

## ANALYSIS OF THE CAUSALITY OF CO<sub>2</sub> EMISSIONS, CONSUMPTION OF FOSSIL FUELS, ELECTRICITY CONSUMPTION, AND ECONOMIC GROWTH IN INDONESIA IN 1990-2019

Melati Intan Kurnia<sup>1\*</sup>, Hadi Sasana<sup>2</sup>, Yustirania Septiani<sup>3</sup>  
<sup>1,2,3</sup> Universitas Tidar, Magelang, Indonesia

### Abstract

*Increasing economic growth will spark against increased energy consumption. But on the other hand, increasing economic growth will also trigger the occurrence of natural damage and degradation of environmental quality derived from CO<sub>2</sub> emissions. CO<sub>2</sub> emissions are caused by oxidation process of fossil fuel energy. This research aims to know the causality relationship between CO<sub>2</sub> emissions, fossil fuel consumption, electricity consumption, and economic growth in Indonesia, as well as long-term relationship between CO<sub>2</sub> emissions, fossil fuel consumption, electricity consumption, to economic growth in Indonesia in 1990 – 2019. The used data is the secondary data that is in the form of data time series. The dependent variables of this study are economic growth, while independent variables are CO<sub>2</sub> emissions, fossil fuel consumption, electricity consumption. The method that is used in this study is Vector Error Correction Model. The results showed that there was a one-way causality between economic growth and fossil fuel consumption, and between electricity consumption and CO<sub>2</sub> emissions. The research also shows that on long-term CO<sub>2</sub> emissions has a negative influence, while the consumption of fossil fuels and electricity has a positive effect on Indonesia's economic growth in 1990-2019.*

**Keywords:** CO<sub>2</sub>, Energy Consumption, Economic Growth.

### 1. INTRODUCTION

Economic growth is a good parameter of the country's economic performance. Economic growth also illustrates how the economy with many goods and services could be better to fulfill the demands of households, corporations, and governments. In recent years, Indonesia's economic growth is experiencing not good-enough trend. The economic growth grew to a rate of 5%. It is due to the impact of decreasing global economy, the uncertainty of financial markets and the decline in world trade volumes. It has also seen in 1998 that showed the economic growth of Indonesia tends to decline drastically even being taken -13%, because on that year it was a massive economic crisis that affecting the country's economic condition.

There are several factors that contribute and has an important role in influencing economic growth. These factors include consumption, government expenditure and trade openness. Consumption is a variable that is closely related to the economy because the consumption has a linear relation to the GDP (Ichvani and Sasana, 2019). Meanwhile, the economic growth has polluted environment and caused the decreasing quality of environment that would cause many environmental problems.

The economic growth grows in tandem with decreased durability and environmental function. Such as, global warming that becoming a serious world problem, especially on this era of globalization. The impact of global warming has been going on for a long time without we realized it. It is started by climate change and quite extreme weather change. From some of these GHG categories, CO<sub>2</sub> emissions is the most important because of the high contribution of CO<sub>2</sub> emissions in GHG, which is about 75% (Sukardi, 2012:13).

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\*Corresponding author. *Email address:* melati.intan.k@gmail.com

The World Meteorological Organization (2012) reported that CO<sub>2</sub> emissions in the atmosphere reached its highest record in 2011 and it is estimated to have accounted for around 85% of the radiation that led to a rising global temperature. Emissions (CO<sub>2</sub>) have the greatest amount and the longest in the atmosphere about hundreds years. As for the sectors that used energy are one of the biggest donors of CO<sub>2</sub> emissions. Emissions, which is caused by CO<sub>2</sub> and not only contributing to the global warming, can also exacerbate the environment especially affecting to our health.

This is in agreement with the research (Sasana, Kusuma, and Setyaningsih., 2019) that the emission of CO<sub>2</sub> gases is very harmful to the human body. The higher the effect of CO<sub>2</sub> emissions on air quality then the worse. The lower the quality of air will greatly affect the condition of human health, which can lead to a variety of diseases that will ultimately increase health care demand so that it will increase government expenditure in the health sector.

