Jurnal Ekonomi Pembangunan
Volume 21 (2): 166-174, December 2023
P-ISSN: 1829-5843; E-ISSN: 2685-0788

Research article

Do the G20 Countries' Increased Economic Growth, Foreign Direct Investment, Industry Value-added, and Population Change Contribute to CO2 Emissions?

Rasyida Pertiwi[*1], Imam Asngari[1], Vinny Dwi Melliny[1], Febrian[2], Gustriani[1]

[1] Department of Development Economics, Universitas Sriwijaya, Indonesia
[2] Department of Economic Development, Ritsumeikan University, Japan
* Correspondence author email: rasyidapertiwi@fe.unsri.ac.id

Article Info: Received: 10 November 2023; Accepted: 29 January 2024; Published: 31 January 2024

Abstract: Economic development plays a crucial role in contributing to CO_2 emissions. Therefore, this research aims to investigate environmental degradation caused by economic activities within the scope of G-20 Countries, which comprise the largest economies and advanced industries. The primary objective of this study is to deliver an empirical study of gross domestic product, foreign direct investment, industry value-added, and population on CO_2 emissions in G20 Countries. Using panel data from 2000-2022, the research found a positive correlation between GDP and CO_2 emissions. Meanwhile, by utilizing GDP squared, the existence of the Environmental Kuznet Curve (EKC) theory was identified. The EKC theory indicates a significant negative correlation between GDP squared and CO_2 emission. This is attributed to several factors, including increased public awareness of environmental protection and technological advancements in developed countries, contributing to improved energy efficiency. For the variables of FDI and population, a negative correlation with CO_2 was found. On the other hand, the value-added industry shows a positive and significant correlation with CO_2 emissions.

Keywords: economic growth, foreign direct investment, industrial value-added, population, EKC

JEL Classification: F21, O14, Q56, R23

Abstrak: Pembangunan ekonomi memainkan peran penting dalam berkontribusi terhadap emisi CO_2. Oleh karena itu, penelitian ini memiliki tujuan untuk menyelidiki degradasi lingkungan yang disebabkan oleh aktivitas ekonomi dalam cakupan Negara-negara G20, yang mencakup ekonomi terbesar dunia dan industri yang maju. Penelitian ini bertujuan untuk menginvestigasi dampak langsung dari produk domestik bruto, Investasi langsung asing, nilai tambah industri, dan populasi terhadap emisi CO_2 di negara-negara G-20. Dengan menggunakan data panel dari tahun 2000 hingga 2022, penelitian ini menemukan bahwa gdp berkorelasi positif terhadap CO_2. Sementara, dengan menggunakan GDP square, didapat bahwa adanya Teori Kurva Kuznet Lingkungan (EKC). Teori EKC menunjukkan adanya korelasi negatif dan signifikan antara GDP Square dan Emisi CO_2. Hal ini disebabkan oleh beberapa faktor yaitu peningkatan kesadaran masyarakat untuk melindungi lingkungan dan kemajuan teknologi pada negara-negara maju, sehingga berkontribusi pada peningkatan efisiensi energi. Pada variabel FDI dan populasi ditemukan bahwa berkorelasi negatif terhadap CO_2. Sedangkan Nilai tambah industri menunjukkan hubungan korelasi positif dan signifikan terhadap emisi CO_2.

Kata kunci: pertumbuhan ekonomi, investasi langsung asing, nilai tambah industri, populasi, EKC

How to Cite:
Pertiwi, R., Asngari, I., Melliny, V. D., Febrian., & Gustriani. (2023). Do the G20 Countries' Increased Economic Growth, Foreign Direct Investment, Industry Value-added, and Population Change Contribute to CO2 Emissions? *Jurnal Ekonomi Pembangunan, 21*(2), 166-174. DOI: 10.29259/jep.v21i2.22984

1. INTRODUCTION

The impact of human-induced climate change is evident in various weather and climate extremes worldwide, causing significant adverse consequences and related harm to both the environment and the human population. This has led to disruptions in food and water security, human health, economies, and societies. Furthermore, climate related-events for instance heatwaves, heavy rainfall, droughts, rising sea levels, and many more (UNEP, 2023). In 2019, according to data from UNEP (2023), approximately 79 percent of all greenhouse gas emissions worldwide were attributed to the energy collective sectors, industry, transportation, and construction, whereas 21 percent came from agriculture, forestry, and other land utilization.

