International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Economic Dynamics And CO2 Emissions In Indonesia: An Analysis Of The Environmental Kuznets Curve

Dennis Aprilianti[1], Wiwin Priana Primadhana[2], Wirya Wardaya[3]

[1,2,3] Department of Development Economics, Faculty of Economics and Business, National Development University "Veteran" Jawa East

.

Corresponding author: 20011010146@student.upnjatim.ac.id

Abstract

Environmental problems are becoming more complex and profound because there is an increase in industrial and human impacts on the environment. There needs to be an effort to achieve the goal of increasing economic efficiency in several economic sectors contained in the sustainable development strategy. The purpose of this study is to analyze the kuznets hypothesis, analyze the influence of economic growth, population, foreign investment, and energy consumption on carbon dioxide emissions. This research was conducted in Indonesia. The data used is in a span of 33 years, namely from 1990 to 2022. The method used is to estimate the Environmental Kuznets Curve (EKC) hypothesis and use the Error Correction Model (ECM) analysis approach. The result of this study is that the environmental Kuznets curve hypothesis in Indonesia is proven to be relevant in the long term. The economic growth variable has a positive and significant relationship in the long term and not significant in the short term to carbon dioxide emissions. The population variable has a negative and significant relationship in the long term and not significant in the short term to carbon dioxide emissions. The long-term and short-term foreign direct investment variables have a positive and insignificant relationship with Emini carbon dioxide. Long-term and short-term energy consumption variables have a positive and significant relationship with carbon dioxide emissions.

Keywords: CO2, Environmental Kuznets Curve, Population, Foreign Direct Investment, Energy Consumption

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

INTRODUCTION

Environmental problems are currently an important problem that is growing rapidly and has not been properly handled. The importance of this issue is reflected in the fact that the Sustainable Development Goals (SDGs) 13, which focus on implementing urgent measures to combat climate change by ensuring access to affordable energy for all citizens (González-Álvarez and Montañés 2023). Environmental problems are increasingly complex due to industrial and human impacts. Efforts are needed to increase ecoefficiency in the economic sector through sustainable development strategies. (Elfaki and Heriqbaldi 2023).

The biggest challenge for global sustainable development is environmental damage due to increasing greenhouse gas emissions, Based on a report by Jones (2023) obtained from Our World In Data in 2021, CO2 concentrations contribute the highest with a contribution of 75.32% of all greenhouse gas emission components. Emissions result from economic growth and activity, which creates unfavorable externalities (Elfaki and Heriqbaldi 2023)

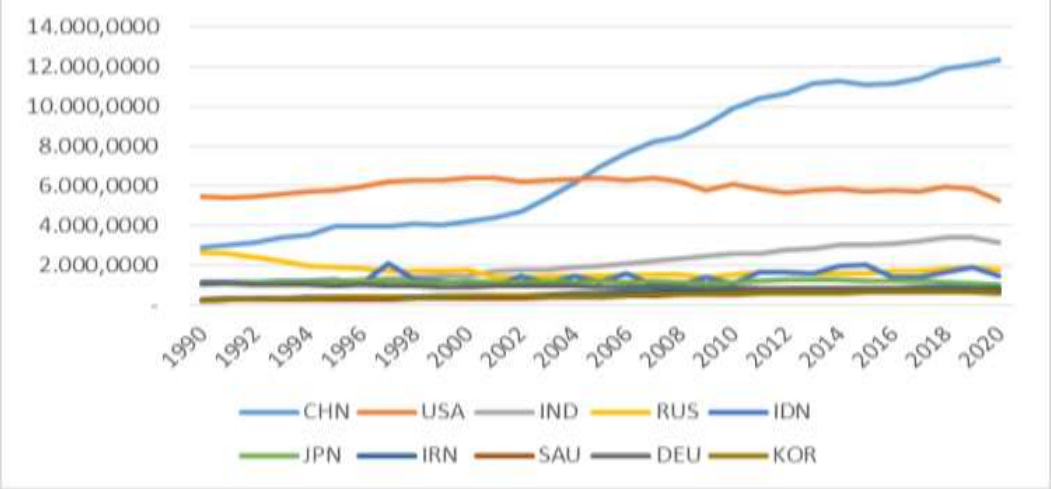


Figure 1 Increasing Trend of CO2 Gas Emissions

Source : Our World In Data, 2024. (Data Processed)

Based on Figure 1, the trend of CO2 emissions from the ten largest countries including Indonesia shows an increase every year. According to the Global Carbon Project, global CO2 emissions in 2023 from fossil fuels consist of coal (41%), gas (21%), petroleum (32%), cement (4%), and others. Increased CO2 emissions due to excessive

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

consumption of fossil energy can damage the environment, causing air pollution, global warming, and increased CO2 emissions. Based on data shown by Our World In Data, in 2022 Indonesia ranks 7th largest in the world as a carbon emitting country that reaches 729 MtCO2.