CO<sub>2</sub> emissions are largely generated by the carbon oxidation process (combustion) in fuel (International Energy Agency, 2013). The carbon emissions in question are carbon emissions derived from the burning of fossil fuels. However, the use of fuel energy is still quite high one in the country of Indonesia. So for the movement of the amount of CO<sub>2</sub> emissions in Indonesia tends to fluctuation. Based on data published by the Ministry of Energy Resources (2005) in the Minister of Environment (2005), the CO<sub>2</sub> generated by the use of energy dominates about 99% of greenhouse gas emissions, while the remaining approximately 1% is produced by methane (CH<sub>4</sub>), and Dinitro-oxide (N<sub>2</sub>O). CO<sub>2</sub> Gas comes from a wide range of energy consumption that airs.

The current economic activity is not spared from the use of natural resources that produce energy. Indonesia's energy consumption is experiencing a trend that continues to increase from year to year. The high energy consumption in Indonesia is caused by growing energy needs all the time. On the other hand, this increase in energy consumption is also triggered by the rate of economic growth that tends to strengthen, the population growth is very high, and accompanied by changes in community life patterns. The increasing number of population resulted in increased consumption. The final energy consumption in Indonesia to date has increased with increasing economic growth. The energy used comes from fossil fuels such as oil, gas, and coal (Indonesia Energy Outlook, 2018). Seen from the year 1990-2019 the consumption of fossil fuels in Indonesia is about 50-60%. According to the energy and Mineral Resources Depertemen (2003), fossil fuel energy consumption consumed 70% of total energy consumption, while the electrical energy occupies the second position by consuming 10% of total energy consumption. This is seen from the final energy consumption per type in Indonesia. Indonesia faced an energy problem that is decreasing fossil energy reserves and has not been balanced with the discovery of new reserves.

Dependence on fossil energy is clearly still considerable, while the contribution from renewable energy is biofuel that only has a share of 3% of the total is still very minimal (Ministry of Energy and Mineral Resources, 2017). In addition to fossil energy, Indonesia also has problems with electrical energy. The need for electrical energy in Indonesia still can not be felt by a small portion of the community where the area is located very far from most of the population settlements. This shows that the distribution of electrical energy channeling provided by the government through PLN company is still not sufficient for community needs.

Indonesia's electricity consumption per capita can have an effect on increasing economic growth, when electricity consumption per capita is used for economic activities directly related to the increase in production output thereby affecting the formation of GDP. However, the increase in electricity consumption in addition to assisting in increasing economic growth through GDP, also affects the increase in CO<sub>2</sub> emissions. This is in line with research (Azam, 2015) that there should be a causal relationship flowing from energy consumption to gross domestic product (GDP) as well as vice versa. Energy can be a cause due to economic growth. Therefore, GDP and energy needs have a mutually affecting relationship so that GDP becomes one of the drivers of energy needs.

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Therefore, the overall problem of energy faced by Indonesia consists of 3 coverage namely low electrification, dependence on fossil energy sources, and low new and renewable energy. In addition, there are other problems that arise related to the increase of CO<sub>2</sub> emissions due to excessive energy consumption. It is due to the consumption of fossil fuels and electricity into the dominant energy used in industrialization and development processes. Of course this will have a positive impact, because the consumption of fossil fuels and electricity used can support economic activities that influence the increase in economic growth.

Economic growth that aims to enrich the people in the end become a destroyer of the life support system, if in consuming excessive energy is not renewable and it will certainly increase the CO<sub>2</sub> emissions. So it will impact on the decline in environmental quality. Economic growth alone is not enough, but also requires environmentally sound development. The aim of the study is to analyse causality and long-term relationships of CO<sub>2</sub> emissions, fossil fuel consumption, electricity consumption and economic growth in Indonesia.

## 2. RESEARCH METHOD

This type of research uses a descriptive type of research with a quantitative approach. The used variables in this study consisted of dependent variables (Y) i.e. economic growth, and independent variables (X) i.e. CO<sub>2</sub> emissions, fossil fuel consumption, and electricity consumption. In an effort to gather information, as well as a foundation of theories required in analysis and discussion of problems, the authors use secondary data in the form of time series of data from 1990-2019 of CO<sub>2</sub> emissions, fossil fuel consumption, electricity consumption and economic growth obtained from the World Bank website, Ministry of Finance, OECD, International Energy Agency, and Indonesia Energy Outlook. The method of analysis used in this study was VECM. Before getting into test causality relationship there are several stages done. Among them test stationeritas, optimal lag test, cointegration test. It was only conducted a test of causality relationship to see the relationship of each variable. As for seeing long-term relationships can be seen from VECM.