Fossil fuels remain the primary energy source in developing nations due to the limited affordability of renewable energy options. However, the utilization of fossil fuels has a significant environmental drawback, as it results in the release of carbon dioxide and other greenhouse gasses into the atmosphere. Carbon dioxide is commonly employed as an indicator to assess environmental degradation. Accounting for approximately 89 percent in 2022 of all greenhouse gas emissions, it stands as the most prominent component (International Energy Agency, 2023). CO_2 emission is often utilized as an indicator or measure of environmental degradation, it is important to recognize that other significant greenhouse gasses like nitrous oxide and methane, which play substantial roles in environmental degradation, tend to receive less attention. As Xepapadeas & Economides (2022) explain energy derived from fossil fuels has a dual impact on productivity with a constricting effect. Firstly, it enhances productivity by serving as an independent input in the production process. However, on the flip side, the greater the reliance on this energy source. The more detrimental it becomes to the climate due to its contributions to rising temperatures.

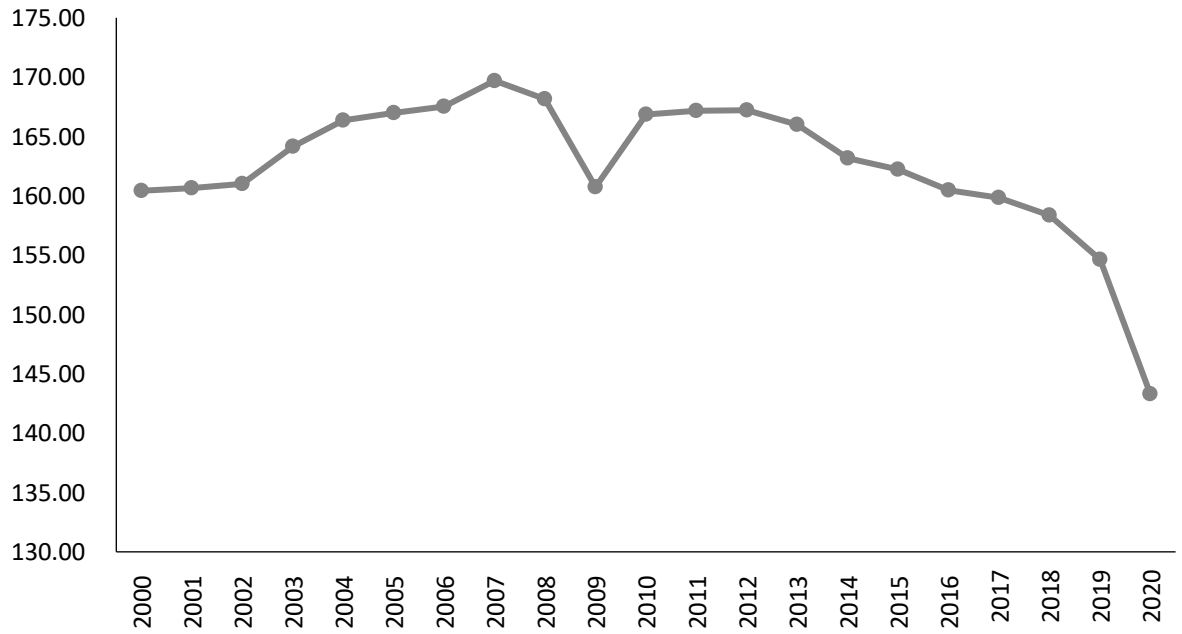

Figure 1. Total CO_2 Metrics Tons Per Capita in G20 Countries, 2000-2020
Source: World Bank, 2023 (Processed by author)

Figure 1. explains the total CO_2 metrics tons per capita in G20 Countries. Overall, from the early 2000s until 2007, the total amount of CO_2 metrics per capita increased. However, during the middle period of the research from 2008 until 2009, the graph illustrates a decrease to 160 metric tons per capita. This happened as a result of the American Subprime Mortgage Credit Crisis, which sparked the global financial crisis. The collapse of major financial institutions in America had a big impact on nearly every country, leading to economic growth declining and slowing down in many nations. In 2010, the total amount of CO_2 metrics per ton per capita rocketed and remained stable until 2013. As the Paris Agreement was signed in 2015, some countries pledged to reduce emissions by under

