Journal of Economics, Finance and Management Studies

ISSN (print): 2644-0490, ISSN (online): 2644-0504

Volume 07 Issue 09 September 2024

Article DOI: 10.47191/jefms/v7-i9-06, Impact Factor: 8.044

Page No: 5525-5531

Economic and Environmental Degradation in ASEAN: A Focus on Indonesia, Singapore, and Myanmar

Sarindang Suci Ramadanti[1], Azwardi[2], Muhammad Subardin[3]

[1,2,3] Department of Economic and Development, Faculty of Economics, Sriwijaya University, Indonesia.

ABSTRACT: This study aims to analyze the determinants of greenhouse gas emissions in several ASEAN countries. The research utilizes secondary data from the World Bank covering the period from 1990 to 2019, employing panel data regression with Fixed Effect Model (FEM) estimation. The findings reveal that all independent variables in the study have a significant relationship with CO2 emissions, with coefficients below 1, indicating an inelastic effect. Specifically, higher GDP per capita increases CO2 emissions, while higher FDI reduces them. This suggests that while economic growth contributes to higher CO2 emissions, foreign investment may help reduce emissions. It is important to note that these results are specific to the countries studied (Indonesia, Singapore, and Myanmar) and cannot be generalized to other countries.

KEYWORDS: Sustainable Development Goals, Economic, GDP perCapita, Foreign Direct Investment, Environment

I. INTRODUCTION

CO2 carbon emissions are one of the main contributors to global climate change, caused by various human activities such as fossil fuel burning, deforestation, and industrialization [1], [2]. In recent years, the increase in CO2 emissions has become a global concern due to its significant impact on global warming, climate change, which is one of the goals of the development goals [3]. Various efforts have been made at the international, national, and local levels to reduce CO2 emissions, including the implementation of renewable energy policies, improving energy efficiency, and developing environmentally friendly technologies [4]. However, despite many efforts to reduce emissions, atmospheric CO2 levels continue to rise, especially in developing countries that are experiencing rapid economic growth [5].

In the Southeast Asian region, the Association of Southeast Asian Nations (ASEAN) has become one of the most dynamic economic blocs in the world [6]. ASEAN consists of ten member countries that have diverse economic, social, and political characteristics. The rapid growth of the ASEAN economy has made it an important contributor to the global economy. In 2023, ASEAN accounted for about 3.4 percent of the global Gross Domestic Product (GDP), with a total GDP of more than $3.3 trillion [7]. This growth is driven by a variety of factors, including a large and growing population, rapid urbanization, and growing regional economic integration [8]. Despite experiencing significant economic growth, ASEAN still has one of the lowest CO2 emissions per capita in the world, at only 3.9 tons of CO2 per capita. This figure is lower than the global average of 4.8 tons of CO2, almost half of China (7.1 tons of CO2), and less than a quarter of the United States (14.0 tons of CO2) [9].

ASEAN is an attractive investment destination for outside investors due to its relative political stability, large market potential, and increasingly open economic policies [10]. Foreign Direct Investment (FDI) in ASEAN has shown a significant upward trend, with ASEAN being one of the top FDI destinations in the world. Cooperation among ASEAN members in attracting FDI, such as through the establishment of the ASEAN Free Trade Area (AFTA) and the ASEAN Economic Community (AEC), has strengthened the region's attractiveness as a global investment hub [11]. FDI plays an important role in determining economic and environmental dynamics in ASEAN. Previous literature has shown that the impact of FDI on CO2 emissions can vary depending on the investment sector and environmental policies of the recipient country. FDI can drive economic growth through technology transfer and increased production capacity, which can increase CO2 emissions if not balanced with environmentally friendly practices [12],

[13]. Meanwhile, FDI can also be a driver for the adoption of more efficient and cleaner technologies, especially if investors implement high environmental standards [14], [15]. The differences between the results of previous studies emphasize the need for further research in ASEAN.

