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Article

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The Influence of Determinats on CO_2 Emission in Indonesia for a Decade

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ABSTRACT

This study aims to see the effect of GDP per capita, income inequality, and population on CO_2 emissions in Indonesia from 1990 to 2021. This research uses a descriptive quantitative method. The data used is secondary data, in the form of annual data for 32 years. The analytical method used is the error correction model (ECM) to see the short and long-term effects between the independent variable and the dependent variable. The results of this study indicate that GDP per capita has a positive and significant effect on Indonesia, both in the short term and in the long term. The income inequality variable has a positive and insignificant effect on CO_2 emissions in Indonesia in the short term. Meanwhile, in the long term, income inequality has a negative and insignificant effect on CO_2 emissions in Indonesia. The population variable has an insignificant negative effect on CO_2 emissions in Indonesia in the short term. However, in the long term, the population significantly affects CO_2 emissions in Indonesia.

Keywords: CO_2 Emissions, GDP Per Capita, Income Inequality, Population
JEL Classifications: O10, P23, Q53

1. INTRODUCTION

Environmental degradation is a topic that is often raised because it is a serious problem at the world level. The most serious impact of environmental degradation is global warming. Global warming is caused by increasing Green House Gases (GHG). Currently, Indonesia continues to experience an increase in GHG emissions from year to year. Based on data from the Ministry of Environment and Forestry (2021), it shows that the energy sector is the largest contributor to GHG emissions in Indonesia, namely 34%, followed by the waste sector (7%), agriculture (6%), and IPPU (3%). This shows that the energy sector has a dominant contribution to national GHG emissions. Based on the 2006 IPCC GL guidelines, gas from the energy sector consists of CO_2, CH4, and N2O. The Ministry of Environment and Forestry (2021) states that CO_2 emissions have the largest contribution to total national GHG emissions, namely 93%, followed by CH4 (6%), and NO2 (1%).

Environmental degradation is defined as a decrease in environmental quality caused by natural and human factors. The main factor that causes environmental degradation is the human factor. Human factors that cause environmental degradation include industrial activities, land conversion, use of fossil energy, and others. Environmental degradation is driven by a country's need to increase economic growth and development and meet human needs (Reswita et al., 2021).

Economic growth and development is an analytical agenda that has a role in improving welfare (Firmansyah, 2021). Economic growth shows an increase in the country's productivity in producing goods and services (Finanda and Toto, 2022). The main indicator that characterizes economic growth is Gross Domestic Product (Grishin et al., 2019). Currently, Indonesia continues to experience a positive trend of economic growth, namely growing by 5.03% in 2016, 5.17% in 2017, and 5.17% in 2018 (Central Bureau of Statistics, 2022). In an effort to increase economic growth, it is necessary to carry out economic activities and energy consumption. According to Nikensari et al. (2019), economic activities that require energy, for example industry, contribute 60% to CO_2 emissions. This is also in line with the contribution of the industrial sector which reached 19.8% of national GDP (Ministry of Industry, 2022), meaning that an increase in GDP causes environmental degradation in the form of CO_2 emissions. The biggest challenge for developing countries is being able to maintain economic growth, but still maintain environmental quality (Fajriani et al., 2023).

Increasing economic growth without improving the development structure causes problems of inequality in society. Income inequality occurs because of disparities in income distribution among social groups. According to Gulzar et al. (2020) income inequality is a factor causing environmental pollution in developing countries. Income inequality causes the government's internal attention to be focused on economic growth policies only, without paying attention to environmental aspects (Magnani, 2000). Economic growth efforts to reduce income inequality lead to increased resource use and energy consumption. This is a factor causing the increase in CO_2 emissions.

In an effort to increase GDP, residents or humans are needed as development actors. Residents become economic actors, both as producers and consumers. Currently, Indonesia's population continues to increase from year to year. According to Mahendra et al. (2022) the increasing population will be followed by an increase in demand for goods and services which in turn increases the use of natural resources. Increasing demand for goods and services has an impact on increasing industrial activity. Apart from that, the increasing population also causes an increase in the use of energy such as fossil fuels which results in environmental degradation in the form of CO_2 emissions.