Viewed from the perspective of economic theory, greenhouse gas emissions are a negative externality of a country's economic activities, leading to global warming (Dosch 2010). Dösch argues that from the point of view of economics, economic growth will drive greenhouse gas emissions resulting in changes in environmental quality.

The relationship between economic growth and environmental quality is known as the Environmental Kuznets Curve (EKC) hypothesis. First researcher (Grossman and Krueger 1995) deep (Acheampong 2018), Environmental Kuznets Curve (EKC) explains that environmental quality will initially deteriorate along with increasing incomes, but will improve in the long term as economic growth continues to increase. In the early stages, economic growth will increase carbon emissions, but over time, emissions will decrease. The EKC also stated that low-income countries tend to focus on increasing income through investment and production of goods, which can lead to sustainable environmental damage due to the unnatural use of natural resources.

The involvement of many parties in efforts to increase economic growth is basically also a contributor to the increase in CO2 emissions. Although there has been an increase in welfare and GDP per capita, the increase has not been proportional to the increase in CO2 emissions obtained.

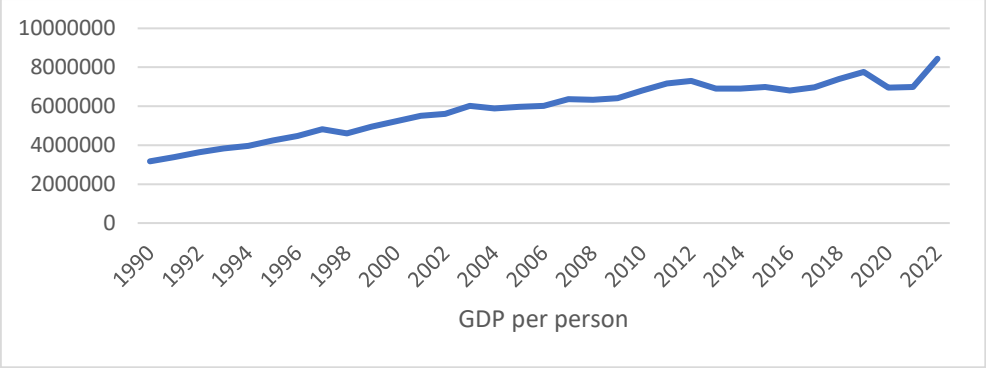


Figure 2 Indonesia's Economic Growth Rate 1990-2022
Source: World Bank, 2024. (Data Processed)

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

From the graph in figure 2 above, it shows that the economic growth rate in Indonesia tends to increase from year to year thereafter. On the one hand, higher income levels will cause CO2 emissions to increase energy demand or encourage industries whose activities produce pollution. On the other hand, the quality of the environment can improve if higher revenues lead to the application of environmentally friendly production techniques and clean and green energy consumption (Aye and Edoja 2017).

One of the factors contributing to the increase in air pollution is population. The increase in population will increase CO2 emissions from energy consumption for economic activities.

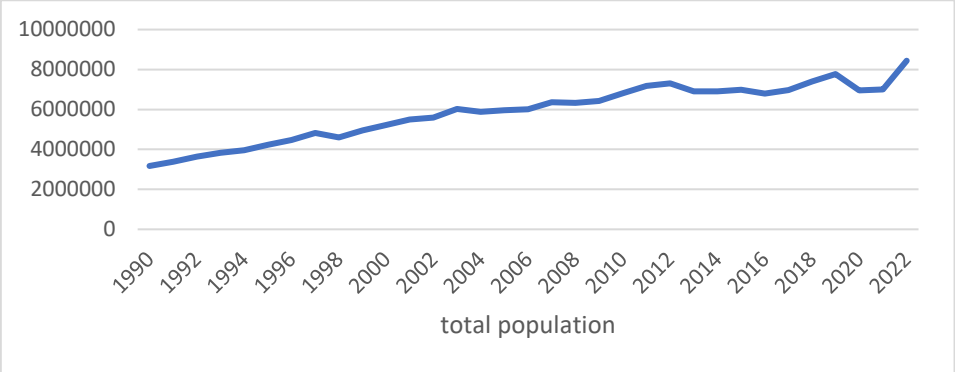


Figure 3 Indonesian Population 1990-2022

Source : World Bank, 2024. (Data Processed)

Based on figure 1 above, it can be seen that Indonesia continues to experience an increase in population. In particular, a high population can lead to increased energy demand and fossil fuel emissions. If consumption increases, there will be environmental pollution due to the burning of fossil fuels from transportation as well as harmful substances from the production process in factories, industries, and households. This pollution produces CO2 gas emissions that can increase greenhouse gases (Kurniarahma, Laut, and Prasetyanto 2020).