Economic and Environmental Degradation in ASEAN: A Focus on Indonesia, Singapore, and Myanmar

Economic growth reflected in an increase in Gross Domestic Product (GDP) per capita is often associated with increased CO2 emissions, especially in developing countries. In developing countries, an increase in GDP per capita is generally accompanied by an increase in industrial activity, urbanization, and energy consumption, all of which significantly contribute to an increase in CO2 emissions [16], [17]. This phenomenon shows that while economic growth brings benefits in terms of improving living standards and reducing poverty, it also brings with it the challenge of environmental degradation. Meanwhile, highincome countries face different challenges, especially in balancing sustainable economic growth with environmental efforts, such as through the implementation of green technologies and clean energy policies. Developed countries often have the financial and technological capacity to reduce CO2 emissions through innovation and strict regulation, but still face a dilemma between economic growth and environmental protection [18]. These dynamic differences underscore the importance of in-depth research to understand the relationship between economic growth and CO2 emissions.

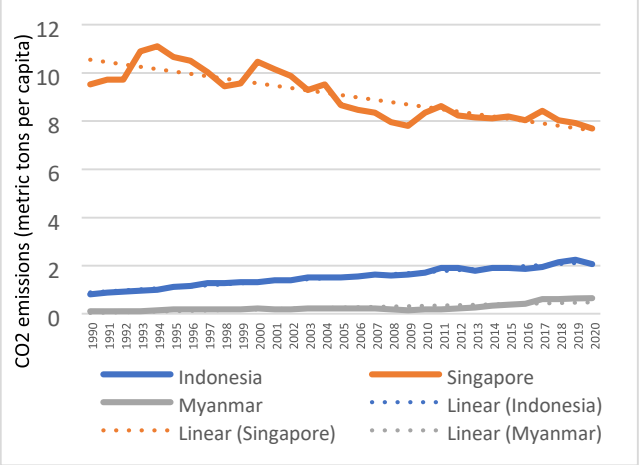

Figure 1. Selected CO2 emissions per capita in ASEAN
Source: *World Bank, data processed, (2024)*

Several previous studies have also shown a link between economic growth and CO2 emissions. Such as research showing that increasing GDP per capita has a positive impact on CO2 emissions, especially in developing countries [19], [20]. This result is also supported by another study that reveals that countries with rapid industrialization tend to have higher CO2 emissions due to increased consumption of fossil-based energy [21]. On the other hand, other studies also found that FDI can also contribute to reducing emissions through cleaner and more efficient technology transfer [22], [23].

This research specifically highlights three ASEAN countries, namely Singapore, Indonesia, and Myanmar. The samples were selected based on variations in their per capita income and CO2 emissions levels. Singapore, as a high-income country, recorded the highest per capita CO2 emission rate among the three countries (Figure 1). Power plants are the main source of carbon emissions in Singapore, accounting for about 40 percent of total emissions today [24]. Due to the limitations in utilizing alternative energy sources, Singapore relies heavily on natural gas imports to meet its electricity needs. However, Singapore has shown a downward trend in CO2 emissions, an interesting phenomenon that needs to be studied further, especially with regard to policies that have succeeded in reducing emissions as part of climate change mitigation efforts. Indonesia, with a middle-income economy or classified as an emerging market, is second in terms of CO2 emissions per capita. Most of Indonesia's CO2 emissions come from the burning of fossil fuels such as coal, oil, and natural gas, which are used for power generation as well as fuel for vehicles and engines [25]. Meanwhile, Myanmar is still in the early stages of economic development, having the lowest per capita CO2 emission levels, reflecting the growing scale of industrialization and energy consumption.

The latest of the study lies in its focus on three ASEAN countries strategically selected to represent different economic spectrums—Singapore as a high-income country, Indonesia as a middle-income country, and Myanmar as a low-income country. As such, the study not only provides insight into how GDP per capita and FDI affect CO2 emissions within individual countries, but also allows for indepth comparisons regarding economic growth dynamics and environmental impacts across income categories in ASEAN. By utilizing the regression of panel data of the fixed effect model, this study was able to examine the differences between countries. This approach makes a significant contribution to the existing literature, as it is able to identify unique patterns and similarities in the relationship between economic growth, FDI, and CO2 emissions in countries with different levels of development.

