Prob.
C	98500.66	4236.411	23.25097	0.0000
Energy_IMP	-130.8408	56.98419	-2.296090	0.0332
FDI	431.6254	123.6170	3.491634	0.0024
GDP_GR	10.46855	493.8344	0.021199	0.9833

R² : 0.797428

Adj.R² : 0.765442

F-statistic : 24.93121

Prob (F-Statistic) : 0.000001

Source : Research Data (processed, 2025)

Based on the test results in Table 4, the regression equation is obtained as follows:

$$CARB_INT = 985000.66 - 130.8408 EnergyIMP + 431.6254 FDI + 10.46855 GDP_GR + \varepsilon_i$$

Hypothesis Test

Based on the regression results in Table 4, it is found that this research model has a high coefficient of determination with R-squared of 0.797 and Adjusted R-squared of 0.765, which means that 79.7% of carbon intensity variation can be explained simultaneously by energy import, FDI, and GDP growth, while the remaining 20.3% is influenced by other factors outside the model. Meanwhile, based on the F test, the result shows that the F-statistic value is 24.93 with the probability of F_Statistic of 0.001 or smaller than $\alpha = 5\%$, so it can be concluded that simultaneously the variables of energy import, FDI, and GDP growth have a significant positive effect on carbon intensity. Furthermore, based on the t-test, it is known that the t-statistic value of energy import variable is -2.30 with a probability of 0.033. This shows that energy import variable has a significant negative effect on carbon intensity at $\alpha=5\%$. In contrast, FDI has a t-statistic of 3.49 with a probability of 0.002. This result shows that FDI has a significant positive effect on carbon intensity at $\alpha = 5\%$. Meanwhile, the GDP

growth variable does not show a significant effect on carbon intensity because the t-statistic probability value of the GDP Growth variable is 0.983 or greater than $\alpha = 5\%$.

Discussion

Based on the regression results, the coefficient value of energy import variable is -130.84 and the t-statistic probability of energy import variable is 0.0332. This result shows that energy imports have a significant positive effect on carbon intensity in Indonesia at $\alpha = 5\%$. The result shows that the variable of energy imports has a significant effect on carbon intensity with a negative coefficient. This finding indicates that an increase in energy imports actually contributes to a decrease in carbon intensity in Indonesia. Theoretically, this condition can be explained by the structure of Indonesia's energy mix which is still highly dependent on domestic coal as the main energy source. When energy imports increase, especially oil and liquefied natural gas, there is a partial substitution from coal to relatively cleaner energy, so that emission intensity per unit of economic output decreases. This finding confirms that an increase in energy imports actually contributes to a decrease in carbon intensity in Indonesia. This phenomenon can be explained by the fact that imported energy generally has a lower carbon intensity than domestic coal-based energy, such as liquefied natural gas and oil.

Moreover, the Indonesian government's concrete policies support this interpretation. Currently, the government announced plans to shift around 60% of energy imports from Singapore to the United States, including oil, LPG and Liquefied Natural Gas (LNG) not by increasing import volumes, but by changing suppliers to obtain energy with better quality and standards (Reuters, 2025). In addition, a USD 1.5 billion project is underway to expand the distribution of Liquefied Natural Gas to diesel-fired plants in eastern Indonesia (Reuters, 2025). This project enables the replacement of domestic diesel with more environmentally friendly Liquefied Natural Gas (LNG), which is in line with empirical results that energy imports can lower carbon intensity. In this case, energy imports serve as a decarbonization instrument through the substitution of carbon-intensive domestic energy. This result is in line with previous research which found that energy diversification through natural gas imports plays a role in reducing carbon emissions in developing countries (Shahbaz et al., 2019).

Furthermore, based on the regression result, the coefficient value of foreign direct investment (FDI) variable is 431.62 with probability 0.0024. This shows that FDI has a positive and significant effect on energy intensity in Indonesia at $\alpha = 5\%$. This means that when FDI increases by 1 billion USD, the carbon intensity increases by 431.62. FDI has a complex impact on the environment, because on the one hand it can encourage sustainable development through the transfer of clean technology, but on the other hand it also has the potential to increase pollution. Ji (2015) showed that the relationship between FDI and pollution in China follows the EKC pattern, but weak environmental regulation makes emission control ineffective. Furthermore, Zhang et al. (2023) confirmed that FDI significantly transfers carbon emissions to low- and middle-income countries through the relocation of polluting industries and changes in energy structure. This finding is relevant for Indonesia, because although FDI plays an important role in

supporting economic growth, without strict environmental regulations and the application of clean technology, FDI inflows have the potential to increase national carbon intensity.