One solution to overcome environmental problems is through green investment. This investment aims to harmonize the natural, human, economic, and technological ecosystems by minimizing the use of non-renewable energy and replacing it with renewable energy. An important component to encourage industry in Indonesia is foreign direct investment (FDI) which increases product competitiveness, technology transfer, and productivity (Arifah 2023).

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

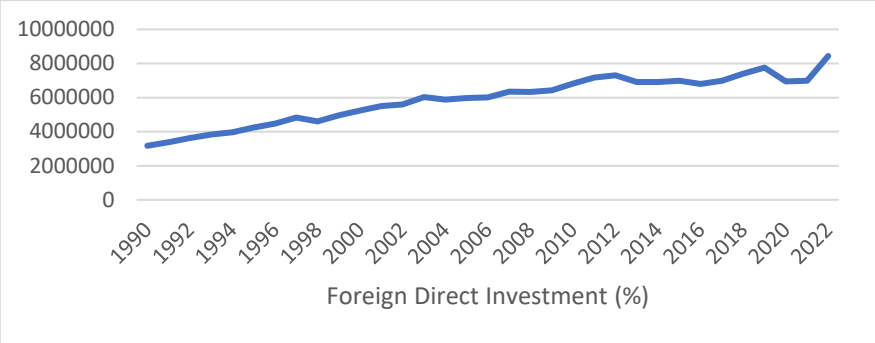


Figure 4 Foreign Direct Investment, Net Inflows in Indonesia in 1990-2022
Source : World Bank, 2024. (Data Processed)

Figure 4 shows that foreign investment in Indonesia began to rise in 2004, but fell significantly in 1998-2003, 2008, and 2016. Financial development can help companies adopt environmentally friendly technologies and attract foreign direct investment (FDI), which supports research and development and boosts economic activities. However, an increase in foreign investment can also increase manufacturing activities leading to industrial pollution and environmental degradation. (Aye & Edoja , 2017)

A number of studies have shown a correlation between energy consumption and increased carbon dioxide emissions. For example, a study conducted by Osobajo et al., (2020) find a long-term relationship between energy consumption, economic growth and carbon dioxide emissions. The following is the development of energy consumption in Indonesia.

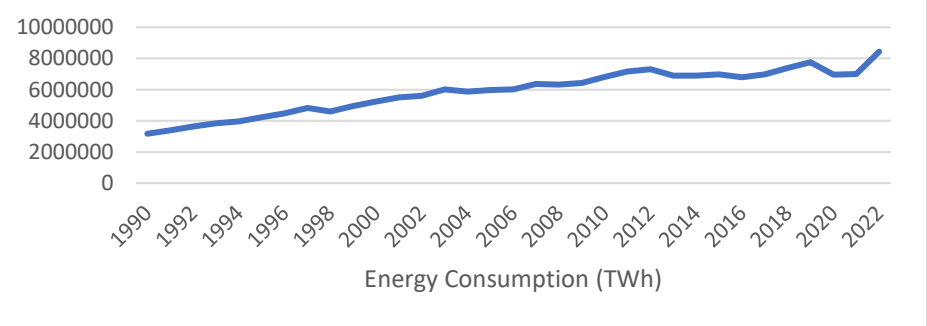


Figure *5* Development of energy consumption in Indonesia
Source : Our World in Data, 2024. (Data Processed)

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Based on figure 5, energy consumption in Indonesia continues to increase every year. According to the Handbook of Energy & Economic Statistics of Indonesia (HEESI) 2022 by the Ministry of Energy and Mineral Resources, the industrial sector has the highest share of energy demand at 43.21%, followed by the transportation sector at 38.49%, the household sector at 12.97%, the commercial sector at 4.34%, and other sectors at 0.99%. The use of domestic coal by the industrial sector is the main cause of the dominance of energy demand in this sector in 2022.

The excessive use of non-renewable energy in economic activities causes sustainable environmental damage, including air pollution and CO2 emissions that contribute to global warming. To reduce global air pollution, the use of renewable energy is needed. Against this background, the author conducted a study on the environmental Kuznets curve hypothesis in Indonesia, examining economic growth, population, foreign direct investment, and energy consumption on CO2 emissions.

