Economics Development Analysis Journal 9 (3) (2020)

Economics Development Analysis Journal

http://journal.unnes.ac.id/sju/index.php/edaj

The Relationship Between Economic Development and Environmental Degradation in Indonesia

Citra Ayu Rossi Wulandari[1✉], Banatul Hayati[2]

Faculty of Economic and Business, Diponegoro University, Semarang

Article Info

Hisrtory of Article
Received April 2020
Accepted June 2020
Pusblished August 2020

Keywords:
Environmental Degradation, CO_2 Emissions, Economic Growth

Abstract

This study examines the relationship between economic growth, population growth, foreign direct investment, export, energy consumption and environmental degradation in the case of Indonesia. The time component of the dataset is 1981-2017 inclusive. The VECM Granger Causality is employed to examine causal relation between variables. The results confirm that the variables are integrated; it means that the long run relationship exists in the presence of structural break stemming in the series. The empirical findings indicate that economic growth, population growth, foreign direct investment, export and energy consumption increases CO_2 emissions are the occurrence of uni-directional causality. The VECM causality analysis has shown between energy consumption and CO_2 emissions are interrelated i.e. bidirectional causality. This means that an increase in energy consumption directly affects CO_2 emissions and CO_2 emissions also stimulate further energy consumption. This study recommends efficient consumption of energy in order to minimize energy consumptions and environment degradation in Indonesia.

✉Corresponding author :
Address: : Plalangan RT 01 RW 01 No.39
Kel.Plalangan Kota Semarang, Jawa Tengah 50225
E-mail: citraayurossi@gmail.com

ISSN 2252-6560

INTRODUCTION

Environmental degradation is a decrease in environmental quality. The reasons for this to occur can be due to pollutants destroying the air supply, over-extraction of resources leaving little for future use, or destruction of habitat resulting in the resources they once contained are no longer available. While natural disasters can also cause environmental degradation, they are more often the result of human activities.

The habits of today's society that tend to want a comfortable life also have negative impacts on the environment. Comfortable life is like choosing to use motorized vehicles such as cars and motorbikes rather than using public transportation such as public buses, motherless vehicles such as bicycles, or walking if the distance is not too far. Another bad habit of living comfortably is the use of electronic devices such as air conditioners and heating excessively. Therefore it can be said that all the activities we carry out have negative impacts on the environment, such as increasing the contribution of greenhouse gas emissions in the atmosphere. Based on the publication of The Intern-Governmental Panel on Climate Change in 2018, anthropogenic greenhouse gas emissions including carbon dioxide (CO_2) continues to increase, and effects the atmospheric concentration of greenhouse gases, together with other anthropogenic activators, it is very likely to be the cause dominance of the observed warming since the mid-20th century. Greenhouse gases are types of gases that can trap solar radiation, some of which should be reflected by the earth. Therefore the higher the concentration of greenhouse gases in the atmosphere, the higher the radiation of solar energy is trapped, resulting in an increase in temperature in the atmosphere.

The release of carbon dioxide (CO_2) emissions resulting from burning energy in commercial, household, industrial, transportation, power generation sectors and others to the atmosphere in a certain amount will have an impact of global warming. Global warming can be reduced in a way improve the energy efficiency of technology and utilization of energy sources which is low in carbon content. Indicators that can be describe the amount of carbon dioxide (CO_2) emissions in a country is an estimation of the relationship between magnitude of carbon dioxide (CO_2) emissions by population and economy.

Carbon dioxide (CO_2) is one of the biggest contributors to the greenhouse effect, which is a major cause of global warming. The rapid industrialization of factories, economic development, and increasing population, causing CO_2 (Carbon dioxide) emissions to continue to increase. Based on the publication of the BP Statistical Review of World Energy in 2018, global CO_2 emissions from the energy sector were 1.6% in 2017, which has rebounded from stagnation during 2014-2016, and faster than last decade average of 1.3%. Increased carbon dioxide (CO_2) emissions lead to environmental degradation caused by the interaction between economic activities and the existence of natural resources. Based on the publication of LAPAN (Samiaji) in 2011, surface CO_2 concentrations in Indonesia from 2004 to 2010 has increased from 373 to 383 ppm, as did those in the troposphere, which tends to rise from September 2002 to July 2010.