The focus of this research is the rapid increase in GDP every year, the existence of income inequality, and the increase in population which causes CO_2 emissions in Indonesia. This research combines economic, environmental and social aspects contained in the concept of sustainable development. This research looks at the influence of GDP per capita, population, and income inequality on CO_2 emissions in Indonesia both in the short and long term.

2. LITERATURE REVIEW

Indonesia continues to experience rapid economic growth. The indicator that characterizes economic growth is Gross Domestic Product (GDP). GDP is the main parameter to determine the economic conditions in two regions in a certain time period because it calculates added value and the value of final goods and services produced (Syari et al., 2017). Indirectly, efforts to increase GDP encourage increased production and industrial activity. Economic growth is a parameter that determines the success of economic development, but on the other hand it can cause environmental degradation in the form of CO_2 emissions. According to Drews and Bergh (2017) there is a trade off between economic growth and environmental preservation.

GDP figures that continue to increase do not guarantee that Indonesia is free from social problems in the form of income inequality. In reality, the richest 10% of people in Indonesia control 75.7% of national wealth and the richest 1% of people in Indonesia control 49.3% of national wealth (Mawardi, 2018). This data proves that Indonesia is still experiencing income inequality, where inequality can affect CO_2 emissions.

According to Adam Smith's theory, one of the most important components in economic growth is population. The increase in population in Indonesia is also accompanied by an increase in economic growth. However, this increase in population causes an increase in the use of natural resources which causes pollution. The increasing population also has an impact on increasing energy use which causes CO_2 emissions. Based on this explanation, the researchers determined the problem formulation as follows: (1) How does GDP per capita affect CO_2 emissions in Indonesia in 1990-2021?; (2) How does population influence CO_2 emissions in Indonesia in 1990-2021?; and (3) How does income inequality affect CO_2 emissions in Indonesia in 1990-2021?

3. RESEARCH METHODS

The research method used is a quantitative method with a descriptive approach. The quantitative method is a research method in the form of numbers measured using statistical tests to provide conclusions. The descriptive approach used functions to describe research results by presenting, analyzing and interpreting them. The scope of this research is Indonesia. The data used is annual data or time series for 32 years starting from 1990 to 2021. Research data was obtained from the World Bank and Our World in Data.

This research consists of three independent variables and one dependent variable. The independent variables used are GDP per capita in US$ units, the population variable in thousands of people, and the income inequality variable which is measured using the Gini ratio. The dependent variable is CO_2 emissions in tons. The CO_2 emissions calculated in this research are only emissions originating from fossil energy and industry.

Time series data requires stationary data. So before estimating the data, it is necessary to carry out a stationarity test. Data is said to be stationary if there are no drastic changes in the data. The first data analysis carried out was the stationarity test. The stationarity test carried out in this study used the Augmented Dickey-Fuller method by comparing the ADF t-statistic with the MacKinnon critical value. If the ADF t-statistic value is greater than the MacKinnon critical value of 5%, then the data is stationary. If the data stationarity test shows results that are not stationary, then an integration test is carried out. Integration tests are carried out to see to what degree the data will be stationary. Next, test cointegration using the Engel Granger (EG) test. The Engel Granger test can determine the cointegration of the stationarity of the residuals.

Data estimation in this study uses an error correction model (ECM). ECM estimation aims to determine whether there is a short-term and long-term influence on the variables being tested. Equality The ECM in this research is as follows:

$$\Delta CO_2 = \alpha 0 + \alpha 1 \Delta PDB_t + \alpha 2 \Delta GR_t + \alpha 3 \Delta P_t + \varepsilon_t \quad (1)$$

For the long-term regression equation, it is written as follows:

$$CO_2 = \beta 0 + \beta 1 PDB_t + \beta 2 GR_t + \beta 3 P_t + \varepsilon_t \quad (2)$$