LITERATURE REVIEW

Economic Growth Theory

Economic growth is defined by (Kuznets 1955) as an increase in the capacity of a country to offer economic goods to its population as a result of institutions, technological advancements, and necessary adjustments. Economic growth, according to Schumpeter in Boediono (2012:48), is characterized as an increase in people's output caused by an increasing number of production factors employed in the production process, without being followed by economic changes showing how much money people make from economic activities in a certain period of time in addition to measuring the rate of production growth in an economy.

Carbon Dioxide (CO2) Emissions

Carbon dioxide is a gas found in the atmosphere that forms during respiration, usually obtained from the combustion of gasoline, oil, kerosene, natural gas, wood, coal and coke. Carbon dioxide has the physical characteristics of being colorless, odorless, non-toxic, and non-flammable (Kubba and Kubba 2017).

Environmental Kuznets Curve Theory

The Environmental Kuznets Curve (EKC) is one of the most common methods for analyzing environmental performance. The Environmental Kuznets curve is based on an inverted U-shaped curve created by Kuznets in 1955. The emergence of the

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Environmental Kuznets Curve triggers a change in the focus of environmental discussions. Prior to the Environmental Kuznets Curve, concerns focused on the earth's limited capacity to absorb municipal and industrial waste. With the existence of the Environmental Kuznets Curve, environmental problems change from scarcity of environmental resources to the inevitable need for income growth to overcome pollution. (Kuznets , 1955) (Rashid Gill dkk., 2018).

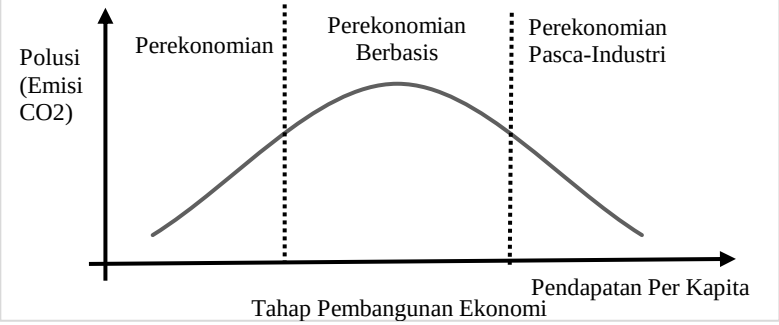


Figure 6 Environmental Kuznets Curve

Source: (processed) (Panayotou , 2000)

Population

According to the Organisation for Economic Co-operation and Development (OECD), population can be defined as all citizens who are in a country or who are temporarily in a country, including foreigners who live permanently in a country (OECD Data, 2024).

Foreign Direct Investment

In general (Sukirno 2000) Describes investment as funds used to purchase goods, capital, and production equipment to improve economic capabilities in providing commodities and services. Foreign Direct Investment is an actual investment in capital goods, factories, land supplies. Investors control the funds invested, and both capital and management are involved.

Energy Consumption

Consumption can be interpreted as the expenditure of goods and services by households or individuals, both primary, secondary, and tertiary goods to meet their living

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

needs. Energy consumption plays an important role in stimulating the economy, but it can also lead to an increase in waste and pollution from burning fossil fuels.(Mankiw, 2012) (Wahyudi & Palupi, 2023)

RESEARCH METHODS

Research Venue

The place of this research is data covering all regions of Indonesia in a span of 33 years, from 1990 to 2022. The basis for choosing the research site is that the phenomena behind this research occur in Indonesia.

Data and Data Sources

The type of data used in this study is secondary data. Secondary data in this study is in the form of time series data in the period 1990-2022 in Indonesia. Secondary data sources are obtained from the climwatch website, the World Bank and our world in data related to data on carbon dioxide emissions, population, foreign direct investment and energy consumption in Indonesia.

Data Analysis

Research Model to Prove the Environmental Kuznets Curve (EKC) Hypothesis

In this study, the Environmental Kuznets Curve (EKC) hypothesis is estimated, using a general model that shows the relationship between economic growth and carbon dioxide emissions as follows:

$$\boldsymbol{LogCO2t = \alpha + \beta 1 LogGDPt + \beta 2 LogGDP2t + \varepsilon t}$$

Information:

CO2	: Carbon dioxide emissions
GDP	: GDP Per Capita
GDP2	: GDP Per Capita Squared
β1,2	: Regression coefficient of each independent variable
ε	: Residual
t	:Time
Log	:Logarithmic

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Research Model to Test the Influence of Economic Growth, Population, Foreign Direct Investment, and Energy Consumption on Carbon Dioxide Emissions

