

# THE EFFECT OF CO<sub>2</sub> EMISSIONS, ENERGY CONSUMPTION, COAL CONSUMPTION ON GROSS DOMESTIC PRODUCT PER CAPITA IN INDONESIA

## THE EFFECT OF CO<sub>2</sub> EMISSIONS, ENERGY CONSUMPTION, COAL CONSUMPTION ON GROSS DOMESTIC PRODUCT PER CAPITA IN INDONESIA

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### Abstract

*Energy consumption in driving the industrialization of the economy in its development must be accompanied by regulatory policies that support so that this energy can be used efficiently. This study aims to determine the effect of CO<sub>2</sub> emissions, energy consumption, and coal use on per capita economic growth in Indonesia. Secondary data used are time series sourced from the World Bank, the Central Bureau of Statistics, and related agencies during the period 1985 to 2019. The analytical tool used in this study is multiple linear regression based on Ordinary Least Square (OLS) along with statistical tests and Classical Assumption Test. The estimation results conducted show that the CO<sub>2</sub> emission variable has a significant effect and has a positive relationship to Gross Domestic Product (GDP) per capita in Indonesia and the variables of coal consumption and energy consumption have a negative correlation to GDP per capita and seen from the probability value of the variable coal consumption statistically does not have a significant effect on GDP per capita in Indonesia.*

**Keywords:** Emission Co<sub>2</sub>, Energy Consumption, Coal Consumption, Gross Domestic Product Per Capita.

### 1. INTRODUCTION

An indicator that is often used to measure a country's economic performance is economic growth. Economic growth is not spared from economic activity by the community, especially since the population of Indonesia has increased from year to year. Data from the Central Statistics Agency shows that in 2020 the total population of Indonesia will reach 271 million people. The rapid population growth has an impact on aspects of human life, one of which is the use of energy resources.

Currently, economic activity is inseparable from the use of natural resources, especially natural resources that produce energy. Economy and energy are two things that are interrelated in today's economy. The nature of energy is very complex and dynamic in the economy for consumption needs in the household and industrial sectors in their production activities. This was revealed by Stern (2003) that the use or consumption of energy is a means to drive economic industrialization. It is further stated that energy consumption is a means of accumulating development capital, either complementary or substitution in producing outputs in the economy.

The policies that regulate energy consumption in Indonesia, which have included an energy diversification program to reduce the consumption of fuel oil (BBM) from the total energy consumption in Indonesia, are still difficult to see the results (Bappenas, 2012). The failure of energy diversification policies in Indonesia can be reflected in the

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slow growth of new and renewable energies and the high consumption of fossil energy. Meanwhile, maintaining economic growth requires energy consumption to convert basic materials into goods and services to meet people's needs (Budiarto, 2013).

The use of coal fossil fuels continues to increase, but is still far below its exports. Concerns that high exports under consumption will rapidly deplete coal reserves in Indonesia (Ministry of Energy and Mineral Resources, 2014). Energy problems, namely the use of renewable energy which is still relatively small due to various factors, including high investment costs, bureaucracy, subsidies, and the higher selling price of renewable energy end products compared to fossil energy.

Another issue that needs attention is the issue of CO<sub>2</sub> emissions in Indonesia. Dependence on fossil fuels has a serious impact on the environment. Carbon dioxide (CO<sub>2</sub>) emissions released by fossil fuels are the main cause of global warming (Oztunk and Eventsuci, 2010). The main sectors that use energy are the power generation, industry and transportation sectors, while the rest comes from households and other sectors (Ministry of Energy and Mineral Resources, 2014). Energy use in this sector has an increasing trend following population growth and economic growth.

The view that economic growth ultimately benefits the environment makes economists argue that maintaining economic growth is important because the most effective way to improve the environment is to get rich (Beckman, 1992) in Bowo (2009). This thinking implies that environmental problems are temporary problems because technological growth and innovation are able to solve environmental problems. The implication of the importance of energy in Indonesia can be seen from its effect on economic growth. As stated by Stern (2003) that energy is also an important factor in production. *This study aims to determine the effect of CO<sub>2</sub> emissions, coal consumption, and energy consumption on economic growth per capita in Indonesia.* The implication of this research is expected to be input for high quality energy regulatory policies so as to encourage economic growth.