Information:
CO_2: CO_2 emissions
GDP: GDP per Capita
GR: Income Inequality (Gini ratio)
P: Population
α0 and β0: Constants
α1, α2, α3 and β1, β2, β3: Regression Coefficients
ϵ: Error term (Redisual)

The error correction model method is characterized by the presence of an error correction term (ECT) element. ECT is a residual that appears in the ECM model. If the ECT coefficient value is <1 and is significant at 5%, then the specification model used is valid. After obtaining the research model, the next stage is to test the classical assumptions. The classic assumption tests used in this research are the normality test, autocorrelation test, heteroscedasticity test, and multicollinearity test. The normality test uses the Jarque-Bera test, if the JB value is >α 5%, then the residuals are normally distributed. The acocorrelation test uses the Durbin-Watson test, if the DW value is between −2 and +2, then there is no autocorrelation problem. The heteroscedasticity test uses the Breusch-Pagan-Godfrey test, if the value of Prob. Chi Square is more than 0.05, then there is no heteroscedasticity problem. The multicollinearity test uses the VIF test, if the test result is below 10, then there is no multicollinearity problem.

4. RESULTS, ANALYSIS, AND DISCUSSION

Time series data requires stationary data. Test stationarity with using the Augmented Dickey-Fuller method shown in the Table 1:

Based on the results of the stationarity test, it shows that the ADF test value for all variables is smaller than the MacKinnon critical value and the probability value is more than α 5%, so that all variables are not stationary at level level. Next, a difference test is carried out to find out at what degree of integration the data will be stationary. In the Table 2 is the integration test in this research:

Based on the results of the integration test, it shows that the ADF test value for all variables is greater than the MacKinnon critical value and the probability value is less than α 5%, so that all variables are stationary at the first difference level. Because all variables are stationary at the first difference level, the next stage is to carry out a cointegration test so that this can be done perform ECM estimation. The cointegration test is shown in the following Table 3:

Based on the results of the cointegration test, it shows that the probability value is 0.0012 <α 5% and the ADF test value is more than the critical value. So, the equation being tested has an equilibrium relationship in the long run. So that the estimation model can be interpreted further. This research uses the Domowitz El badawi ECM estimation model to determine the short-term and long-term effects of GDP per capita, income inequality and population on CO_2 emissions. The short-term regression results are shown in the Table 4.

Based on the short-term estimation results, the following regression equation is obtained:

$$CO_2 = 62045241 + 40630.62PDB$$
$$+698885.5GR - 16.79596P - 0.832239$$

This equation shows that the constant value is 62045241, meaning that if the value of all independent variables is zero, then the CO_2 emission value is 62045241 tonnes. The coefficient value for the GDP per capita variable is 40630.62, meaning that when GDP per capita increases by 1 US$, CO_2 emissions will increase by 40630.62 tons (cateris paribus). The coefficient on the income inequality variable is 698885.5, meaning that when inequality increases by 1%, CO_2 emissions will increase by 698885.5 tons (cateris paribus). The coefficient on the population variable is −16.79596, meaning that when the population increases by 1 million people, CO_2 emissions will decrease by 16.79596 tons (cateris paribus). Meanwhile, the coefficient value for the ECT

Table 1: Stationarity test at level level

Variable	ADF test value	McKinnon's critical values			Prob.	Information
		1%	5%	10%		
CO_2	−0.492203	−3.661661	−2.960411	−2.619160	0.8797	Not Stationary
GDP	0.248447	−3.661661	−2.960411	−2.619160	0.9714	Not Stationary
GR	−0.981690	−3.661661	−2.960411	−2.619160	0.7473	Not Stationary
P	−1.889931	−3.737853	−2.991878	−2.635542	0.3311	Not Stationary

Table 2: Integration test on first difference

Variable	ADF test value	McKinnon's critical values			Prob.	Information
		1%	5%	10%		
CO2	−5.405547	−3.679322	−2.967767	−2.622989	0.0001	Stationary
GDP	−4.314652	−3.670170	−2.963972	−2.621007	0.0020	Stationary
GR	−4.396564	−3.670170	−2.963972	−2.621007	0.0016	Stationary
P	−3.036626	−3.699871	−2.976263	−2.627420	0.0441	Stationary