This study examines the long-term and short-term effects of economic growth, population, foreign direct investment and energy consumption on carbon dioxide emissions in Indonesia using the Error Correction Model (ECM) analysis approach.
The following are the common models used in this analysis:

$$CO2t = \alpha + \beta1GDPt + \beta2POPt + \beta3FDIt + \beta4KEt + \varepsilon t$$

Information:
CO2 : Carbon dioxide emissions
GDP : GDP Per Capita
POP :Population
FDI : Foreign Direct Investment
TO : Energy Consumption
β1234 : Regression coefficient of each independent variable
ε : Residual
t :Time

RESULT
Error Corection Model (ECM)
Environmental Kuznets Curve (EKC) Hypothesis Proofing Model

Table 1 Long-Term ECM Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG_GDP	17.41947	5.897298	2.953805	0.0061
LOG_GDP2	-0.556729	0.198707	-2.801758	0.0088
C	-121.4332	43.74378	-2.776010	0.0094
R-squared	0.936909			
Adjusted R-squared	0.932702			
F-statistic	222.7499			
Prob(F-statistic)	0.000000			

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Source: Data Processed by Eviews 12 (2024)

Based on data processing, it is estimated that in the long term, economic growth (LOG_GDP) has a positive coefficient of 17.41947 to CO2 emissions. A 1% increase in GDP increases CO2 emissions by 17.41947 tons with a probability of 0.0061 ($p<0.05$), showing a significant influence. Quadratic economic growth (LOG_GDP2) has a negative coefficient of -0.556729, which means a 1% increase LOG_GDP2 reduce CO2 emissions by -0.556729 tons with a probability of 0.0088 ($p<0.05$), showing a significant influence and supporting the EKC hypothesis in Indonesia.

Table 2 Short-Term ECM Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG_GDP)	0.732692	15.56513	0.047073	0.9628
D(LOG_GDP2)	0.004475	0.530205	0.008441	0.9933
ECT(-1)	- 0.440150	0.161182	-2.730773	0.0108
C	0.005642	0.013161	0.428705	0.6714
R-squared	0.374424			
Adjusted R-squared	0.307398			
F-statistic	5.586257			
Prob(F-statistic)	0.003926			

Source: Data Processed by Eviews 12 (2024)

From short-term estimates, the economic growth variable (LOG_GDP) has a positive coefficient of 0.732692 to CO2 emissions, meaning that a 1% increase in GDP increases CO2 emissions by 0.732692 tons. However, a probability value of 0.9628 indicates that this variable is not significant to CO2 emissions because it is 0.9628 > 0.05. The quadratic economic growth variable (LOG_GDP2) has a positive coefficient of 0.004475 to CO2 emissions, meaning that a 1% increase in GDP increases CO2 emissions by 0.004475 tons. However, a probability value of 0.9933 indicates that this variable is not significant to CO2 emissions because it is 0.9933 > 0.05.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Models of the Effects of Economic Growth (GDP), Population, Foreign Direct Investment, and Energy Consumption on Carbon Dioxide Emissions

Table 3 Long-Term ECM Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG_GDP	-0.466583	0.110277	4.230993	0.0002
LOG_POP	2.512124	1.109181	-2.264846	0.0315
LOG_FDI	0.000779	0.008553	0.091035	0.9281
LOG_KE	1.541363	0.259004	5.951124	0.0000
C	19.01429	6.640595	2.863342	0.0079
R-squared	0.984215			
Adjusted R-squared	0.981960			
F-statistic	436.4623			
Prob(F-statistic)	0.000000			

Source: Data processed by Eviews 12, 2024.

Interpetation from the table above:

a) The economic growth variable (LOG_GDP) has a positive coefficient of 0.466583 to CO2 emissions, meaning that a 1% increase in GDP will increase CO2 emissions by 0.466583 tons. A probability of 0.0002 indicates a significant influence on CO2 emissions (0.0002 < 0.05).
b) The population variable (LOG_POP) has a negative coefficient of -2.512124 to CO2 emissions, meaning that a 1% increase in population will reduce CO2 emissions by -2.512124 tons. A probability of 0.0315 indicates a significant influence on CO2 emissions (0.0315 < 0.05).
c) The foreign direct investment (LOG_FDI) variable has a positive coefficient of 0.000779 to CO2 emissions, meaning that a 1% increase in foreign direct investment will increase CO2 emissions by 0.000779 tons. A probability of 0.9281 indicates no significant effect on CO2 emissions (0.9281 > 0.05).
d) The energy consumption variable (LOG_KE) has a positive coefficient of 1.541363 to CO2 emissions, meaning that a 1% increase in energy

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

consumption will increase CO2 emissions by 1.541363 tons. A probability of 0.0000 indicates a significant influence on CO2 emissions (0.0000 < 0.05).