### Stationerity Test

The stationerity test is used to see whether the root unit is contained in variables from the data time series. In this study, it used the methods of Augmented Dickey-Fulley and Phillips-Perron. Data is considered to be stationary if the probability value is smaller than  $\alpha = 5\%$  because the data does not have the unit root so that the data is stationary, conversely if the probability is more than  $\alpha = 5\%$ , then the data has root unit roots so it is not stationary.

### Optimal Lag Test

An optimal lag test is done to avoid autocorrelation on models. Determination of the optimal lag is done by choosing the smallest number of accountability criteria (AIC) information, Schwarz Cruterion (SC), and Hannan-Quinn criteria (HQ).

### Cointegration Test

The Cointegration test aims to determine which next method will be taken by using the VAR or VECM method. Variables that are not stationary on a level but in first difference, increase the potential for cointegration between variables, so that the cointegration test needs to be done. The cointegration test was done by using the Johansen Cointegration.

### Causality Relationship Test

The causality relationship test is done by using granger causality that is intended to know whether two variables have causality relation or not between another variable. In other words, if one variable have cause and effect relation with other variables significantly, because every variable in a research has a chance to be endogenic or exogenic variable.

### **Long-Term Relationship Test**

The long-term relationship in this study, was seen using the VECM analysis with the aim to see the variables affecting economic growth on the short and long term, to figure out the influence of variables in short and long term by paying attention to the value of the T test. Where to compare between T-Statistics obtained from VECM calculations with T-table.

## **3. RESULTS AND DISCUSSION**

### **Stationerity Test**

Table 1 Augmented Dicky - Fulley Root Test Results

<b>Variable</b>	<b>Level</b>	<b>Information</b>	<b>First Difference</b>	<b>Information</b>
Economic growth	0.2901	Not stationary	0.0000	Stationary
CO2 emissions	0.9996	Not stationary	0.0107	Stationary
Fossil Fuel Consumption	0.9865	Not stationary	0.0072	Stationary
Electricity Consumption	1.0000	Not stationary	0.0150	Stationary

Source: The data is processed with e-views 10, 2020

Table 2 Phillips Perron Root Test Results

<b>Variable</b>	<b>Level</b>	<b>Information</b>	<b>First Difference</b>	<b>Information</b>
Economic growth	0.2904	Not stationary	0.0000	Stationary
CO2 emissions	0.9996	Not stationary	0.0107	Stationary
Fossil Fuel Consumption	0.9865	Not stationary	0.0000	Stationary
Electricity Consumption	0.9921	Not stationary	0.0094	Stationary

Source: The data is processed with e-views 10, 2020

Based on the results of table 1 and 2, it can be concluded that all economic growth variables, CO2 gas emissions, fossil fuel consumption, and electricity consumption have a root test and Srasioner unit in first difference as the probability value in the study is smaller than  $\alpha = 5\%$ . When stationary data in first difference then the cointegration test is done. When each variable is cointegrated then the method used is VECM. If no Cointegration method is used is VAR first difference.

### **Optimal Lag Test**

Table 3 Optimum Lag Test Results

<b>Lag</b>	<b>AIC</b>	<b>SC</b>	<b>HQ</b>
0	29,52879	29.72381	29,58288
1	22.99997	23.97507 *	23,27042
2	22.67982 *	24.43501	23.16664 *

Source: The data is processed with e-views 10, 2020

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Table 3 shows that the value of lag is found in Lag 2, where at this lag there is the lowest value for the Akaike Information Criterion (AIC) of 22.67982, and Hannan – Quinn Criterion (HQ) amounted to 23.16664. As for Schwarz Criterion (SC) optimum in lag 1 of 23.97507. Then the optimization lag length is at lag 2.

**Cointegration Test**

Table 4 Cointegration Test Results

Hypothesized No. of CE (s)	Trace Statistics	0.05 Critical Value	Prob. **	Conclusion
None	66.19976	47,85613	0.0004	Cointegrated

  

Hypothesized No. of CE (s)	Max-Eigen Statistics	0.05 Critical Value	Prob. **	Conclusion
None	35.20267	27,58434	0.0043	Cointegrated

Source: The data is processed with e-views 10, 2020

Based on table 4, it can be seen that the trace statistic and Max-Eigen Statistic values are more than the 5 percent critical value. Based on the result of processed eviews above, it can be seen that the value of trace statistic is greater than the value of critical value 5 percent of  $66.19976 > 47.85613$ , as well as the value of Max-Eigen Statistic is greater than the critical value value of 5 percent is  $35.20267 > 27.58434$ , which means that there is a cointegration in the model of the equation.