2 degrees Celsius. We can observe from the graph from 2015 to 2019, there was a diminishing amount of CO_2 metrics per capita. Furthermore, from 2019 to 2020, a sharp decline occurred due to the COVID-19 pandemic. The worldwide economy was the most frightening issue compared to the Financial Crisis of 2009. It is reasonable why the total CO_2 metrics per ton experienced a decline. The most substantial rise in emissions within a specific sector in 2022 came from the field of electricity and heat generation, followed by Industry, transport, and building (International Energy Agency, 2023). Emissions from the electricity and heat sector saw a 1.8 percent increase, equivalent to 261 million metric tons. The primary factor behind this growth was the transition from gas to coal in various areas. The production of electricity using coal increased CO_2 emissions by 2.1 percent; developing economies and emerging markets in Asia saw the biggest increases.

Figure 2. Total of CO_2 Emission in G20 countries (2000-2022)
Source: Climate Watch, 2023 (Proceed by Author)

Figure 2 shows how G20 countries contribute to the environmental economy. The two countries that emit the most CO_2 are China and the United States. Several factors play a role in determining the amount of CO_2 emission. Foreign Direct Investment, industrialization, and population contribute to economic growth. However, they also have significant potential for causing environmental harm. This is largely because a significant portion of their operation is linked to the extraction and utilization of natural resources. The economic conditions play a crucial role in contributing to CO_2 emissions. According to research by (Yang et al., 2021), there is a correlation between CO_2 emissions and economic growth in the developing Silk Road Economic Belt (SREB) project countries. These findings suggest that a one percent rise in GDP would lead to an approximately 0.25 percent increase in CO_2 emission. The nexus between economic growth and environmental degradation is explained by the Kuznet theory. The environmental Kuznets Curve is the most widely used approach for evaluating environmental performance. EKC is derived from a U-shaped curve, originally proposed by Kuznets in 1955.

Numerous studies examining the influence of some variables on CO_2 emissions continue to yield diverse and inconclusive findings. Additionally, the researcher has explored the relationship between various economic factors and alterations in the environment. Suci et al. (2023) confirmed that GDP per capita will diminish carbon emissions, while it found no evidence of a meaningful connection between increased carbon emissions and financial development. Hanif et al. (2019) delves into FDI and economic growth in 15 developing Asian Nations by using panel data and employing the ARDL model. The study notes that economic growth contributes to an increase in CO_2 and FDI as a factor that escalates domestic carbon emissions. This study also affirms the presence of an environmental Kuznet Curve EKC that as income increases, the degradation environment initially worsens but eventually improves as nations adopt more environmentally conscious practices. Aslam et al. (2021) research to measure the impact of population density, industrialization usage on CO_2 emission, and the interaction to trade openness, as well as the relationship with China's Gross Domestic Product and the square of these factors on CO_2 emission by using the ARDL Approach from 1962-2018.

The study on the impact of economic development on carbon emission remains relatively scarce in G20 Countries. Thus, we intend to research to investigate the nexus between gross domestic product**,** foreign direct investment, industry value-added, and population to CO_2 emission within the G-20 Countries. This needs investigation to understand how the economic growth of countries with large economies influences emissions and to collaboratively mitigate the impacts of climate change. The limitation of this research only discusses the scope of G20 countries, due to the group of the largest economies countries and advanced industries throughout the world which represent approximately 80 percent of the Global Gross Domestic Product (GDP), and bear responsibility for around 80 percent of Greenhouse gas (GHG) emissions, resulting in 70 percent of the climate-related consequences (Habib et al., 2021). G20 countries also provide a diverse representation of both developed and developing countries. Additionally, G20 is the primary culprit to global carbon emissions (D'Orazio & Dirks, 2022). Therefore, this topic is worth researching within the scope of the G20.