Table 4 Short-Term ECM Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG_GDP)	0.308485	0.209197	1.474616	0.1523
D(LOG_POP)	-0.405589	4.621512	-0.087761	0.9307
D(LOG_FDI)	0.009269	0.007293	1.270921	0.2150
D(LOG_KE)	1.632090	0.284724	5.732175	0.0000
ECT(-1)	-0.877825	0.191624	-4.580975	0.0001
C	-0.009109	0.026976	-0.337669	0.7383
R-squared	0.785032			
Adjusted R-squared	0.743692			
F-statistic	18.98961			
Prob(F-statistic)	0.000000			

Source: Data processed by Eviews 12, 2024.

Interpetation from the table above:

a) The economic growth variable (LOG_GDP) has a positive coefficient of 0.308485 to CO2 emissions, showing that a 1% increase in GDP increases CO2 emissions by 0.308485 tons. However, with a probability of 0.1523 (more than 0.05), the effect is not significant.
b) The population variable (LOG_POP) has a negative coefficient of -0.405589 to CO2 emissions, which indicates a 1% increase in population reduces CO2 emissions by 0.405589 tons. The probability of 0.9307 indicates that the economic growth variable is not significant to CO2 emissions because the value is >0.05.
c) The foreign direct investment (LOG_FDI) variable has a positive coefficient of 0.009269 to CO2 emissions, which means that a 1% increase in foreign direct investment increases CO2 emissions by 0.009269 tons. However, a probability of 0.2150 indicates that the effect is not significant because it is greater than 0.05.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

d) The energy consumption variable (LOG_KE) has a positive coefficient of 1.632090 to CO2 emissions, meaning that a 1% increase in energy consumption will increase CO2 emissions by 1.632090 tons. A probability of 0.0000 indicates a significant influence of economic growth variables on CO2 emissions because this probability value is less than 0.05.

Hypothesis Test
Partial Test (T-Test)

Table 5 t-Statistics Test Results

	Long-Term Regression		Short-Term Regression	
Variable	t-stats	Probability	t-stats	Probability
LOG_GDP	4.230993	0.0002	1.474616	0.1523
LOG_POP	-2.264846	0.0315	-0.087761	0.9307
LOG_FDI	0.091035	0.9281	1.270921	0.2150
LOG_KE	5.951124	0.0000	5.732175	0.0000

Source: Data processed by Eviews 12, 2024.

Thus, the hypothesis can be proven as follows:

1. Economic Growth Variables
   Based on the results of the t-statistical test, in the long term with a probability of 0.0002 < 0.05, H0 is rejected and H1 is accepted, meaning that economic growth has a significant effect on carbon dioxide emissions partially. Meanwhile, in the short term with a probability of 0.1523 > 0.05, H0 is accepted and H1 is rejected, meaning that economic growth does not have a significant effect on carbon dioxide emissions partially.
2. Population Variables The results of the t-statistical test show that in the long term (probability 0.0315 < 0.05), H0 is rejected and H1 is accepted, so the population variable has a significant effect on carbon dioxide emissions. However, in the short term (probability 0.9307 > 0.05), H0 is accepted and H1 is rejected, meaning that the population variable has no significant effect.
3. The results of the t-statistical test show that both in the long and short term, the probability is greater than 0.05, so H0 is accepted and H1 is rejected. This means

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

that the foreign direct investment variable does not have a significant effect on carbon dioxide emissions.

4. Energy Consumption Variable The results of the t-statistical test show that in the long term and short term (probability 0.0000 < 0.05), H0 is rejected and H1 is accepted, so that the energy consumption variable has a significant effect on carbon dioxide emissions.

Simultaneous Test (Test F)

Table 6 Test Results F

	Long-Term Regression	Short-Term Regression
Prob (F-statistic)	0.000000	0.000000

Source: Data processed by Eviews 12, 2024.

The results of the F test showed a probability value of 0.000000, below the significance level of 5%. This shows that there is a significant influence of economic growth, population, foreign direct investment, and energy consumption on CO2 emissions, so H0 is rejected and H1 is accepted.

Determination Coefficient Test (R2)

Table 7 R2 Test Results

Adjusted R-squared	0.785032

Source: Data processed by Eviews 12, 2024.