The rest of this research is described as follows. The second part examines concepts, theories, and previous research. The third part discusses the data, operational variables, models, and methods to be used. The fourth part discusses the results and discussions. The fifth section concludes the findings and some implications.

II. LITERATURE REVIEW

Several studies suggest that economic activity may lead environment degradation. The study by Anwar et al. (2021)[26] investigates the macroeconomic determinants of carbon dioxide (CO2) emissions in G-7 countries, emphasizing the roles of technological innovation and institutional quality. The findings reveal that technological advancements and improvements in institutional quality are crucial in influencing CO2 emissions. Technological innovation contributes to emission reductions by promoting more efficient and cleaner production methods, while high-quality institutions facilitate better implementation and enforcement of environmental policies. The study underscores the importance of integrating technological progress and robust institutional frameworks into environmental strategies to effectively manage and mitigate CO2 emissions.

Shahbaz et al. (2015)[27] examine how foreign direct investment (FDI) impacts environmental quality across various income levels. They find that FDI's effect varies by income level; in high-income countries, it tends to have a less negative or even positive impact on environmental quality due to advanced technologies and stringent regulations. Conversely, in middle- and low-income countries, FDI is often linked to environmental degradation due to lower standards and less advanced technologies. The study by Bashir et al. (2021)[28] explores the relationships between urbanization, economic growth, energy consumption, and CO2 emissions in Indonesia. The research finds that urbanization and economic growth significantly impact CO2 emissions, with both factors contributing to increased emissions. Energy consumption is identified as a major driver of CO2 emissions, highlighting its role in the environmental impact of economic and urban development. The study suggests that while economic growth and urbanization are vital for development, they are associated with higher emissions, primarily due to increased energy consumption. To mitigate these effects, the authors advocate for integrating sustainable energy practices and policies that balance growth with environmental protection in Indonesia.

Sharma (2011)[29] investigates CO2 emission determinants across 69 countries, finding that economic growth, energy consumption, and industrial activity are significant factors. The study emphasizes that higher economic growth and energy use lead to increased emissions, highlighting the need for energy efficiency and cleaner technologies. Zhang and Zhang (2018)[30] explore how GDP, trade structure, exchange rates, and FDI inflows affect China's carbon emissions. They find that GDP and trade structure significantly contribute to higher emissions, while FDI can reduce emissions through cleaner technologies.

The study by Nguyen and Kakinaka (2019)[31] explores the relationship between renewable energy consumption, carbon emissions, and development stages using panel cointegration analysis. The research finds that increased consumption of renewable energy is associated with a reduction in carbon emissions, particularly in advanced stages of development. The analysis suggests that as countries progress through different development stages, the role of renewable energy in mitigating emissions becomes more significant. This underscores the importance of transitioning to renewable energy sources to effectively manage carbon emissions and achieve sustainable development. The study highlights that integrating renewable energy into energy policies can play a crucial role in reducing emissions, especially as economies advance.

III. METHODS

The scope of this research discusses the driving factors of CO2 emissions in three selected ASEAN countries. The independent variables used are GDP per capita and Foreign Direct Investment (FDI). This study employs panel data with a cross-section of three ASEAN member countries over a 29-year period from 1990 to 2019. The research data is sourced from the World Bank, along with supporting literature from journals, theses, and other relevant references. The analytical technique used in this research is panel data analysis. This method is employed to observe the impact of GDP per capita and FDI in the three study countries over 29 years. The influence of the independent variables on the carbon emission index is determined using the following regression equation:

$$CO2it = \beta 0 + \beta 1 GDPit + \beta 2 FDIit + eit$$

Where:

CO2	= CO2 emissions
ß0	= Constant
ß1, ß2	= Regression Coefficients
GDP	= GDP per capita
FDI	= Foreign Direct Investment (%)
e	= Error

The regression model of panel data can be estimated using three approaches, including the common effect, fixed effect, and random effect estimation methods. After estimating the regression model of panel data, the next step is to select the best model for analysis. There are three tests for selecting the best model, namely using the Chow test, and the Hausman test. However, if there is inconsistency, the LM test is conducted next, as outlined in Figure 2.