## **2. LITERATURE STUDY**

### **Economic Growth**

Neoclassical growth theory was introduced by Robert M. Solow and T.W Swan (1956) in Mankiw (2007). The Solow-Swan model as a model of economic growth provides a static analysis of the relationship between capital accumulation, population growth and technological development and the effect of these three on the level of output production. Economic growth depends on the increasing supply of production factors (population, labor, and capital accumulation) and the level of technological progress. This view is based on the assumption underlying the classical analysis, namely that the economy will continue to experience full employment and capital equipment capacity will remain fully utilized at all times. In other words, the extent to which the economy will develop depends on population growth, capital accumulation, and technological advances.

### **The Theory of Economic Growth with Energy**

Tverberg (2011) explains that the general assumption states that most resources have an elastic supply, where a higher price will cause more resources to be produced. But in the case of energy, such as oil, the production or supply of oil did not increase much in spite of fluctuating prices. Economists call it inelastic supply, where the shape

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of the supply curve is vertical, which means that when prices are high, no more energy is produced. Brendt and Wood (1975) were the first to see the linkage of energy to other inputs and to long-term economic growth in the United States. This research results in the finding that it is possible to substitute energy input with non-energy input even in limited conditions. More specifically, he found that: (1) energy demand is very responsive to the elasticity of the energy price itself, (2) energy and labor have a slightly substantive relationship, (3) while energy and capital are complementary. The long-term model used is a modification of the neoclassical model and the development of a resource model to become

$$Y = F(K, L, E, M)$$

Where Y is the GDP of America which is influenced by Capital (K), labor (L), Energy (E) and other material inputs (M). According to Griffin and Steele (1989) in Yusgiantoro (2000), the relationship between the energy economy and macroeconomics and economic growth can be seen from the empirical evidence that has occurred. The world energy crisis in the 1970s at least shows this connection. The United States at that time experienced various events that turned out to be significant with the world crisis. The 1970s saw the first decline in US real income per capita since the 1930s. At the same time, there was a stagflation / state of inflation which was always stagnant and could not change for the better. The unemployment rate also looks high. This phenomenon does not only occur in the United States, but also spreads to almost all industrialized countries. According to Maunasinghe (1987) in Yusgiantoro (2000) The energy crisis also has an impact on developing countries. The economic development of developing countries, especially energy exporting and importing countries, during the last ten to fifteen years since the world energy crisis has clearly shown the linkage of energy to economic growth.

### **Energy Consumption Elasticity Calculation**

By realizing that energy consumption is closely related to GDP, it can be estimated that some increase in consumption is needed to obtain certain output. The magnitude of the increase in energy consumption required to increase one unit of output can be determined by calculating the elasticity of energy consumption against national output. The elasticity (E) can be formulated as follows:

$$E = (\Delta EC/EC) / (\Delta PDB/PDB)$$

#### **Information:**

- E = Elacity of Energy Consumption
- $\Delta EC$  = Incremental Energy Consumption at specified intervals
- EC = Energy consumption for a certain time
- $\Delta PDB$  = Incremental GDP at certain intervals (PDB2-PDB1)
- PBD = Gross domestic product at a certain time

Apart from being an indicator that can be used as a basis in the development strategy decision-making process, energy elasticity can also be used to measure the extent to which the efficiency and stage of a country's industrialization are. The smaller

energy elasticity illustrates that the production structure is more efficient and energy has a large added value to national production. However, this small elasticity can sometimes represent misleading information. Such elasticity figures are usually found in countries that are still based on agriculture. Meanwhile, high elasticity does not mean bad either. Great elasticity is usually found in developed industrial countries. Large elasticity also does not always indicate that the country's industry is advanced, but perhaps because this country is too wasteful to use the available energy.