Based on the table above, the Adjusted R-Square shows that the variables of economic growth, population, foreign direct investment, and energy consumption collectively account for 78.50% of CO2 emissions, while other variables outside of this model account for 21.50%.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

DISCUSSION

Proof of the Environmental Kuznets Curve (EKC) Hypothesis in Indonesia in the Period 1990-2022

Table 8 Results of EKC Hypothesis Testing

Variable	Short-Term Coefficients	Long-Term Coefficients
Per Capita Income	-1.320168ts	17.41947**
Per Capita Quadratic Income	0.078867ts	-0.556729**
EKC Occurs	**NOT**	**YES**
Turning Point		15.644.478

Source: Personal processing. (**) = significant at a rate of 5%, (ts) = insignificant.

In accordance with the results of the ECM test, it can be concluded that the hypothesis of the Environmental Kuznet Curve theory in Indonesia is only relevant in the long term. According to the EKC theory, as a country's per capita income increases, environmental degradation measured by CO2 emissions initially also increases. However, after some time, the increase in revenue no longer increases CO2 emissions, but instead decreases. The results of this study are in line with the research (Elfaki & Heriqbaldi 2023) and research (Muhammad Fajar and Hariyanto 2021). Based on this study, the results were obtained that in the long term quadratic economic growth there was a decrease in CO2 emissions.

The Effect of Economic Growth on Carbon Dioxide Emissions in Indonesia

Based on the results of the ECM test conducted in this study, the long-term economic growth variable has a positive and significant effect on carbon dioxide emissions. . And in the short term, economic growth variables have a positive but insignificant effect. The results of this study are in line with previous research conducted by (Noor and Saputra 2020; Arifah 2023; Osobajo et al. 2020) which also found that the relationship between economic growth and carbon dioxide emissions was positive. This is due to the fact that the production, distribution, and consumption processes that drive

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

economic expansion also produce externalities such as pollution that increase carbon dioxide emissions.

The Effect of Popuation on Carbon Dioxide Emissions in Indonesia

Based on the results of the ECM test conducted in this study, population variables in the long term have a significant effect on CO2 emissions. In the short term, population variables have a negative and insignificant relationship. This means that population variables do not have a significant effect on carbon dioxide (C02) gas emissions. The results of this study are in line with the research (Mu Tashim and Rudatin 2024) that the population has no positive effect on CO2 emissions. This can happen due to population growth caused by other causes such as increased awareness of environmental protection among human resources and strict environmental regulations through the implementation of efficient environmental policies. can help reduce carbon emissions (Larissa and Eduardo, 2022).

The Effect of Foreign Direct Investment on Carbon Dioxide Emissions in Indonesia

Based on the results of the ECM test conducted in this study, it shows that in the long and short term, the direct foreign investment variable has a insignificant influence on carbon dioxide emissions. The results of this study are in line with the research (Annas Pratama and Lukis Panjawa 2022) which states that foreign direct investment does not have a significant effect on CO2 emissions. Therefore, increasing investment will not necessarily increase the level of carbon dioxide (CO2) emissions, this can be anticipated by investors where they will minimize the impact of environmental problems that will occur through careful design and environmentally friendly technology.

The Effect of Energy Consumption on Carbon Dioxide Emissions in Indonesia

Based on the results of the ECM test conducted in this study, energy consumption variables in the long term and in the short term have a positive and significant effect on carbon dioxide emissions. This is in accordance with the hypothesis that the variable energy consumption has a positive effect on CO2 emissions, so that when energy consumption increases, CO2 emissions also increase. The results of this study are in line with the research conducted by (Nikensari et al., 2019) and research (Osobajo et al., 2020) which states that the intensity of carbon dioxide emissions is positively influenced by energy consumption based on this indicates that the current energy use in Indonesia is still not using environmentally friendly energy types, because the use of energy still has

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

an impact on pollution output which further contributes to an increase in carbon dioxide emissions.

CONCLUSION

In the period 1990-2022, the environmental Kuznets curve hypothesis in Indonesia has proven to be relevant in the long term. The economic growth variable has a positive and significant relationship in the long term and not significant in the short term to carbon dioxide emissions. The population variable has a negative and significant relationship in the long term and not significant in the short term to carbon dioxide emissions. The long-term and short-term foreign direct investment variables have a positive and insignificant relationship with Emini carbon dioxide. Long-term and short-term energy consumption variables have a positive and significant relationship with carbon dioxide emissions.

SUGGESTION

Based on the study, the researcher provides advice to academics, namely that the EKC hypothesis is susceptible to variations in data and research methods, which can affect the results and interpretation. It is recommended to select study data carefully and carefully and apply a careful approach. And for the government, the main role of the government in reducing CO2 emissions lies in the implementation of state policies, including measures to support the reduction of CO2 emissions and encourage the development of environmentally friendly industries according to the EKC theory.