**Causality Test**

Table 5 Causality Test Results

Null Hypothesis:	Obs	F-Statistics	Prob.	Information		
CO2 does not Granger Cause EG	25	0.69480	0.5108	CO2 ≠ EG		
EG does not Granger Cause CO2		1,03641	0.3730	EG ≠ CO2		
Fossil does not Granger Cause EG	25	0.42844	0.6574	Fossil ≠ EG		
EG does not Granger Cause Fossil		4.86339	0.0190	EG → Fossil		
Electricity does not Granger Cause EG	25	0.31288	0.7349	Electric ≠ EG		
EG does not Granger Cause Electricity		0.56439	0.5775	EG ≠ Electric		
Fossil does not Granger Cause CO2	25	0.35385	0.7063	Fossil ≠ CO2		
CO2 does not Granger Cause Fossil		0.85251	0.4413	CO2 ≠ Fossil		
Electricity does not Granger Cause CO2	25	8.91040	0.0017	Electric → CO2		
CO2 does not Granger Cause Electricity		0.71040	0.5034	CO2 ≠ Electric		
Electric does not Granger Cause Fossils	25	0.79682	0.4646	Electric ≠		
Fossil does not Granger Cause Electric				0.27195	0.7647	Fossil
						Fossil ≠ Electric

Source: The data is processed with e-views 10, 2020

According to the table 5, it shows the results of causality test that CO2 emissions against economic growth showing a probability number of 0.5108 which is more than  $\alpha = 5\%$  so Ho

is accepted. As for the probability of economic growth of CO2 emissions by 0.3730 which is greater than  $\alpha = 5\%$  so Ho is accepted. The test results of the causality of fossil fuel consumption to economic growth have shown a probability number of 0.6574 which is greater than  $\alpha = 5\%$  until Ho is accepted. On the other hand, the probability of economic growth in fossil fuel consumption has a probability of 0.0190 which is less than  $\alpha = 5\%$  so Ho is rejected. The test results of the causality of the electricity consumption against economic growth showed a probability number of 0.7349 which was greater than  $\alpha = 5\%$  until Ho was accepted. While the probability of economic growth of electricity consumption has a probability of 0.5775 which is greater than  $\alpha = 5\%$  until Ho is accepted.

### **Long-Term Relationship Test**

Table 6 Long-Term Relationship Test Results

<b>Variable</b>	<b>Coefficient</b>	<b>T-statistic</b>	<b>Information</b>
D (CO2 emissions (-1))	-0.330947	-4.11172	Significant
D (Electricity Consumption (-1))	0.152705	5.65121	Significant
D (Fossil Fuel Consumption (-1))	1,626309	1,82915	Significant

Source: The data is processed with e-views 10, 2020

Based on the results of the long-term estimate of table 6 variable CO2 emissions at lag 1 has a negative relationship and significantly affects economic growth at  $\alpha = 5\%$  with a coefficient of -0.330947. The fossil fuel consumption variable at lag 1 has a positive relationship and significantly affects the economic growth at  $\alpha = 5\%$  with a coefficient of 1.626309. The electrical consumption variable at lag 1 has a positive relationship and significantly affects the economic growth at  $\alpha = 5\%$  with a coefficient of 0.152705.

### **Discussion**

#### **Causality relationship between CO2 emissions, fossil fuel consumption, electricity consumption, and economic growth in Indonesia**

Based on the analysis of data that has been conducted through a test the causality of a Granger relationship is obtained that from variable CO2 emissions and economic growth has no causality relationship. This means that during the high research period low economic growth does not affect CO2 emissions, and conversely the low high CO2 emissions do not affect economic growth. This increase in CO2 emissions is followed by increased energy consumption. So when consuming, people use many natural resources and technologies that are not environmentally friendly causing environmental damage without any countermeasures. While the consumption of energy made by the community tends to consume that does not do economic activities.