These results suggest that foreign investment inflows tend to increase emissions relative to economic output. The phenomenon is in line with the pollution haven hypothesis, where developing countries such as Indonesia are destinations for foreign investment in energy-intensive and polluting sectors, including mining, heavy manufacturing, and fossil-based energy infrastructure. However, empirical findings on the impact of FDI on carbon emissions are contradictory: some studies find that FDI can reduce emissions through the pollution halo effect and increased energy efficiency (Li et al., 2023); (Tian, 2023); Perkins et al., (2009). According to Yi et.al. (2023) Foreign investment can contribute to improving energy efficiency in the manufacturing sector. Meanwhile, other research results show that FDI increases emissions by moving polluting industries to developing countries with looser environmental regulations (Jiang, 2019). This difference in findings indicates that the effects of FDI are highly contextualised and depend on the structural conditions and environmental policies of recipient countries. Thus, although FDI plays an important role in promoting economic growth, the impact of foreign direct investment activities on the environment cannot be ignored. This shows that FDI flows to Indonesia during the study period have not consistently brought environmentally friendly technologies that can reduce carbon emissions.

Foreign Direct Investment (FDI) has a dual role in carbon emissions. On the one hand, FDI can increase emissions if it flows to pollution-intensive sectors (Pollution Haven Hypothesis), as shown by Zhou et al. (2018) who found an increase in carbon intensity through the implicit trade carbon mechanism even though in the long run it has the potential to reduce it. Guo et al. (1995) also confirmed that large foreign capital flows support industrial adjustment, but carbon leakage can weaken the effectiveness of emission reduction policies and increase global emissions. Consistent with these findings, Munir & Ameer (2020); Pazienza (2019); Corneo et.al (2025); show a positive and significant relationship between FDI and CO₂ emissions, especially in the manufacturing sector of OECD countries. However, these results differ from Zhang et al. (2016) who emphasise that FDI can also reduce long-term emissions through technology transfer. Therefore, the impact of FDI on emissions depends on the direction of the flow, the destination sector, and the accompanying mechanism.

Meanwhile, the GDP Growth variable has a coefficient of 10.46855 with a probability of 0.9833. This result shows that the variable GDP Growth or economic growth has no effect on carbon intensity at $\alpha = 5\%$. This means that changes in economic growth in Indonesia during the period 2000-2022 have no effect on carbon intensity. In this case, although the economy is growing, the pattern of energy consumption and energy use efficiency still has not experienced significant changes in overcoming carbon intensity. Based on the data, Indonesia's GDP growth is constantly fluctuating, especially during the 2008-2009 global financial crisis and the COVID-19 pandemic in 2020, which showed negative growth. However, despite the economic contraction in that period, carbon intensity did not decrease drastically. In 2020, the carbon

intensity is still relatively high at 118.549, indicating that a decrease in economic output does not necessarily reduce emissions per unit of energy used.

Actually, there are currently no studies that explicitly find an insignificant effect of GDP growth on carbon intensity. Existing evidence is only indicative, such as a panel of 70 countries (1970-2013) showing an elasticity of ≈ 1 without formal tests Wang et.al (2019), as well as estimates for Latin America and the Caribbean with a consumption elasticity of around 0.95 (Balza, et.al, 2024). In contrast, some studies show a decrease in carbon intensity with economic growth (Pathiranage, 2024); (Balza, et.al, 2024). Other studies also find no causality from GDP to CO₂ (Awais et.al (2024), (Özden & Beşe, 2021). Thus, the evidence favours a moderate decrease in carbon intensity, while directly tested insignificant findings are still rare.