REFERENCES

Acheampong, Alex O. 2018. "Economic Growth, CO2 Emissions and Energy Consumption: What Causes What and Where?" Energy Economics. https://doi.org/10.1016/j.eneco.2018.07.022.

Annas Pratama, Ikhwan, and Jihad Lukis Panjawa. 2022. "Analysis of the Effect of Gross Domestic Product, Financial Development, Foreign Direct Investment, and Energy on Co2 Emissions in Indonesia for the 1990-2020 Period." Journal of Humanities, Social Sciences and Business (Jhssb).

Arifah, Lidyana. 2023. "ECONOMIC GROWTH, FOREIGN DIRECT INVESTMENT AND CARBON EMISSIONS IN INDONESIA FOR THE PERIOD 1990-2022." Elasticity - Journal of Development Economics. https://doi.org/10.29303/e-jep.v5i1.79.

Aye, Goodness C., and Prosper Ebruvwiyo Edoja. 2017. "Effect of Economic Growth on CO2 Emission in Developing Countries: Evidence from a Dynamic Panel

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Threshold Model." Cogent Economics and Finance. https://doi.org/10.1080/23322039.2017.1379239.

Dosch, Jörn. 2010. "Balancing Trade Growth and Environmental Protection in ASEAN : Environmental Issues in Trade and Investment Policy Deliberations in the Mekong Subregion." ISSD.

Elfaki, Khalid Eltayeb, and Unggul Heriqbaldi. 2023. "Analyzing the Moderating Role of Industrialization on the Environmental Kuznets Curve (EKC) in Indonesia: What Are the Contributions of Financial Development, Energy Consumption, and Economic Growth?" Sustainability (Switzerland) 15 (5). https://doi.org/10.3390/su15054270.

González-Álvarez, María A., and Antonio Montañés. 2023. "CO2 Emissions, Energy Consumption, and Economic Growth: Determining the Stability of the 3E Relationship." Economic Modelling. https://doi.org/10.1016/j.econmod.2023.106195.

Grossman, Gene M., and Alan B. Krueger. 1995. "Economic Growth and the Environment." Quarterly Journal of Economics. https://doi.org/10.2307/2118443.

Kubba, Sam, and Sam Kubba. 2017. Chapter Seven – Indoor Environmental Quality. Handbook of Green Building Design and Construction.

Kurniarahma, Lulu, Lorentino Togar Laut, and Panji Kusuma Prasetyanto. 2020. "Analysis of Factors Affecting CO2 Emissions in Indonesia." Directory Journal of Economic 2 (2): 368–85.

Kuznets, Simon. 1955. "Economic Growth and Income Inequality. The American Economic Review." Academy of Management Review.

Mu Tashim, Tsaqifu, and Ari Rudatin. 2024. "Economic Analysis of BRICS Countries on Carbon Dioxide (CO2) Emissions." Journal of Economic and Financial Policy. https://doi.org/10.20885/jkek.vol2.iss2.art12.

Muhammad Fajar, and Hariyanto. 2021. "Testing the Existence of the Environmental Kuznets Curve in Indonesia." Journal of Lebesgue : Scientific Journal of Mathematics, Mathematics and Statistics Education 2 (1): 62–68. https://doi.org/10.46306/lb.v2i1.56.

Nikensari, Sri Indah, Sekar Destilawati, and Siti Nurjanah. 2019. "STUDY OF THE ENVIRONMENTAL KUZNETS CURVE IN ASIA: BEFORE AND AFTER THE MILLENNIUM DEVELOPMENT GOALS." Journal of Development Economics. https://doi.org/10.14203/jep.27.2.2019.11-25.

Noor, Muhamad Ameer, and Putu Mahardika Adi Saputra. 2020. "Carbon Emissions and

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Gross Domestic Product: An Investigation of the Environmental Kuznets Curve (EKC) Hypothesis in Middle-Income Countries in the ASEAN Region." Journal of Region and Environment 8 (3): 230–46. https://doi.org/10.14710/jwl.8.3.230-246.

Osobajo, Oluyomi A., Afolabi Otitoju, Martha Ajibola Otitoju, and Adekunle Oke. 2020. "The Impact of Energy Consumption and Economic Growth on Carbon Dioxide Emissions." Sustainability (Switzerland). https://doi.org/10.3390/SU12197965.

Sukirno, Sadono. 2000. "The Development of Thought from Classical to New Keynesian." In Modern Macroeconomics.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.