### **Environmental Kuznet Curve**

Economists suggest a relationship between changes in income and environmental quality, this relationship is known as the Environmental Kuznets Curve which is a standard measure in technical discussions about the environment according to Grossman and Krueger (1991) in Bowo (2009) Environmental Kuznets curve describes the relationship between environmental quality which is expressed as pollutant emissions and per capita income. The relationship between various indicators of environmental damage and per capita income forms an inverted U. This illustrates the basic idea of the income distribution theory introduced by Kuznet which found that the shape of the U curve is inverted (inverse U) between an indicator of inequality and the level of income. When consuming, people use a lot of natural resources and dirty technology, causing environmental damage without any mitigation efforts. On the Kuznet curve it is also seen that when people's income starts to increase, the quality of the environment will be better and the marginal utility of consumption will decrease. This suggests that the community is starting to appreciate the better the quality of the environment.

From the Kuznet curve it can be seen that the increase in people's income, which means economic growth, will initially cause pollution. However, in the end it will improve the quality of the environment again because the longer the community tends to reduce economic activities that cause externalities, and with the increase in community income, it will tend to increase awareness of the environment through the use of environmentally friendly technology. According to Mark (2006) in Umniati (2015) CO<sub>2</sub> emissions have the resulting economic impact, namely (1) CO<sub>2</sub> emissions change income and reduce the value of production by climate change and (2) CO<sub>2</sub> emissions result in additional costs for emission reduction. An efficient economic policy chooses a mix of emission reductions and adjustments in which the marginal benefit of reduced GHG concentrations from reducing greenhouse gas concentrations (Greenhouse Gases) equals the marginal cost. Such as a policy that has the lowest cost to reduce greenhouse gas emissions (Greenhouse Gases).

### **Previous Research**

The results of research conducted by (Bashir et al., 2019) shows that there is no causal evidence of human capital, per capita energy consumption, and per capita CO<sub>2</sub> emissions to real GDP per capita, in both long and short term causality. Therefore, the Indonesian government's policy of conservative energy policies and policies to reduce CO<sub>2</sub> emissions in the long term without hampering economic growth. Chor Foong Tang, Bee Wah Tan, Iihan Ozturk (2015), The results show that there is a stable and

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long-term equilibrium relationship between economic growth and its determinants (namely energy consumption, FDI, capital, etc.). In general, energy consumption, FDI and capital positively affect economic growth in Vietnam. The results of research conducted by Loesse Jacques Esso, Yaya Keho (2016), The results of the Granger causality test show evidence that in the short term economic growth causes CO2 emissions in Benin, Democratic Republic of Congo, Ghana, Nigeria and Senegal. This implies that economic expansion cannot be achieved without affecting the environment. The results of research conducted by Dalia Streimikien, Rafal Kasperowiz (2016), FMOLS panel and Dols estimator reveal that the relationship between energy consumption, gross fixed capital and positive economic growth. Shaojian Wang, Qiuying Li, Chuanglin Fang, Chunshan Zhou (2016), impulse response analysis (which describes the reaction of each variable as a function of time in response to external shocks) found that the impact of CO2 emission shocks on economic growth or energy consumption had only a slight significant impact. The results of the research by Irina Dolgoplova, Qazi Adnan Muhammad Hye, Iyala Tam Stewart (2012) show that there is a long-term relationship between real GDP, labor, real capital, oil consumption, electricity consumption, gas consumption and coal consumption.

### 3. RESEARCH METHODOLOGY

#### Data

In this study, the data source used was secondary data obtained from the World Bank, the Central Statistics Agency (BPS), and related agencies. Secondary data used is the Indonesian timeseries data from 1985-2019 (35 years), in the form of Co2 Emission Data (metric ton), Coal Consumption (metric ton), Energy consumption (per capita), and Real GDP per capita.