The results of this study are in line with several previous studies that emphasise that the relationship between economic growth and carbon intensity in developing countries is often weak or insignificant. Iskandar (2019) stated that the Environmental Kuznets Curve (EKC) is not consistently proven in Indonesia, which suggests that economic growth has not been followed by improvements in energy efficiency or a transition to low carbon energy sources. Based on the Environmental Kuznets Curve (EKC) theory, there is an inverted U-shaped curve between economic growth and environmental pressure. Pollution increases in the early stages of development, then decreases due to technological efficiency and increased institutional capacity (Grossman & Krueger, 1991). As the results of research conducted by Ozturk & Al-Mulali (2015) and Shahbaz et al. (2019) confirm the EKC pattern in several developing countries, but its implementation in Indonesia still needs deeper exploration and long term analysis.

Therefore, it can be concluded that Indonesia's economic growth during 2000-2022 is mostly driven by sectors that are still fossil energy intensive, thus not significantly reducing carbon intensity. This confirms the importance of economic decarbonisation policies, such as renewable energy transition, energy efficiency in the industrial sector, as well as the implementation of clean technology standards to ensure that future economic growth can take place sustainably without increasing the environmental burden.

Conclusion

Based on the regression results, this study concludes that energy imports significantly reduce carbon intensity in Indonesia, mainly through the substitution of coal with relatively cleaner fuels such as LNG and oil. In contrast, foreign direct investment (FDI) has a positive and significant effect on carbon intensity, reflecting the dominance of pollution-intensive sectors as well as weak environmental regulations in accommodating foreign capital. Meanwhile, GDP growth has no significant effect on carbon intensity, indicating that Indonesia's economic expansion over the 2000-2022 period has not been accompanied by structural improvements in energy efficiency or a transition to low-carbon energy sources. These findings emphasise the need for stricter environmental governance, more selective and clean technology-oriented FDI policies, and an accelerated energy transition to ensure sustainable economic growth while reducing carbon emissions.

References

1. Gujarati, D. N., & Porter, D. C. (2009). Basic econometrics (5th ed.). New York, NY: McGraw-Hill.
2. Acaravci, A., & Ozturk, I. (2010). On the relationship between energy consumption, CO₂ emissions and economic growth in Europe. *Energy*, 35(12), 5412–5420.
3. Apergis, N., & Payne, J. (2010). Renewable Energy Consumption And Economic Growth: Evidence From A Panel Of OECD Countries. *Energy Policy*, 38(1), 656–660.
4. Awais, M., Akram, S., & Safdar, H. (2024). Exploring the Relationship between CO₂ Emission, Economic Growth, and Energy Consumption at Aggregate Level: A Panel Data Analysis. *Journal of Economic Impact*, 6(3), 218–225.
5. Balza, L.H., Heras-Recuero, Matias, D., & Yepez-Garcia, R.A. (2024). Green or Growth? Understanding The Relationship Between Economic Growth and CO₂ Emission. Inter-American Development Bank Energy Division.
6. Cole, M.A., & Elliott, R.J.R. (2005). FDI and the Capital Intensity of Dirty Sectors: A Missing Piece of the Pollution Haven Puzzle. *Review of Development Economics*, 9, 530–548.
7. Corneo, T. A., Afsari, A. T., Handayani, L. D., Deli, V. R., & Septriani, S. (2025). ANALISIS PENGARUH INVESTASI DAN PERTUMBUHAN EKONOMI TERHADAP DEGRADASI LINGKUNGAN DI INDONESIA. *Salam (Islamic Economics Journal)*, 6(1), 204-223.
8. Dewi, F. D., & Septriani, S. (2023). Analysis of factors affecting foreign direct investment in ASEAN countries. *ISAR Journal of Economics and Business Management*, 1(6), 36–40.
9. Elish, E. (2022). Political and productive capacity characteristics as outward foreign direct investment push factors from BRICS countries. *Humanities & Social Sciences Communications*, 9(1), 1–10.
10. Eskeland, G.S., & Harrison, A.E. (2003). Moving to greener pastures? Multinationals and the pollution haven hypothesis. *Journal of Development Economics*, 70(1), 1–13.
11. Fazaaloh, A.M. (2024). FDI and economic growth in Indonesia: a provincial and sectoral analysis. *Economic Structures*, 13, 3.
12. Gligorić, D., Borović, Z., & Vujanić, V. (2017). Impact of foreign direct investment on the economic growth: the case of Commonwealth of Independent States. *Proceedings of the Faculty of Economics in East Sarajevo*, 6, 23–35.
13. Gökçeli, E., Fidrmuc, J., & Ghosh, S. (2022). Effect of Foreign Direct Investment on Economic Growth and Domestic Investment: Evidence from OECD Countries. *European Journal of Business Science and Technology*.
14. Grossman, G. M., & Krueger, A. B. (1991). Environmental Impacts of a North American Free Trade Agreement. National Bureau of Economic Research Working Paper, No. 3194. Cambridge, MA: NBER.
15. Grossman, G. M., & Krueger, A. B. (1995). Economic Growth and the Environment. *The Quarterly Journal of Economics*, 110(2), 353–377.
16. Guo, K., & Li, H. (1995). Zhongguo duiwai kaifang diqu chanyi yanjiu [A study of regional variations in China's opening to the outside]. *China Industrial Economy*, 61, 8
17. IEA. An Energy Sector Roadmap to Net Zero Emissions in Indonesia. Executive Summary IEA.