Changes in population greatly affect the magnitude and composition of energy needs, both directly and as a result of the impact it has on economic development. The consequence is energy demand and energy consumption will experience an increase. Energy demand is highly correlated with economic activity. Increase of energy demand and consumption will have the effect of higher carbon dioxide (CO_2) emissions. The higher carbon dioxide (CO_2) emissions will cause the occurrence of environmental degradation.

Malthus's theory has questioned the carrying capacity of the environment and the capacity of the environment. Due to the increasing population burden so the carrying capacity of the land as a component of the environment decreases. Furthermore the population must be balanced with the environmental threshold, so it does not become an environmental burden or disturb the carrying capacity and environmental capacity. In addition, population spikes also result in environmental degradation or the erosion of very limited natural resources (Todaro, 2000). In low-income communities, the triggers for environmental degradation are high population pressure and overuse of natural resources. On the other hand, people with high incomes have a tendency to keep increasing consumption patterns therefore it will affect production patterns.

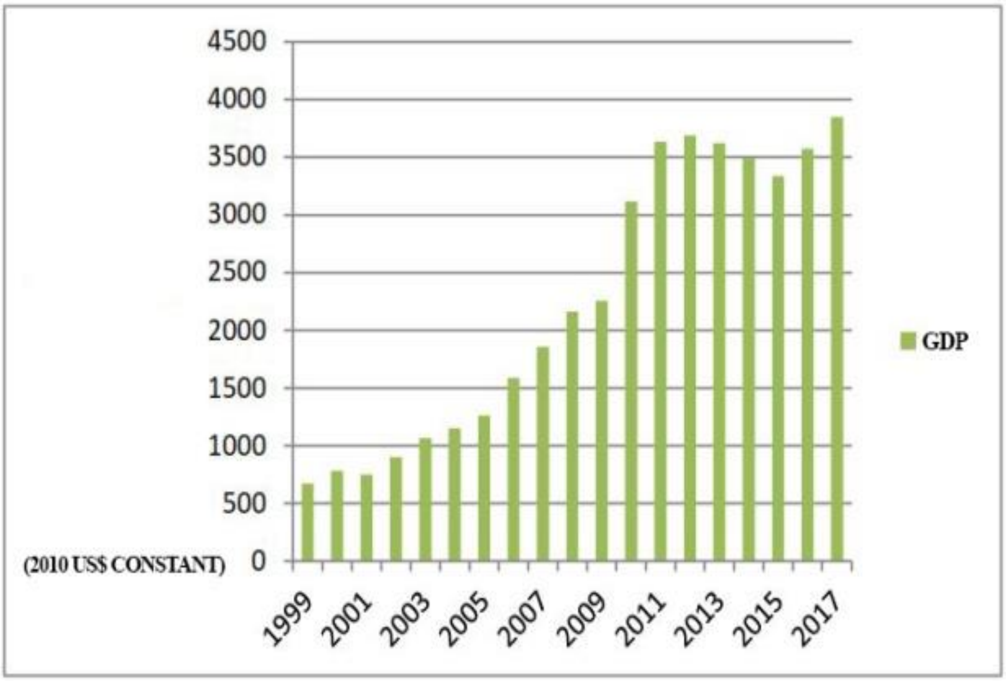

Figure 1. GDP Per Capita Indonesia 1999-2017
Source: World Bank (processed, 2018)

Based on the publication of the World Bank in 2018, the Indonesia population continued to increase from 1960 to 2017. As seen from the data in 2016 with population of 261,115,456 million people and experienced an increase 2,875,923 million people, so it became 263,991,379 million people in 2017. The increasing of population in Indonesia has caused GDP per capita also increasing. Indonesia's GDP per capita has risen sharply over the past decade even though in 2011 and 2015 has been slowed growth. Gross domestic income increased from 1999 to 2017. Thus, the GDP which has increased indicates that it will increase household consumption. Which means that household consumption growth in Indonesia has slowed down and has become stagnant in recent years, 2013-2017. Indonesia has also changed from a country whose economy is highly dependent on agriculture to a country with a more balanced economy, where the manufacturing sector is now more dominant than the agricultural sector. The role of the industrial sector developed very strongly between 1965 to 2010, which was supported by the fast growing manufacturing sector.