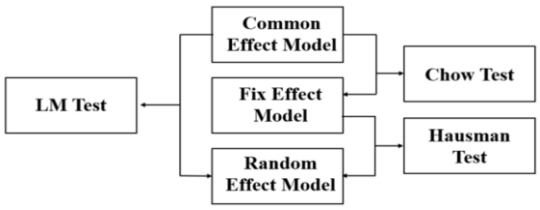

Figure 2. Flowchart of Panel Data Regression Model

Selection

The first test is the Chow test. The Chow test is employed to determine which model should be used for this study. The Chow test can be observed from the probability value of the cross-section F-test.

H_0 = common effect, if Prob > 0,05

H_1 = fixed effect, if Prob < 0,05

If the test results indicate a probability value below 0.05, the **fixed effect model** will be chosen. However, if the results show a probability value above 0.05, the **common effect model** will be chosen.

The Hausman test to determine whether the test results favor fixed effects or random effects. The outcome of the Hausman test can be observed from the chi-square statistic probability value.

H_0 = random effect, if Prob > 0,05

H_1 = fixed effect, if Prob < 0,05

If the statistical probability value is less than 0.05, then the model used is **fixed effect**. if the test result shows a number above the probability value of 0.05, then the chosen model is **random effect**.

The Lagrange-multiplier (LM test) is conducted when there is no consistency between Chow test and the Hausman test. The LM test is used to examine whether the random effect model is superior to the common effect model. The LM test result can be observed from the Breusch-Pagan LM-test value.

H_0 = common effect, if Prob > 0,05

H_1 = random effect, if Prob < 0,05

IV. RESULT AND DISCUSSION

A. Model Estimation

The regression model of panel data can be estimated using three approaches, including the common effect, fixed effect, and random effect estimation methods. After estimating the regression model of panel data, the next step is to select the best model for analysis. There are three tests for selecting the best model, namely using the Chow test, and the Hausman test. However, if there is inconsistency, the LM test is conducted next.

Table 1. Chow, Hausman, and LM Test

Test	*H0*	*H1*	*P-Value*	*Conclusion*
Chow test	CEM	FEM	0.0000 < 0.05	FEM
ıusman test	REM	FEM	0.0000 < 0.05	FEM
LM test	CEM	REM	0.0000 < 0.05	REM

Source: *Eviews 12, Processed Data (2024)*

Based on three conducted tests, it can be concluded that the most suitable estimation model is ***Fix Effect Model****.*

B. Classical Assumption Test

a. Multicollinearity Test

Table 2. Multicollinearity Test.

	LN_GDP	*LN_FDI*
LN_GDP	1	0.7039025132154532
LN_FDI	0.7039025132154532	1

Source: *Eviews 10, Processed Data (2024).*

The multicollinearity test revealed that the correlation values between independent variables were all less than 0.8, indicating no violation of multicollinearity requirements among the independent variables.

b. Heteroscedasticity test

Table 3. Heteroscedasticity Test.

Independent variable	*t-statistic*	*Prob.*
LN_GDP	-0.086820	0.9310
LN_FDI	0.075552	0.9399

Source: *Eviews 10, Processed Data (2024).*

The test using the Glejser test shows that the probability of Ln-GDP and Ln_FDI is greater than the alpha level of 0.05, which means that H0 is accepted, indicating that the residuals are constant or homoscedastic, and the model does not exhibit heteroscedasticity.