2. RESEARCH METHODS

This study investigates the nexus among GDP, Foreign Direct Investment, Industrialization, and population in G-20 countries. The countries included are Argentina, Australia, Brazil, Canada, China, Germany, the European Union, France, the United Kingdom, Indonesia, India, Italy, Japan, and Korea. Rep, Mexico, Russian Federation, Saudi Arabia, Turkiye, United States, and South Africa. The data utilized the panel data, consisting of time series and cross-sectional data from 2000 to 2022, giving 444 observations. All-time series are taken from the World Bank and Climate Watch. After a comprehensive review of existing literature (Li & Lin, 2015; Sikder al., 2022) and the theoretical framework presented earlier the connection between GDP, foreign direct investment, industry value-added, and population to CO_2 emission is elucidated a fundamental panel model This approach is employed to see the impact of covariates on the level of CO_2 emission in G20 Countries. The estimation of the panel data model is written as follows:

$$\mathrm{CO2}_{i,t} = f(\mathrm{GDP}_{i,t}, \mathrm{FDI}_{i,t}, \mathrm{IVA}_{i,t}, \mathrm{POP}_{i,t}) \quad (1)$$

Next, the model is transformed to natural logarithms to stabilize variance and linearize the relationship in the data as follows:

$$\ln\mathrm{CO2}_{i,t} = \beta_0 + \beta_1 \ln\mathrm{GDP}_{i,t} + \beta_2 \ln\mathrm{FDI}_{i,t} + \beta_3 \ln\mathrm{IVA}_{i,t} + \beta_4 \ln\mathrm{POP}_{i,t} + \varepsilon_{i,t} \quad (2)$$

where, $\mathrm{CO2}$ is total carbon emissions (metric tons in million) which is used as a determinant of environmental degradation, GDP is Gross Domestic Product, FDI is Foreign direct investment (net inflows), IVA is Industry value-added, and POP is measured by data on the total of people living in an area. In this context, t denotes time, i signifies the cross section (1….N), and epsilon stands for

residual term. All variables have been converted into log natural form to achieve more efficient estimation (Yang et al., 2021).

3. RESULT AND DISCUSSION

3.1. Results

An overview of the descriptive statistics for the used data is given in Table 1. the CO_2 variables exhibit a minimum value of 2.33 metric tons, and a maximum value is gaining 4.10 metric tons throughout the research period. The GDP variables show a minimum value of US$ 11.34 billion, while the maximum value reaches US$ 13.32 billion. Furthermore, the FDI variable has a minimum value of US$ 7.29 billion and a maximum value of US$ 12.16 billion. Next, the industry value-added (percent of GDP) variables range from a minimum of 1.21 percent, and a maximum of 1.82 percent. Lastly, the population variable indicates a minimum population total of 7.27 million people and a maximum population total of 9.15.

Table 1. Descriptive Statistics of Variables

Descriptive	ln CO_2	GDP	lnFDI	lnIVA	lnPOP
Mean	3.006	12.244	10.426	1.439	8.045
Median	2.863	12.178	10.454	1.425	7.912
Maximum	4.107	13.321	12.169	1.822	9.151
Minimum	2.338	11.345	7.293	1.217	7.279
Std. Dev	0.401	0.458	0.680	0.122	0.489
Jarque-Bera	64.291	24.484	53.709	41.831	50.755
Probability	0.000	0.000	0.000	0.000	0.000
Observations	460	460	460	460	460

Source: Authors Calculations, 2023

Before delving deeper into the correlation between CO_2 emissions, GDP, FDI, Industry value added, and Populations in G20 countries, certain steps need to be undertaken for estimation. The stationary test was conducted using the Levin, Lin % Chu t* method. Table 2 indicates that all variables are declared stationary or do not have unit roots.

Table 2. Result of Unit Root test

Variables	LLC-stat	
	Level	1st differences
ln CO_2	-4.536***	-5.675***
lnGDP	-6.772	-9.384
lnFDI	-3.683	-8.941
lnIVA	-2.838	-11.015
lnPOP	-2.661	2.572

Note: *** denotes significance at 5%
Source: Authors Calculations, 2023

In the process of choosing the optimal model for this study, a selection test was conducted to identify the most appropriate panel data regression model for testing the hypothesis of the developed research model. Chow test and Hausman test can be seen in Table 4, the probability values for Chow and Hausman test, denoted by α where 0.000 < 0.05 and 0.004 < 0.05, respectively. Therefore, it can be concluded that the fixed effect model is more appropriate than Random and common effect models. The Fixed Effect model was selected twice, consequently, further selection by using the Lagrange Multiplier test is not necessary since the Fixed Effect Model is the best choice for addressing the research objectives.