Based on data of the World Bank in 2018, shows in 2015 the value of GDP per capita was 3.329 and in 2016 it increased to 3.603. Taking into household consumption accounts for 55%-58% of Indonesia's total economic growth, a rising GDP indicates that it will increase household consumption. Which is where the growth in household consumption in Indonesia has slowed down and become stagnant in recent years, 2013 – 2017.

On the other hand, an increased CO_2 emission causes the environmental degradation caused by the interaction between economic activities and the existence of natural resources. Tang (2010) said that the entry of foreign direct investment will encourage energy consumption through the expansion of industrialization, transportation, and development of the manufacturing sector, while energy is urgently needed to support the manufacturing process. Activities in the production process also require energy and remove CO_2 emissions from the use of agricultural equipment. Not only in the production process, in the distribution process of agricultural goods also requires energy.

Industrialization in the economy includes company or factory expansion, industrialization expansion, transportation expansion and manufacturing sector development. An industry or company cannot be separated from production machines that need energy supplies to carry out its production activities and release emissions and waste. Electricity and diesel or gasoline are input from machines in a company or factory with the output that is released in the form of waste (liquid, solid, and gas) including CO_2 emissions. One of the causes of company or factory expansion is the increase in foreign direct investment, and the increasing number of companies or factories that are established will increase the amount of carbon emissions in the atmosphere causing environmental degradation in the long run. Hettige et al (2000) revealed to measure the performance of an industrial environment, Hettige relies on industrial grade pollution intensity, which is defined as the number of pollutant emissions per unit of the value of industrial products. Pollution intensity is expected to be negatively correlated with highly skilled workers in the industrial sector. Hettige found that workers' wages were inversely correlated with industrial pollution intensity. On the other hand, economic improvements in development will expand investment opportunities in the industrial and service sectors and increase production.

Apart from that, exports or trade are also linked to energy consumption and CO_2 emissions. Trade is inseparable from the use of energy in production activities, for example in recent years farmers have used machines to help their production process, some of these tools are tractors for plowing rice fields that have replaced buffaloes, there are also harvesting machines used for harvest replaces conventional labor, namely the farmer himself. These tools or machines cannot be separated from the use of energy. These tools require diesel or gasoline to operate the engine. Activities in production process also require energy and remove carbon emissions from the use of agricultural tools.

Export activities are not only in the production process, the distribution process of agricultural goods also requires energy. One of the distribution factors is transportation, here the means of transportation is a motorized vehicle which includes a car, truck, or pick-up car. This vehicle also release carbon emissions into the atmosphere from the combustion of energy in the form of diesel or gasoline fuel to run the engine. Therefore trading activities also consume energy and produce carbon emissions into the atmosphere.

Based on the publication of Indonesia Energy Outlook in 2015, Indonesia was ranked 69^{th} out of 129 countries in 2014. Energy security is measured based on three aspects, namely the availability of energy sources, affordability of energy supplies, and the continued development of new and renewable energy. The National Energy Council also said that Indonesia's position in the energy security ranking was due to an imbalance in the rate of energy availability with energy needs in society. In recent years domestic oil production has continued to decline, while demand has continued to increase. With the increasing standard of living of the community, there is a need of energy will also be greater, for example for transportation and household needs, such as air conditioning. The condition of energy in Indonesia in an effort increase the rate of economic growth, which has an impact on energy conditions, both at the national and global levels.

The Ministry of Energy and Mineral Resources of Indonesia noted that Indonesia's energy consumption in 2017 reached 1,23 billion BOE (Barrels Oil Equivalent), up 9% from 2016. Based on the publication of Indonesia Energy Outlook in 2017, over the last five years, Indonesia's primary energy consumption per capita has always increased from 0,71 TOE per capita in 2010 to 0,76 TOE per capita in 2015 or grew 1,5% per year. The growth of primary energy demand during the last five years has been faster than the growth rate of Indonesia's GDP. As a result, with constant 2010 prices, primary energy intensity tends to increase from 25 TOE per billion rupiah in 2010 to 22 TOE per billion rupiah in 2015.