According to Mudrajat in his book *Metode Riset untuk Bisnis dan Ekonomi*, panel data regression using the Fixed Effect model does not require tests for normality and autocorrelation. It only needs tests for heteroscedasticity and multicollinearity. Since the data is free from issues of heteroscedasticity and multicollinearity, it is concluded that the regression model in this study is suitable for use, as it meets the classical assumption requirements.

C. Regression Result

After conducting a series of tests to select the best analytical model, the Fixed Effect model was chosen to estimate the factors driving carbon dioxide emissions in Indonesia, Singapore, and Myanmar.

Table 4. Hypothesis test

Variable	*coefficient*	*t-statistics*	*p-value*
C	-1.843139	-7.850212	0.0000
LN_GDP	0.300876	9.882222	0.0000
LN_FDI	-0.020626	-3.439198	0.0009
R-squared	0.979331		
djusted Rsquared	0.978358		
F-statistic	1006.854		0.00000

Source: *Eviews 10, Processed Data (2024).*

Based on the results of the table above, the panel data regression equation can be formed as follows :

$Ln\_CO2_{it} = -1.843139 + 0.300876 Ln\_GDP_{it}$
$- 0.020626 Ln\_FDI_{it} + e_{it}$

Based on the estimation results, an R-squared value of 0.97 indicates that the variations in the independent variables (GDP per capita and FDI) explain 97% of the variation in CO2 emissions, with the remaining 3% attributed to other variables not included in the model. The p-value for the F-statistic is 0.000, which is less than 0.05, leading to the rejection of the null hypothesis (H0). This suggests that all independent variables simultaneously have a significant impact on the dependent variable, CO2 emissions.

The impact of GDP per capita is significant and positive at the 1% level, meaning that higher GDP per capita is associated with increased CO2 emissions. With a coefficient of 0.3, the effect is inelastic with respect to CO2 emissions. Conversely, the impact of foreign direct investment (FDI) is significant and negative at the 1% level, indicating that higher FDI is associated with lower CO2 emissions. The coefficient for FDI is 0.02, suggesting an inelastic effect on CO2 emissions. It is important to note that these results are specific to the countries studied (Indonesia, Singapore, and Myanmar) and cannot be generalized to other countries.

CONCLUSIONS

This study aims to analyze the determinants of greenhouse gas emissions in several ASEAN countries. The data used in this research is secondary, sourced from the World Bank, covering the period from 1990 to 2019. The analytical technique employed is panel data regression with Fixed Effect Model (FEM) estimation.

The results indicate that all independent variables in the study have a significant relationship with CO2 emissions, with coefficients below 1, suggesting an inelastic effect. The R-squared value of 0.99 means that variations in the independent variables (GDP per capita and FDI) explain 99% of the variation in CO2 emissions.

The regression results using the fixed effect model show that GDP per capita has a significant positive impact, indicating that higher GDP per capita is associated with higher CO2 emissions. On the other hand, FDI has a significant negative impact, meaning that higher FDI is associated with lower CO2 emissions. This implies that economic growth contributes to higher CO2 emissions, while foreign investment may help reduce CO2 emissions. It is important to note that these results are specific to the countries studied (Indonesia, Singapore, and Myanmar) and cannot be generalized to other countries.