Table 4 provides a concise overview of regression data panel results by analyzing the fixed effect model using Panel EGLS. From the Table 4, we can see that lnGDP, lnFDI, lnIVA, and lnPop have a significant effect on CO_2. To test normality, we used the Jarque-Berra value, which is 3.701

with a p-value of 0.157, where a value greater than 0.05 indicates that the residuals are normally distributed. The CD test result indicates a probability value of 0.964 exceeding 0.05. Therefore, it can be concluded that the research model does not exhibit symptoms of autocorrelation. Among G20 countries, 12 countries show a decrease in CO_2 emission. They are Argentina, Australia, Brazil, Germany, France, United Kingdom, Italy, Japan, Korea. Rep, Mexico, Saudi Arabia, and Turkiye. Meanwhile, the rest of the countries maintain a positive level of CO_2 emissions.

Table 4. Results of Fixed Effects Regression using Panel EGLS

Dependent variable = lnCO_2			
Variables	Coefficient	Std. Error	t-Statistics
Constant	-17.958***	1.963	-9.148
lnGDP	2.860***	0.233	12.274
lnGDP²	-0.091***	0.009	-10.222
lnFDI	-0.013***	0.003	-4.704
lnIVA	0.773***	0.090	8.550
lnPOP	-0.170***	0.019	-8.770
R^2	0.999		
F-Stat	-27.791***		
Diagnostics test	X^2	Prob.	
Chow test	191.531	0.000	
Hausman test	17.312	0.004	
Normal test	3.701	0.157	
CD test	-0.045	0.964	

Note: ***, **, and * represent statistically significant level at 1%, 5%, and 10%, respectively.
Source: Authors calculation, 2023

3.2. Discussion

Our finding shows GDP has a positive impact on CO_2 emission, Table 4 reports lnGDP value has a significant positive impact on Carbon Dioxide in G20 Countries. This implies increasing GDP by 1 percent will raise CO_2 by 0,2860 percent. On the other hand, the squared GDP per capita elasticity indicates a negative and statistically significant impact on CO_2 emission. The elasticity of per capita emissions concerning GDP per capita is expressed as $-\beta_2/2(\beta_2) = -2.860/2.(-0.091) = 15.714$. The findings additionally disclose that the turning point for the Environment Kuznets Curve (EKC) is identified at an income level of 15.714 (in logarithms). Among the G20 countries during the period of 2022, Australia, Canada, Germany, the European Union, France, the United Kingdom, Italy, Japan, Korea Rep. Saudi Arabia, and the United States have reached this turning point level. This implies that these countries are capable of decreasing CO_2 emissions as GDP per capita rises. However, other countries in G20 have not yet achieved this turning point level. These findings align with Bashir et al. (2021); Hanif et al. (2019); Lestari et al. (2020); and Mendonça et al. (2020). Mendonça et al. (2020) researched to measure the impact of GDP, population growth, and the generation of renewable energies on CO_2 emission in the 50 largest world economies in the period of 1990-2015 by using a hierarchical regression modeling. Their findings reveal that GDP per capita deteriorates CO_2 emission in the long run, and a one percent increase in GDP results in a 0.27 percent increase in CO_2 emission. Islami et al. (2022) also found the positive impact of GDP on CO_2 in G20 Countries but insignificant. It is due to the process of achieving the GDP using various components. On the contrary, Adebayo et al. (2020) and Aslam et al. (2021) have different perspectives on GDP and Carbon Dioxide, which state that there is a negative nexus between economic growth and CO_2 emission. Haug & Ucal (2019) recognizes the existence of the Kuznets Theory, when the real GDP per capita has increased, there has been a decline in CO_2 emission. In the short run, Niyonzima et al. (2022) identified a negative impact between CO_2 emission and GDP. However, it is important to note that people now experience improved living standards and tend to become more aware of protecting the environment. China is to shift its economy away from coal reliance by taking steps

for climate change mitigation. As a part of this strategy, they have made a significant investment in renewable energy sources like solar, wind, and biomass. In 2015, these investments amounted to about US$ 103 billion (Mendonça et al., 2020).