18. International Energy Agency. (2021). World energy outlook 2021. Paris: OECD/IEA.
19. Iskandar, A. (2019). Economic Growth and CO2 Emissions in Indonesia: Investigating the Environmental Kuznets Curve Hypothesis Existence. *Jurnal BPPK*, 12(1), 42–52.
20. Jeutang, P., & Kesse, K. (2021). A novel measure of political risk and foreign direct investment inflows. *Journal of Risk and Financial Management*, 14, 482.
21. Jiang, X., & Zhao, S. (2019). Does FDI Suppress Carbon Emissions from the Perspective of Dual Environmental Regulation: An Empirical Study Based on Dynamic System GMM Estimation and Threshold Model. *International Trade*, 115–130.
22. Ji, Z., & Lai, X. (2015). Study on the Impact of FDI Scale on Environmental Pollution in China: An empirical test based on 30 Provincial Panel Data Models. *World Economic Research*, 56–64.
23. Khan, H., Weili, L., & Khan, I. (2022). The role of institutional quality in FDI inflows and carbon emission reduction: evidence from the global developing and Belt Road Initiative countries. *Environmental Science and Pollution Research International*, 29(20), 30594–30621.
24. Le, A.N.N., Pham, H., Pham, D.T.N., & Duong, D. (2023). Political stability and foreign direct investment inflows in 25 Asia-Pacific countries: the moderating role of trade openness. *Humanities and Social Sciences Communications*, 10, 606.
25. Lestari, W., Angraini, C. P., Apriyanti, W., Rifa'ah, A. S., & Septriani, S. (2025). Determinasi Kualitas Udara pada Wilayah Pertambangan: Bukti Empiris dari Peran PDRB, Produksi Batubara, dan Kepadatan Kendaraan Truk di Indonesia. *Salam (Islamic Economics Journal)*, 6(1), 224–237.
26. Li, Y. (2023). Analysis of the impact of Foreign Direct Investment on China's Carbon Emission Pollution from the perspective of environmental regulation. *Journal of Beijing Forestry University Social Sciences*, 22(2), 16–25.
27. Marjanać, D., & Grujić, M. (2021). Does Foreign Direct Investment Lead To Economic Growth? Evidence From Developed Countries, Developing Countries, And Least Developed Countries. *Proceeding of The Faculty of Economics in East Sarajevo*, 10(23).
28. Munir, K., & Ameer, A. (2020). Nonlinear Effect of FDI, Economic Growth, and Industrialization on Environmental Quality. *Management of Environmental Quality: An International Journal*, 31(1), 223–234.
29. Ozturk, I., & Al-Mulali, U. (2015). Natural Gas Consumption And Economic Growth Nexus: Panel Data Analysis For GCC Countries. *Renewable and Sustainable Energy Reviews*, 51(C), 998–1003.
30. Özden, C., & Beşe, E. (2021). Environmental Kuznets Curve (EKC) in Australia: Evidence from Nonlinear ARDL Model with a Structural Break. *Polish Journal of Environmental Studies*, 30(3), 2245–2254.
31. Pathiranage, H. S. K. (2024). Navigating the trade-offs between economic growth and environmental sustainability: A global analysis of long-term trends and strategic policies. *Sustainable Environment*, 10(1).
32. Paziienza, P. (2019). The impact of FDI in the OECD manufacturing sector on CO2 emission: Evidence and policy issues. *Environmental Impact Assessment Review*, 77, 60–68.
33. Perkins, R., & Neumayer, E. (2009). Transnational linkages and the spillover of environment-efficiency into developing countries. *Global Environmental Change*, 19(3), 375–383.