REFERENCES

1) K. O. Yoro and M. O. Daramola, *CO2 emission sources, greenhouse gases, and the global warming effect*. Elsevier Inc., 2020. doi: 10.1016/B978-0-12-819657-1.00001-3.
2) M. Kabir *et al.*, "Impacts of anthropogenic activities & climate change resulting from increasing concentration of Carbon dioxide on environment in 21st Century; A Critical Review," *IOP Conference Series: Earth and Environmental Science*, vol. 1194, no. 1, 2023, doi: 10.1088/17551315/1194/1/012010.
3) P. Bergquist and C. Warshaw, "Does global warming increase public concern about climate change?," *Journal of Politics*, vol. 81, no. 2, pp. 686–691, 2019, doi: 10.1086/701766.
4) Y. Lu, Z. A. Khan, M. S. Alvarez-Alvarado, Y. Zhang, Z. Huang, and M. Imran, "A critical review of sustainable energy policies for the promotion of renewable energy sources," *Sustainability (Switzerland)*, vol. 12, no. 12, pp. 1–30, 2020, doi: 10.3390/su12125078.
5) S. Fankhauser and F. Jotzo, "Economic growth and development with low-carbon energy," *Wiley Interdisciplinary Reviews: Climate Change*, vol. 9, no. 1, pp. 1–16, 2018, doi: 10.1002/wcc.495.
6) X. Shi and L. Yao, "Economic integration in Southeast Asia: The case of the ASEAN power grid," *Journal of Economic Integration*, vol. 35, no. 1, pp. 152–171, 2020, doi: 10.11130/jei.2020.35.1.152.
7) Kominfo, "Interesting Facts and Data about the ASEAN Region," Kominfo. Accessed: Aug. 18, 2024. [Online]. Available: https://asean2023.id/en/news/interesting-factsand-data-about-the-asean-region
8) H. M. Nguyen and L. D. Nguyen, "The relationship between urbanization and economic growth an empirical study on ASEAN countries," *International Journal of Social Economics*, vol. 45, no. 2, pp. 316–339, 2018, doi: 10.1108/IJSE-12-2016-0358.
9) ASEAN, "ASEAN charts course for a sustainable future with ambitious ASEAN Strategy for Carbon Neutrality," ASEANstats Official Web Portal. Accessed: Aug. 18, 2024. [Online]. Available: https://asean.org/asean-charts-course-for-asustainable-future-with-ambitious-asean-strategyfor-carbon-neutrality/
10) S. Kamis and D. H. Muhd Yusuf, "Determinants of Foreign Direct Investment Flows in Asean Countries," *International Journal of Entrepreneurship and Management Practices*, vol. 6, no. 22, pp. 114–124, 2023, doi: 10.35631/ijemp.622008.
11) S.-H. Lee, "ASEAN's economic security and regional economic cooperation: Past, present, and future," *Asian Journal of Comparative Politics*, vol. 7, no. 1, 2021, doi: 10.1177/20578911211032135.
12) Y. Bai, Q. Qian, J. Jiao, L. Li, F. Li, and R. Yang, "Can environmental innovation benefit from outward foreign direct investment to developed countries? Evidence from Chinese manufacturing enterprises," *Environmental Science and Pollution Research*, vol. 27, no. 12, pp. 13790–13808, 2020, doi: 10.1007/s11356-020-07819-z.
13) A. Rauf, N. Ali, M. N. Sadiq, S. Abid, S. A. Kayani, and A. Hussain, "Foreign Direct Investment, Technological Innovations, Energy Use, Economic Growth, and Environmental Sustainability Nexus: New Perspectives in BRICS Economies," *Sustainability (Switzerland)*, vol. 15, no. 18, 2023, doi: 10.3390/su151814013.
14) Y. Hao, Y. Wu, H. Wu, and S. Ren, "How do FDI and technical innovation affect environmental quality? Evidence from China," *Environmental Science and Pollution Research*, vol. 27, no. 8, pp. 7835–7850, 2020, doi: 10.1007/s11356-019-07411-0.
15) A. Devine and M. McCollum, "Understanding social system drivers of green building innovation adoption in emerging market countries: The role of foreign direct investment," *Cities*, vol. 92, no. March, pp. 303–317, 2019, doi: 10.1016/j.cities.2019.03.005.
16) F. Dong, Y. Wang, B. Su, Y. Hua, and Y. Zhang, "The process of peak CO2 emissions in developed economies: A perspective of industrialization and urbanization," *Resources, Conservation and Recycling*, vol. 141, no. July 2018, pp. 61–75, 2019, doi: 10.1016/j.resconrec.2018.10.010.