FDI shows a negative and significant influence on carbon dioxide emission. One percent increase in FDI will reduce CO_2 emissions by 0.013. Hence, a reasonable inference can be concluded that FDI in G20 countries is effective in reducing CO_2 emissions. Generally, they have greater environmental awareness and implement environmental control standards. This result is consistent with the findings of Huang et al. (2019) who did research in China provinces. Paramati et al. (2017) explain that FDI will diminish the level of CO_2 emission in developing economies. Meanwhile, FDI will lead to a CO_2 emission increase in developed economies. This suggests that FDI inflows in developing countries have been using advanced technology and methods, consequently resulting in a reduction of CO_2 emissions. Haug & Ucal (2019) observed The role of Trade and FDI in CO_2 emission in Turkey. They found that in the long term, FDI does not lead to increased per capita CO_2 emission in Turkey. After 2003, Turkey's developmental path has aligned with an environmental Kuznet curve, the increase in real net GDP per capita since then has been leading to reductions in CO_2 emissions per capita in the short and long run. Contrary to Ahmed et al. (2022) observed the impact of industrialization and foreign direct investment: empirical evidence from the Asia-Pacific Region in the period of 1995 to 2020 by using the ARDL model. It explains that FDI exhibited a significant and adverse effect on the environment and led to increased emissions of methane and CO_2. Meanwhile, Sabir et al. (2020) asserted that FDI leads to significant environmental degradation in South Asia Countries, it occurs because foreign investors introduce traditional production technologies, which contribute to a higher concentration of CO_2 in the environment.

Industry value-added shows a positive and significant impact on CO_2 emission in G20 Countries. The coefficient Industry value-added of 0.773 indicates that a 1 percent increase in the IVA variable will increase CO_2 emissions by 0.773. The higher the added value of the industry, the more industrial activity is taking place. These activities, such as production, energy consumption and transportation, generate CO2 emissions. Industry uses a lot of fossil fuels, such as coal, petroleum, and natural gas, as energy sources. Burning fossil fuels produces CO2 emissions. Many industrial processes, such as metal smelting and manufacturing, produce CO2 emissions as a byproduct. This suggests that Industrialization still relies heavily on energy from fossil fuels, which are the major source of CO_2 emissions. Our study supports the claim of Aslam et al. (2021), Li & Lin (2015), Patel & Mehta (2023), and Sikder et al. (2022).

The last variable that will be discussed is population. The result shows that population has a negative and significant impact on CO_2 emission in G20 Countries. One percent increase in population will diminish 0.170 percent of CO_2 emissions. This suggests that the majority of citizens in G20 countries are conscious of the adverse effects on the environment. These findings are in line with Guo et al. (2023) who conducted a quantitative analysis to examine the influence of aging on CO_2 emission at various stages of regional development in China by using STIRPAT balanced panel from 1995 to 2019. The study found that with every one percent increase in the aging population in the eastern region, CO_2 decreased by 0.689. However, the central and western region shows a contrary effect on CO_2 emission. It is because the eastern region is a more advanced region than other regions. Lawal (2019), Lin & Raza (2019), and Mendonça et al. (2020) who had reported the positive influence between population and CO_2 emission. Mendonça et al. (2020) states that a 1 percent increase in population generates a 1.67 percent increase in countries' CO_2 emissions.

4. CONCLUSIONS

Using panel data covering 20 countries, this paper empirically investigated the impact of Gross Domestic Product, Foreign Direct Investment, Industry Value added, and Population on Carbon Dioxide Emission in the period of 2000 to 2022. Based on the results and discussion research, GDP has a positive and significant effect on CO_2 emission. As GDP increases, CO_2 emissions will rise. It is due to G20 countries remaining using harmful energy and are still in preparation to face the energy transition. On the other hand, GDP^2 has a negative impact on CO_2. According to our research findings, we recommend that governments in developing countries should create a comprehensive

environmental protection framework that addresses specific challenges. The government should establish policies that promote the adoption of eco-friendly manufacturing methods and the emergence of environmentally responsible industries. Additionally, the government should consider implementing regulatory measures such as a carbon incentive, an environmental incentive, or a green incentive to discourage carbon dioxide emissions. Developing countries should prioritize investment not only in enhanced regulatory measures, but also in technology and infrastructure projects aimed at advancing green industrialization, fostering GDP growth, and mitigating carbon dioxide. Government and stakeholders should work together and prioritize research in inventing the new-renewable resources.