#### Model Specifications

The analytical tool in this study uses multiple linear regression analysis based on Ordinary Least Square (OLS) with time series data along with statistical tests and classical assumption tests which aim to determine whether the data is worth estimating and to see the effect simultaneously on the dependent variable. The data processing tool used is the E-views 9.0 program. The following regression equation model is used:

$$\text{GDPK}_t = \beta_0 + \beta_1 \log \text{EMS}_t + \beta_2 \log \text{COCO}_t + \beta_3 \text{ECO}_t + e$$

#### Which :

GDPK	= Economic growth per capita
$\beta_0$	= Intercept / regression constant
$\beta_1, \beta_2, \beta_3$	= Estimation Coefficient
EMS	= Co2 Emissions
COCO	= Coal consumption
ECO	= Energy Consumption
e	= random error

4. RESULT AND DISCUSSION

Multiple Linear Regression Test

Table 1. Multiple Linear Regression Output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1902.864	549.4581	3.463165	0.0016
LOGEMS	31.74115	10.27980	3.087720	0.0042
LOGCOCO	-745.4305	729.4699	-1.021880	0.3147
ECO	-454.4053	144.1565	-3.152167	0.0036
R-squared	0.940494	Mean dependent var		1730.569
Adjusted R-squared	0.934735	S.D. dependent var		1304.497

Source : processed data, E-views 9.0

Based on the result of statistical calculations as in table 1 we obtain the results of multiple linear regression for the per capita economic growth variable are as follows:

$$GDP = 1902.86 + 31.741EMS -745.430COCO -454.405 + ei$$

The coefficient results show the coefficient value for the Co2 Emission variable (EMS) is 31,741 and has a positive relationship, which means that when the Co2 Emission variable increases, it will increase per capita economic growth by 31,741 with a probability value of 0.0042 <0.05 degree of error 5% so that it is statistically significant to our economic growth. The coefficient results for the variable coal consumption (COCO) and energy consumption (ECO) are -745,430 and -454,405, both of which have a negative relationship, if the variable coal consumption decreases it will increase per capita economic growth by -745,430, and if the energy consumption variable increases it will increase reduce per capita economic growth by -454,405. The probability value of the two variables is 0.3147 (COCO) and 0.0036 (ECO) with a degree of error of 5% (0.05), so that statistically the energy consumption variable is not significant to economic growth per capita and the energy consumption variable is statistically significant on per capita economic growth.

Residual Normality Test

The normality test used in this study was the Jarque Bera Test. The results of the residual normality test in the attachment show that the jarque fallow value is 1.914306 with a p value of 0.383985 where > 0.05. so that H0 is accepted, which means that the data distribution residuals are normal.

Multicollinearity Test

Table 2. Multicollinearity Test Output

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	301904.2	95.14159	NA
LOGEMS	105.6743	4090.230	816.8021
LOGCOCO	532126.3	326.0621	144.6150
ECO	20781.09	3080.476	308.7030

Source : processed data , E-views 9.0

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The data above shows that the Centered VIF value for both the Co2 Emission Variable, coal consumption, and energy consumption is above or greater than 10, so it can be stated that there is a multicollinearity problem in the model.

### Heterokedastisitas Test (Breusch-Pagan dan White)

Table 3. The output of the Breusch-Pagan & White heteroscedasticity test

<b>Heteroskedasticity Test: Breusch-Pagan-Godfrey</b>			
F-statistic	2.237559	Prob. F(3,31)	0.1036
Obs*R-squared	6.229834	Prob. Chi-Square(3)	0.1009
Scaled explained SS	4.668707	Prob. Chi-Square(3)	0.1977
<b>Heteroskedasticity Test: White</b>			
F-statistic	1.312476	Prob. F(9,25)	0.2798
Obs*R-squared	11.23076	Prob. Chi-Square(9)	0.2602
Scaled explained SS	8.416457	Prob. Chi-Square(9)	0.4928