17) R. Salim, S. Rafiq, S. Shafiei, and Y. Yao, "Does urbanization increase pollutant emission and energy intensity? evidence from some Asian developing economies," *Applied Economics*, vol. 51, no. 36, pp. 4008–4024, 2019, doi: 10.1080/00036846.2019.1588947.
18) H. Wang and W. Wei, "Coordinating technological progress and environmental regulation in CO2 mitigation: The optimal levels for OECD countries & emerging economies," *Energy Economics*, vol. 87, p. 104510, 2020, doi: 10.1016/j.eneco.2019.104510.
19) B. Aslam *et al.*, "The nexus of industrialization, GDP per capita and CO2 emission in China," *Environmental Technology and Innovation*, vol. 23, p. 101674, 2021, doi: 10.1016/j.eti.2021.101674.
20) M. A. Afridi, S. Kehelwalatenna, I. Naseem, and M. Tahir, "Per capita income, trade openness, urbanization, energy consumption, and CO2 emissions: an empirical study on the SAARC Region," *Environmental Science and Pollution Research*, vol. 26, no. 29, pp. 29978–29990, 2019, doi: 10.1007/s11356-019-06154-2.
21) S. A. Sarkodie and P. A. Owusu, "Escalation effect of fossil-based CO2 emissions improves green energy innovation," *Science of the Total Environment*, vol. 785, p. 147257, 2021, doi: 10.1016/j.scitotenv.2021.147257.
22) C. Zhang and X. Zhou, "Does foreign direct investment lead to lower CO2 emissions? Evidence from a regional analysis in China," *Renewable and Sustainable Energy Reviews*, vol. 58, pp. 943–951, 2016, doi: 10.1016/j.rser.2015.12.226.
23) P. Pazienza, "The impact of FDI in the OECD manufacturing sector on CO2 emission: Evidence and policy issues," *Environmental Impact Assessment Review*, vol. 77, no. November 2018, pp. 60–68, 2019, doi: 10.1016/j.eiar.2019.04.002.
24) National Climate Change Secretariat, "Singapore
25) Climate Action: Power," National Climate Change Secretariat. Accessed: Aug. 18, 2024. [Online]. Available: https://www.nccs.gov.sg/singaporesclimate-action/mitigationefforts/power/#:~:text=Power generation is one of,gas to power our nation.
26) International Energy Agency, "How much CO2 does Indonesia emit?," International Energy Agency. Accessed: Jun. 05, 2024. [Online]. Available: https://www.iea.org/countries/indonesia/emissio ns
27) A. Anwar, A. R. Chaudhary, S. Malik, and M. Bassim, "Modelling the macroeconomic determinants of carbon dioxide emissions in the G7 countries: the roles of technological innovation and institutional quality improvement," *Global Business Review*, p. 09721509211039392, 2021.
28) M. Shahbaz, S. Nasreen, F. Abbas, and O. Anis, "Does foreign direct investment impede environmental quality in high-, middle-, and lowincome countries?," *Energy Econ*, vol. 51, pp. 275– 287, 2015.
29) A. Bashir, D. Susetyo, S. Suhel, and A. Azwardi, "Relationships between urbanization, economic growth, energy consumption, and CO 2 emissions: empirical evidence from Indonesia," *The Journal of Asian Finance, Economics and Business*, vol. 8, no. 3, pp. 79–90, 2021.
30) S. S. Sharma, "Determinants of carbon dioxide emissions: empirical evidence from 69 countries," *Appl Energy*, vol. 88, no. 1, pp. 376–382, 2011.
31) Y. Zhang and S. Zhang, "The impacts of GDP, trade structure, exchange rate and FDI inflows on China's carbon emissions," *Energy Policy*, vol. 120, pp. 347–353, 2018.
32) K. H. Nguyen and M. Kakinaka, "Renewable energy consumption, carbon emissions, and development stages: Some evidence from panel cointegration analysis," *Renew Energy*, vol. 132, pp. 1049–1057, 2019.