ACKNOWLEDGEMENT

This study would not have been possible without the support from our Department of Development Economics. Therefore, we would like to express our gratitude.

REFERENCES

Adebayo, T. S., Awosusi, A. A., & Adeshola, I. (2020). Determinants of CO2 Emissions in Emerging Markets: An Empirical Evidence from Mint Economies. *International Journal of Renewable Energy Development*, *9*(3), 411–422. https://doi.org/10.14710/ijred.2020.31321

Ahmed, F., Ali, I., Kousar, S., & Ahmed, S. (2022). The Environmental Impact of Industrialization and Foreign Direct Investment: Empirical Evidence from Asia-Pacific Region. *Environmental Science and Pollution Research*, *29*(20), 29778–29792. https://doi.org/10.1007/s11356-021-17560-w

Aslam, B., Hu, J., Shahab, S., Ahmad, A., Saleem, M., Shah, S. S. A., Javed, M. S., Aslam, M. K., Hussain, S., & Hassan, M. (2021). The Nexus of Industrialization, GDP Per Capita, and CO2 Emission in China. *Environmental Technology and Innovation*, *23*, 101674. https://doi.org/10.1016/j.eti.2021.101674

Bashir, A., Susetyo, D., Suhel, S., & Azwardi, A. (2021). Relationships between Urbanization, Economic Growth, Energy Consumption, and CO2 Emissions: Empirical Evidence from Indonesia. *Journal of Asian Finance, Economics and Business*, *8*(3), 79–90. https://doi.org/10.13106/jafeb.2021.vol8.no3.0079

Climate Watch. (2023). *GHG emission G20 Total Metrics*. Climate Watch: Historical GHG Emission

D'Orazio, P., & Dirks, M. W. (2022). Exploring the Effects of Climate-Related Financial Policies on Carbon Emissions in G20 Countries: a Panel Quantile Regression Approach. *Environmental Science and Pollution Research*, *29*(5), 7678–7702. https://doi.org/10.1007/s11356-021-15655-y

Guo, H., Jiang, J., Li, Y., Long, X., & Han, J. (2023). An Aging Giant at the Center of Global Warming: Population Dynamics and its Effect on CO2 Emissions in China. *Journal of Environmental Management*, *327*(February 2022), 116906. https://doi.org/10.1016/j.jenvman.2022.116906

Habib, Y., Xia, E., Hashmi, S. H., & Ahmed, Z. (2021). The Nexus between Road Transport Intensity and Road-related CO2 Emissions in G20 Countries: an Advanced Panel Estimation. *Environmental Science and Pollution Research*, *28*(41), 58405–58425. https://doi.org/10.1007/s11356-021-14731-7

Hanif, I., Faraz Raza, S. M., Gago-de-Santos, P., & Abbas, Q. (2019). Fossil Fuels, Foreign Direct Investment, and Economic Growth have Triggered CO2 Emissions in Emerging Asian Economies: Some Empirical Evidence. *Energy*, *171*, 493–501. https://doi.org/10.1016/j.energy.2019.01.011

Haug, A. A., & Ucal, M. (2019). The Role of Trade and FDI for CO2 Emissions in Turkey: Nonlinear Relationships. *Energy Economics*, *81*, 297–307. https://doi.org/10.1016/j.eneco.2019.04.006

Huang, Y., Chen, X., Zhu, H., Huang, C., & Tian, Z. (2019). The Heterogeneous Effects of FDI and Foreign Trade on CO2 Emissions: Evidence from China. *Mathematical Problems in Engineering*, *2019*. https://doi.org/10.1155/2019/9612492

International Energy Agency. (2023). CO2 Emissions in 2022. *Publication of CO2 Emissions in 2022*.