The results of the analysis by testing the causality of Granger are seen that the consumption of fossil fuels and economic growth has a direct causality relationship between the economic growth of fossil fuel consumption. This means that during periods of high research or low economic growth affects fossil fuel consumption. Because almost some activities of economic sector use fossil fuels in the production process. Economic growth relies heavily on fossil fuels, which are a primary source of energy. So it is always used for daily activities by the Community especially for developing countries such as in Indonesia. The use of fossil fuels alone tends to be used for industries, transportation to power plants. The influence of fossil fuel use is increasingly because the government has begun to eliminate subsidies for fossil fuels such as premium oil. On the other hand it shows the Indonesian economy is almost completely supported by the consumption of fossil fuels.

The results of the analysis of the testing of causality for electricity consumption and economic growth is no causality relationship. So during periods of high research or low electricity consumption does not affect economic growth, and conversely the low high economic growth does not affect electricity consumption. Due to high electricity consumption even in every year always have an increase. The policy implications of the absence of causality

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is that economic growth does not influence or negatively affect the consumption of electrical energy and vice versa. Due to the fact that the consumption of electricity in Indonesia in significant quantities is used only for the fulfillment of basic needs (lighting and entertainment).

**Long term relationship among CO<sub>2</sub> emissions, fossil fuel consumption, electricity consumption with economic growth in Indonesia**

Based on the results of long-term estimation via VECM calculations it is known that there is a long term relation between CO<sub>2</sub> emissions with economic growth. It is due to the pollution from CO<sub>2</sub> emissions, it is considered to be able to directly lower the output which impacts to the decreasing capital and labor productivity, because pollution causes health problems and loss to workers. Many future CO<sub>2</sub> emissions will come from emerging economies today, due to the population and faster economic growth and increasing of industries that needed much energy. It is based on sectors that use energy to be the largest contributor of CO<sub>2</sub> emissions from total national GHG emissions.

The consumption of fossil fuels and economic growth has long-term relationships. It happens because almost all of the Indonesian economy sector are supported by the consumption of fossil fuels, so in the long-term all types of fossil fuels affect the rate of economic growth. It means that in the long term fossil fuel consumption will still be influential in increasing the economic growth due to the absence of renewable energy that could replace fossil-fueled energy. Because almost in every sector of fossil fuels' consumption is still used.

Electricity consumption to economic growth has a long-term relationship. The effect of electricity use especially in the era of industrialization nowadays is very helpful to the economic growth. So, it is possible in the future to more accelerating the implementation of industrialization. Moreover, the government begins to implement sustainable development and increase the standard of living that would affect the increasing of electricity consumption in the future.

**5. Conclusion**

Based on the analysis result and discussion as described above, the following conclusions may be taken as follows:

1. In the Granger causality test, it shows that there is no relationship between variables in the causality of economic growth and emissions of CO<sub>2</sub>. Meanwhile, there is a direct causality relationship that occurs between economic growth and fossil fuel consumption. The causality of economic growth and electricity consumption has no relationship between them.
2. In the VECM test, it indicates that in the three long-term variable namely CO<sub>2</sub> emissions, fossil fuel consumption, and electricity consumption has a significant influence on economic growth in Indonesia. Whereas in the short-term variable that affect economic growth is variable of CO<sub>2</sub> emissions.

According to the research discussion above, the researchers give some suggestions for the next research, such as:

1. The Government is expected to optimize the investment sector in a friendly energy infrastructure and optimize new renewable energy in industrialization in order to increase the eco-friendly economic growth firstly, by the way of increasing the capacity of the unit of PLT EBT units that are there and the EBTKE project (new Energy renewable energy consumption) that is running according to the RUPTL (Business Plan of Electricity supply), secondly the efforts to create EBT market. In addition, the use of renewable new energy that is environmental friendly aims to minimize the use of fossil fuel consumption, electricity consumption so it could compress the level of higher CO<sub>2</sub> emissions and also minimize the use of fossil fuel energy due to the less stock of fossil energy, using some systems firstly, optimize the development of electric transportation, secondly, reduce

fossil-fueled subsidies and switch into the optimalization of conservative renewable energy.

2. The Government is expected to create policies such as emission taxes whose purpose is to minimize the increasing of CO<sub>2</sub> emissions in the future. The government has to revise or improve some regulations, and increase the activity for research funds in the renewable energy use expected to suppress the use of fossil fuel energy.

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