Table 3: Cointegration test

Cointegration Test	t-Statistics	Prob.*
Augmented Dickey-Fuller test Statistics	−4.507542	0.0012
Test Critical values: 1% level	−3.661661	
5% level	−2.960411	
10% levels	−2.619160	

Table 4: Short term estimation results

Variables	Coefficient	SE	t-Statistics	Prob.
C	62045241	77047907	0.805281	0.4280
D (GDP)	40630.62	17211.78	2.360629	0.0260
D (INEQUALITY)	698885.5	3124697.	0.223665	0.8248
D (POPULATION K)	−16.79596	25.13333	−0.668274	0.5098
ECT(−1)	−0.832239	0.195686	−4.252934	0.0002
R-squared	0.593224			
Adjusted R-squared	0.530643			
F-statistic	9.479298			
Prob (F-statistic)	0.000073			

variable is −0.832239, because it has a negative sign (ECT <1) and is significant at α 5%, the specification model used is valid. The R-squared value has a coefficient of 0.593224, meaning that GDP per capita, income inequality and population together can explain 59.3224% of CO_2 emissions. Meanwhile, the rest is explained by other variables outside the research model. Table 4 also shows that based on the t test, the GDP per capita variable has a significant positive effect (Prob <0.05), the income inequality variable has an insignificant positive effect (Prob >0.05), and the population variable has an insignificant negative effect (Prob >0.05) on CO_2 emissions. in Indonesia in the short term. Meanwhile, simultaneously (f test) all variables together have a significant effect on C2 emissions in Indonesia (Prob f-statistic <0.05).

Next is the classical assumption test which aims to find out whether the estimation results violate the classical assumptions or not. The first classical assumption test is the normality test. Based on the results of the normality test, the Jarque-Bera value was 0.900505 >0.05, so it can be concluded that the data is normally distributed. Then, based on the results of the autocorrelation test, it shows that the Durbin-Watson value in this study is 1.920450, so it can be concluded that there is no autocorrelation problem in the regression model. Based on the results of the heteroscedasticity test, it shows that the value of Prob. ChiSquare is 0.4816>0.05, so it can be concluded that there is no heteroscedasticity problem. Based on the results of the multicollinearity test, a VIF value of less than 10 was obtained for each variable, so it can be concluded that there is no heteroscedasticity problem in the regression model. The long-term estimation model is shown in the Table 5.

Based on the long-term estimation results, the following regression equation is obtained:

$$CO_2 = -3.19 + 50154.20PDB - 4716203GR + 3.344576P$$

The regression equation shows that the constant value is −3.19, meaning that in the long term if all independent variables are zero then the CO_2 emissions value will be −3.19 tons. The coefficient value for the GDP per capita variable is 50,154.20, meaning that if GDP per capita increases by 1 US$, CO_2 emissions will increase by 50,154.20 tons (cateris paribus). The coefficient value of the income inequality variable is −4716203, meaning that if income inequality increases by 1%, CO_2 emissions will decrease by 4716203 tonnes (cateris paribus). The coefficient value for the population variable is 3.344576, meaning that if the population increases by 1 million people, CO_2 emissions will increase by 3.344576 tons (cateris paribus). Meanwhile, the R-squared coefficient of 0.983160 means that GDP per capita, income inequality and population together can explain 98.3160% of CO_2 emissions. Meanwhile, the rest is explained by other variables outside the research model. Table 4 shows that based on the t test the GDP per capita variable has a significant positive effect (Prob < 0.05), the income inequality variable has an insignificant negative effect (Prob>0.05), and the population variable has a significant positive effect (Prob < 0.05) on CO_2 CO_2 emissions. in Indonesia in the long term. Meanwhile, based on the simultaneous test (f test) it shows that all independent variables have a significant effect on CO_2 emissions in Indonesia in the long term. This can be seen from the f statistical probability value of 0.000000 < 0.05.