https://doi.org/10.1787/12ad1e1a-en
Islami, F. S., Prasetyanto, P. K., & Kurniasari, F. (2022). The Effect of Population, GDP, Non-Renewable Energy Consumption and Renewable Energy Consumption on Carbon Dioxide Emissions in G-20 Member Countries. *International Journal of Energy Economics and Policy*, *12*(2), 103–110. https://doi.org/10.32479/ijeep.12548
Lawal, I. M. (2019). Impact of Population Growth on Carbon Dioxide (CO2) Emission: Empirical Evidence from Nigeria. *Jurnal Perspektif Pembiayaan dan Pembangunan Daerah*, *6*(6), 701–708. https://doi.org/10.22437/ppd.v6i6.6730
Lestari, I. D., Effendi, N., & Priyono, A. F. (2020). Financial Development, Economic Growth, and Environmental Degradation Nexus in ASIAN Emerging Markets. *Jurnal Ekonomi Pembangunan, 18*(2), 177–189. https://doi.org/10.29259/jep.v18i2.12565
Li, K., & Lin, B. (2015). Impacts of Urbanization and Industrialization on Energy Consumption/CO2 Emissions: Does the Level of Development Matter? *Renewable and Sustainable Energy Reviews*, *52*, 1107–1122. https://doi.org/10.1016/j.rser.2015.07.185
Lin, B., & Raza, M. Y. (2019). Analysis of Energy-related CO2 Emissions in Pakistan. *Journal of Cleaner Production*, *219*, 981–993. https://doi.org/10.1016/j.jclepro.2019.02.112
Mendonça, A. K. de S., de Andrade Conradi Barni, G., Moro, M. F., Bornia, A. C., Kupek, E., & Fernandes, L. (2020). Hierarchical Modeling of the 50 Largest Economies to Verify the Impact of GDP, Population, and Renewable Energy Generation in CO2 Emissions. *Sustainable Production and Consumption*, *22*, 58–67. https://doi.org/10.1016/j.spc.2020.02.001
Niyonzima, P., Yao, X., & Ofori, E. K. (2022). How do Economic Growth and the Emissions of Carbon Dioxide Relate? *OALib*, *09*(03), 1–16. https://doi.org/10.4236/oalib.1108516
Paramati, S. R., Mo, D., & Gupta, R. (2017). The Effects of Stock Market Growth and Renewable Energy Use on CO2 Emissions: Evidence from G20 Countries. *Energy Economics*, *66*, 360–371. https://doi.org/10.1016/j.eneco.2017.06.025
Patel, N., & Mehta, D. (2023). The Asymmetry Effect of Industrialization, Financial Development, and Globalization on CO2 Emissions in India. *International Journal of Thermofluids*, *20*(June), 100397. https://doi.org/10.1016/j.ijft.2023.100397
Sabir, S., Qayyum, U., & Majeed, T. (2020). FDI and Environmental Degradation: The Role of Political Institutions in South Asian Countries. *Environmental Science and Pollution Research*, *27*(26), 32544–32553. https://doi.org/10.1007/s11356-020-09464-y
Sikder, M., Wang, C., Yao, X., Huai, X., Wu, L., KwameYeboah, F., Wood, J., Zhao, Y., & Dou, X. (2022). The Integrated Impact of GDP Growth, Industrialization, Energy Use, and Urbanization on CO2 Emissions in Developing Countries: Evidence from the Panel ARDL Approach. *Science of the Total Environment*, *837*(February), 155795. https://doi.org/10.1016/j.scitotenv.2022.155795
Suci, S. C., Zahara, V. M., Ginanjar, R. A. F., & Anwar, C. J. (2023). Does Globalization Worsen Environmental Quality in ASEAN Countries? *Jurnal Ekonomi Pembangunan*, *20*(2), 173–180. https://doi.org/10.29259/jep.v20i2.19176
UNEP. (2023). *Climate Change 2023: Synthesis Report UNEP - UN Environment Programme*. 35–115. https://doi.org/10.59327/IPCC/AR6-9789291691647
World Bank. (2023). *CO2 Emissions (Metric Tons Per Capita)*. World Bank: World Bank Open Data.
Xepapadeas, A., & Economides, G. (2022). Monetary Policy Under Climate Change. *SSRN Electronic Journal*, *7021*. https://doi.org/10.2139/ssrn.4196636
Yang, Z., Abbas, Q., Hanif, I., Alharthi, M., Taghizadeh-Hesary, F., Aziz, B., & Mohsin, M. (2021). Short-run and Long-run Influence of Energy Utilization and Economic Growth on Carbon Discharge in Emerging SREB Economies. *Renewable Energy*, *165*, 43–51. https://doi.org/10.1016/j.renene.2020.10.141