34. Rashid, M., Looi, X.H., & Wong, S.J. (2017). Political stability and FDI in the most competitive Asia Pacific countries. *Journal of Financial Economic Policy*, 9(2), 140–155.
35. Rao, D.T., Sethi, N., Dash, D.P., & Bhujabal, P. (2023). Foreign aid, FDI and economic growth in Southeast Asia and South Asia. *Global Business Review*, 24(1), 31–47.
36. Reuters. (2025). Indonesia embarks on long-stalled LNG push to displace diesel in power plants. www.reuters.com
37. Sabir, S., Rafique, A., & Abbas, K. (2019). Institutions and FDI: evidence from developed and developing countries. *Financial Innovation*, 5(1), 1–20.
38. Saraswati, A., Hartono, D., & Indriyani, W. (2022). The impact of FDI on energy intensity: a spatial econometric analysis of Indonesian provinces. *Journal of Environmental Studies and Sciences*, 12(4), 853–869.
39. Satria, R., & Al Putra, F.A. (2018). Evaluation towards Foreign Direct Investment (FDI) in Indonesia and Its Relation with Democracy after 20 Years of the Collapse of Orde Baru. *Advances in Social Science, Education and Humanities Research*, 241.
40. Septriani, S., (2024). HOW FDI, EXPORT AND PRODUCTIVE-AGE POPULATION INFLUENCE GRDP: INSIGHTS FROM INDONESIA'S ECONOMIC DATA. *ISAR Journal of Economics and Business Management*, 2(12), 63-68.
41. Septriani, S. POLITICAL RISK INDICATORS AND FOREIGN DIRECT INVESTMENT (FDI) ATTRACTION IN INDONESIA.
42. Shahbaz, M., Shafiullah, M., & Mahalik, M. K. (2019). The dynamics of financial development, globalisation, economic growth and life expectancy in sub-Saharan Africa. *Australian Economic Papers*, 58(4), 444–479.
43. Tian, Z., & Yunyun, W. (2023). How does foreign direct investment affect carbon productivity? *Ecological Economics*, 39(10), 13–23.
44. Wang, R., Assenova, V. A., & Hertwich, E. (2019, April 23). Empirical Explanations of Carbon Mitigation during Periods of Economic Growth.
45. Xu, dkk. (2017). Does FDI affect carbon intensity? New evidence from dynamic panel analysis. *International Journal of Climate Change Strategies and Management*.
46. Yu, S., Qian, X., & Liu, T. (2019). Belt and road initiatives and Chinese firms' outward foreign direct investment. *Emerging Markets Review*, 41, 100629.
47. Yi, J., Hou, Y., & Zhang, Z.Z. (2023). The impact of foreign direct investment (FDI) on China's manufacturing carbon emissions. *Innovation and Green Development*, 2(4).
48. Zhang, C., & Zhou, X. (2016). Does foreign direct investment lead to lower CO2 emissions? Evidence from a regional analysis in China. *Renewable and Sustainable Energy Reviews*, 58, 943–951.
49. Zhang, H., Abd Hakim, T., & Mohd Fikri Lai, A.A. (2024). FDI Impact on China's Sectoral Performance: A Panel

- Cointegration and Causality Analysis. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*.
49. Zhang, Y., & Xia, Y. (2023). Carbon emission effects and impact mechanisms of foreign direct investment. *Shanghai Economic Research*, 8, 70–84.
 50. Zhou, Y., Fu, J., Kong, Y., & Wu, R. (2018). How Foreign Direct Investment Influences Carbon Emissions, Based on the Empirical Analysis of Chinese Urban Data. *Sustainability*, 10(7), 2163.