Schmalensee et al (1998) argue that increasing international trade will deplete natural resources which will cause an increase in CO_2 emissions and will reduce environmental quality. The relationship between economic growth and CO_2 emissions is important to know to be compatible with economic and environmental policies. Shahbaz et al (2018) revealed that there is a cointegration relationship between the variables of energy consumption, economic structure, FDI, and urbanization that significantly influence CO_2 emissions in Vietnam. Katircioglu (2017) did not verify the EKC relationship of oil induced in Turkey but found an EKC link between emissions and income in Turkey. Rahman (2017) in his study, energy use, exports and population density which has an impact on the quality of the environment in the long run. Lindmark (2002) in his study about carbon dioxide (CO_2) emissions for the period 1870-1997 in Sweden and found that changes in fuel prices, growth economic, technological and structural changes can be explain variations in carbon dioxide (CO_2) in Sweden during the period 1870-1997. Omri and Kahouli (2014) has proposed a theoretical analysis through a model that includes elements of energy consumption, foreign direct investment, and economic growth, they found that energy consumption and foreign direct investment have a positive and statistically significant effect on economic growth. And the effect of economic growth and energy consumption on foreign direct investment is positive. And also the effect of economic growth and foreign direct investment on energy consumption is positive.

It is important to know the relationship between economic growth and CO_2 emissions in order to comply with economic and environmental policies. Based on the Kuznets environmental curve (EKC) which studies the relationship between environmental degradation and GDP per capita that during the initial stages of economic growth, pollution will increasing along with the increase in economic growth, then at a certain level of GDP trends reverse and pollution decreases due to economic growth (Stern, 2004).

Bratt (2006) compares three different theories which are EKC (Environmental Kuznets Curve), EBC (Environmental Brundtland Curve) and EDC (Environmental Daly Curve) explaining the relationship between environmental degradation and GDP. All of the three hypotheses recognize that the level of GDP affects environmental degradation in a different way.

The EKC theory is based on the effects of the transition from rural agricultural to industrial in urban areas making industries more intensive in increasing pollution. Pollution is expected to increase to scale with economic growth (Grossman & Krueger, 1991). The name EKC theory was inspired of almost the same relationship between income inequality and the economic growth proposed by Kuznets.

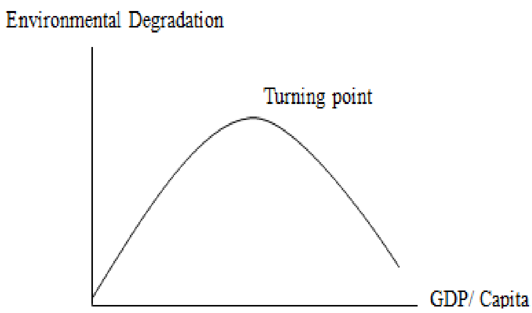

Figure 2. Environmental Kuznets Curve
Source: Kuznets (1955)

The Environmental Kuznets Curve (EKC) was first recognized in 1992 in the World Development Report as a relationship between ambient sulfur dioxide (SO_2) concentrations and per capita GDP in 47 cities in 31 countries. The EKC follows an inverted U-form where GDP per capita and environmental degradation are positively correlated with certain points at which trends change and opposite relationships can be observed.

The EKC theory is based on the effects of the transition from agricultural production in rural areas into industrial production in urban areas into industry more intensively increase pollution. This development is a thought to counteract the increase in pollution and finally causing pollution levels to drop. The result of sophisticated technology and effective economic production is thought to contribute to reduced pollution, as well as the high demand for a clean climate from consumers and higher political interest in environmental welfare.

Kuznets' Environmental Curve Theory explains how the relationship between the rate of economic growth and environmental degradation in a country. Changes in CO_2 emissions cause changes in economic growth. The increase in CO_2 emissions indicates a production process which is an economic activity. Energy as a production input plays a role in the occurrence of CO_2 emissions, therefore the production process that involves the use of energy causes CO_2 emissions, but it can be causing the increase of economic growth because the income from production process increases.

The Environment Kuznets Curve is not the only hypothesis curve used to explain the influence of the environment on economic development. While the EBC hypothesis explain that initially poor countries caused high levels of environmental degradation due to lack of ability to prioritize environmental welfare, followed by a decline in environmental degradation when economic growth reached a turning point, pollution is expected to increase along with economic growth and eventually become high as at the beginning. In contrast to the EKC curve, EBC curve is U-shaped.