*Source : processed data, E-Views 9.0*

The heteroscedasticity test in this research model uses two tests, namely the Breusch-Pagan test and the White test. In the first test of heteroscedasticity, namely the Breusch-Pagan test, it can be indicated by the value of Prob. Chi square (3) at Obs \* R-squared which is equal to 0.1009 or p value  $0.1009 > 0.05$  then  $H_0$  is accepted or which means the regression model in the Breusch-pagan test is homocedasticity or in other words there is no problem with the assumption of non-heterocedasticity. And so on the white test, it was found that the value Prob. Chi Square (9) on Obs \* R-Squared is 0.2602, where the critical value is  $\alpha = 0.05$ , so that  $H_0$  is accepted, and it can be said that the model does not contain heteroscedasticity problems.

### Linieritas Test (with Ramsey Test)

Table 4. Linearity Test Output

	Value	df	Probability
t-statistic	0.666141	30	0.5104
F-statistic	0.443743	(1, 30)	<b>0.5104</b>
Likelihood ratio	0.513909	1	0.4735

*Source : processed data, E-views 9.0*

The linearity test in this study used the Ramsey reset test, with the p value shown in the probability column of the F-statistic row of 0.5104 where  $> 0.05$ , so it can be concluded that the independent variable is linear with the dependent variable.

### Determination Coefficient Test ( $R^2$ )

From the results of the calculation of multiple linear regression analysis, it can be seen that the  $R^2$  coefficient value is 0.94 which is almost close to 1. This means that the per capita economic growth in Indonesia during the 1985-2019 period can be explained by around 94% by the variable Co2 Emissions, Coal Consumption, and Energy Consumption. While the remaining 6% is explained by other variables which are not included in this research model.

### F Test Statistics

The F test aims to determine the effect of all independent variables together (simultaneously) on the dependent variable.

Table 5. Output F-Statistics

F-statistic	163.3175	Durbin-Watson stat	0.649756
Prob(F-statistic)	0.000000		

*Source; processed data, E-views 9.0*

In the results of the table above, it is found that the F-count value with a significance level of 5% or 0.05 is  $163.3175 > F\text{-table} (0.343)$  and the F-count Probability value is  $0.000 < 0.05$ , so it can be concluded that H1 is accepted, that the independent variable is simultaneously (together) affect the dependent variable.

### **Co2 Emissions**

Based on the Kuznet environmental curve theory, it can be seen that the increase in people's income, which means economic growth, will initially cause pollution. However, in the end it will improve the quality of the environment because the longer people tend to reduce economic activities that cause externalities, with increasing income, people will tend to increase awareness of the environment through the use of environmentally friendly technology.

According to Stern (2003) CO2 emissions have a strong correlation to GDP. As a result, since 1850, North America and Europe have produced about 70% of all CO2 emissions due to energy production, while the remainder is generated by developing countries. Much of the growth in emissions in the future will come from developing countries today, due to their faster population and GDP growth and the increasing number of their energy-intensive industries.

For the conditions in research in Indonesia, an increase in CO2 emissions is followed by an increase in energy consumption. When consuming, people use a lot of natural resources and dirty technology, causing environmental damage without any mitigation efforts. It can be seen that the increase in people's income will have an impact on economic growth which will initially cause pollution. The Kuznet curve also shows that when people's income starts to increase, the quality of the environment will be better and the marginal utility of consumption will decrease. So at the same time energy consumption causes high CO2 and is followed by economic growth caused by energy consumption. However, recently the Indonesian government has begun to aggressively issue new policies in an effort to reduce the use of CO2 emissions. This policy is an emission tax policy imposed on motorized vehicles.

### **Coal Consumption**

Coal is a source of energy used in various countries that plays a role in economic growth. The findings of this study point to the relationship between coal consumption (in metric tonnes) and per capita economic growth in Indonesia. The results of this study indicate that coal consumption has a negative relationship with per capita economic growth, that is, if an increase in coal consumption occurs, it will reduce per

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capita economic growth and vice versa. Statistically, it is seen from the significance value with a threshold of the degree of error of 5% (0.05) that coal consumption does not have a significant effect on per capita economic growth in Indonesia.