Table 5: Estimation results in the long term

Variables	Coefficient	SE	t-Statistics	Prob.
C	−3.19E+08	1.38E+08	−2.319187	0.0279
GDP	50154.20	12143.09	4.130268	0.0003
Inequality	−4716203.	2911658.	−1.619765	0.1165
Number_ Population K	3.344576	0.395793	8.450317	0.0000
R-squared	0.983160			
Adjusted R-squared	0.981355			
F-statistic	544.8930			
Prob (F-statistic)	0.000000			

4.1. The Effect of GDP per Capita on CO_2 Emissions in Indonesia

The GDP per capita variable has a positive and significant influence on CO_2 emissions in Indonesia in 1990-2021, both in the long term and in the short term. The results of this test are the same as research conducted by Putri et al. (2022) and Fattah et al. (2021). This research provides results that in the short and long term GDP per capita has a positive effect on CO_2 emissions in Indonesia. Efforts to increase GDP require economic activities such as consumption and production. GDP that continues to increase shows that people's purchasing power is increasing. The higher the consumption, the higher the production in industries that require the use of fossil energy. This triggers CO_2 emissions. So it can be concluded that the increase in GDP per capita in Indonesia causes an increase in CO_2 emissions through increased consumption of fossil energy and industrial activities.

4.2. The Effect of Income Inequality on CO_2 Emissions in Indonesia

The estimation results in this study show that the income inequality variable has a positive and insignificant influence on CO_2 emissions in Indonesia in the short term. Meanwhile, in the long term, income inequality has an insignificant negative influence on CO_2 emissions in Indonesia. The results of this research are the same as research conducted by Ghazouani and Beldi (2022) and Ali (2022). This research shows that there is no significant influence between income inequality and CO_2 emissions. The mechanism of influence of income inequality on CO_2 emissions in the short term can be explained through efforts to increase economic growth. Income inequality drives GDP increases through increased production which requires energy use. This is the main trigger for CO_2 emissions. This reason is also supported by a development focus that only prioritizes economic growth rather than environmental sustainability. However, in the long term the relationship between income inequality and CO_2 emissions becomes negative. This is due to efforts to reduce income inequality and develop clean technology innovation. So in the long term the relationship between income inequality and CO_2 emissions becomes negative

4.3. The Influence of Population on CO_2 Emissions in Indonesia

The estimation results in this study show that population size has an insignificant negative influence on CO_2 emissions in the short term. Meanwhile, in the long term the effect is positive and significant. This research is the same as research conducted by Trisiya (2022), which gave results that the effect of population on CO_2 emissions in Indonesia was insignificantly negative in the short term and significant positive in the long term. The ever-increasing population causes an increase in society's need for energy and increases in production, thereby causing an increase in CO_2 emissions. However, in the short term the influence of population on CO_2 emissions becomes negative due to the decreasing effect of economic growth which reduces the use of fossil energy and reduces industrial activity.

5. CONCLUSION

The GDP per capita variable has a positive and significant influence on CO_2 emissions in Indonesia in 1990-2021, both in the long term and in the short term. So it can be concluded that the increase in GDP per capita in Indonesia causes an increase in CO_2 emissions through increased consumption of fossil energy and industrial activities. The estimation results in this study show that the income inequality variable has a positive and insignificant influence on CO_2 emissions in Indonesia in the short term. Meanwhile, in the long term, income inequality has an insignificant negative influence on CO_2 emissions in Indonesia. Income inequality drives GDP increases through increased production which requires energy use. This is the main trigger for CO_2 emissions.

The estimation results in this study show that population size has an insignificant negative influence on CO_2 emissions in the short term. Meanwhile, in the long term the effect is positive and significant. The ever-increasing population causes an increase in society's need for energy and increases in production, thereby causing an increase in CO_2 emissions. However, in the short term the influence of population on CO_2 emissions becomes negative due to the decreasing effect of economic growth which reduces the use of fossil energy and reduces industrial activity.

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