The results of this study are in line with those conducted by Li and Li (2011) with the state objects of India and China. The results obtained indicate that in China there is a unidirectional causality of GDP and coal consumption. According to (Aprilia et al., 2018) that economic growth has no significant effect on coal consumption.

One of the efforts to ensure continuity and renewal is to choose resources that can be renewed. Attachment to the non-renewable economic sector can also serve as a potential energy source that can endanger economic growth.

### **Energy consumption**

One of the components that affect economic development is the amount of energy use nationally. The increasing use of energy encourages the industrialization process. The energy demand in the manufacturing industry to run machines is indeed very high. On the other hand, energy contribution support, especially in export revenue and government revenue, is a means of accumulating development capital. By realizing that energy consumption is closely related to GDP, it can be estimated how much increase is needed to get a certain level of output.

According to (Humbatova et al., 2020) Explaining the relationship between energy consumption and economic growth can play an important role in setting and adjusting energy policies. Given the close relationship between Energy consumption and economic growth in certain countries, determining the quality of the relationship between these two variables helps to explain effectively energy sector policies. This study examines the causal relationship between energy consumption and economic growth in Azerbaijan using annual data covering the period 1990-2015 in the vector autoregressive framework (VAR). Applying a modified version of the Granger causality test due to Toda and Yamamoto, we find a two-way causality between energy consumption and economic growth. If a two-way causality is found, economic growth may demand more energy whereas more energy consumption can drive economic growth. Energy consumption and economic growth can complement each other and energy conservation measures can have a negative impact on economic growth. Based on the findings, we therefore recommend that policies that promote energy consumption and economic growth be introduced.

According to (Carfora et al., 2019) There are different results between countries in Asia. Especially in the countries of India and Indonesia in the causality analysis that energy does not generate income. In the results, it is explained that why energy does not generate income, that is, the countries analyzed in this study over the last twenty years have experienced major changes that have an impact on the relationship between income and energy. These changes were caused by the financial crisis in Asia and caused a very serious economic slump.

In recent decades Indonesia has experienced an economic downturn, particularly in terms of income, energy prices and energy consumption. The efficiency of the policy which caused this decline did not have a positive relationship to income because the policy in terms of removing state control over the monopolistic oil and gas supplier led

to an increase in gasoline and diesel prices. The relationship between income and energy consumption needs to consider energy policy settings and changes and how to discuss policies for controlling environmental pollution and protecting energy efficiency, which will have a perspective of sustainable income and economic growth in the future.

## **5. CONCLUSION**

Based on the results of the above research, it can be concluded that CO<sub>2</sub> emissions have a positive and significant effect on economic growth per capita. Energy consumption and coal consumption variables have a negative correlation, but energy consumption statistically has a significant effect on per capita economic growth in Indonesia in 1985-2019.

Coal consumption and energy consumption have a negative relationship to economic growth. If there is an increase in coal and energy consumption, economic growth will decline. In recent decades Indonesia has experienced an economic downturn, particularly in terms of income, energy prices and energy consumption. The efficiency of the policy that caused this decline did not have a positive relationship to income due to policies in terms of lifting state control over monopolistic oil and gas suppliers which led to an increase in gasoline and diesel prices and made policies on industrialization of machines using technology that was low in emissions and could reduce pollution levels environment. The relationship between income and energy consumption needs to consider setting changes in renewable energy policies and how to discuss policies on environmental pollution control and protection of energy efficiency.

CO<sub>2</sub> emissions are related to economic growth and have a positive correlation. Which means that if there is an increase in CO<sub>2</sub> emissions, economic growth will occur. The things that encourage these activities can occur due to the high level of industrialization that still uses low technology, which in fact will have an impact on the quality of the environment or negative externalities on the environment. One of the efforts to ensure continuity and renewal is to choose resources that can be renewed. Attachment to the non-renewable economic sector can also cause it to become a potential source of energy that can endanger economic growth and damage the environment.

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