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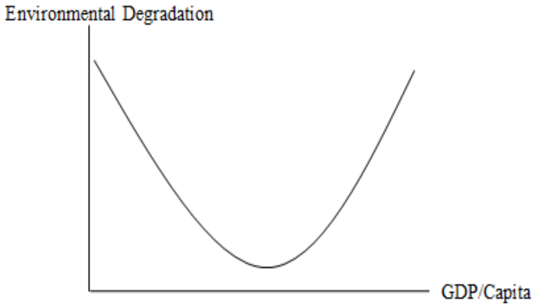

Figure 3. Environmental Brundtland Curve
Source: Brundtland (1978)

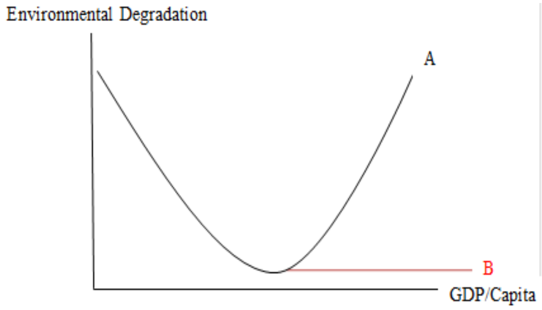

Figure 4. Alternative Environmental Brundtland Curve
Source: Brundtland (1978)

Along with economic growth, environmental damage decreased (because the high level of environmental damage has been resolved so that poverty is reduced). When the turning point is reached, pollution estimated to increase along with economic growth and finally became as high as it was at the beginning.

Daly's environmental curve (EDC) shown that environmental degradation will increase in line with GDP per capita which is supposed to increase production. Daly's curve shows no turning points, such as EKC and EBC (Bratt, 2006). Based on Ecological Economics: Principles and Applications in 2004 Daly wrote about questions the impact of human creativity and innovation (discovery) and incentivized opinions green technology is not enough to reduce pollution. Some non-renewable natural resources, and others used at a higher level than needed to keep the numbers sustainable.

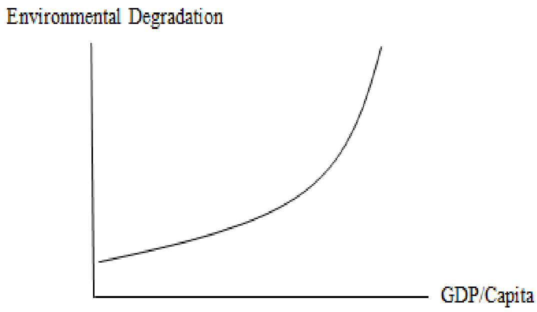

Figure 5. Environmental Daly Curve
Source: Bratt (2006)

Daly argues that green development is not enough to compensate for the use of scarcity of natural resources and overall environmental damage. Daly's environmental curve indicates environmental degradation will increase in line with GDP per capita is supposed to increase production. The Daly curve does not show any turning points, such as EKC and EBC (Bratt, 2006).

Because of that, population growth will increase energy consumption so it will cause increased energy fuel production which results in increased exploration of natural resources to meet the needs of energy sources that will leave damage in the surrounding environment. Population growth will also increase economic growth, so economic growth will increase energy consumption as well. Likewise, the increase in incoming foreign direct investment will cause expansion of companies that require more energy consumption than before. In addition, increased exports will cause environmental degradation.

RESEARCH METHODS

This research is a qualitative research with a case study approach that explores phenomena by involving various sources of information (Raco, 2018). This study discusses in detail about sustainable tourism in Pujon Kidul Village and its impact on community economic development using a predetermined procedure, namely using a case study approach.

This research used time series data, from 1981-2017 data in Indonesia. The data in this study were obtained from World Bank publications in World Development Indicators include: economic growth (GDP per capita constant 2010 US$), population growth (in percent), foreign direct investment (net inflows constant 2010 US$), and exports (constant 2010 US$). Meanwhile, energy consumption (Million Tones) and CO_2 emissions (Million Tones) were obtained from BP Statistics of Energy. The data analysis method used vector error correction model (VECM) granger causality analyzed with Eviews 9 software.

The variables in this research used consisted of independent and dependent variables. The dependent variable in this study is environmental degradation. Whereas the independent variables include population growth, economic growth, foreign direct investment, exports and energy consumption.

This study will adopt a model that has been developed by Omri and Kahouli (2014) with several developments. The formulated a mathematical model to explain the relationship between economic growth, population growth, foreign direct investment, exports, energy consumption and environmental degradation in Indonesia, takes the following form:

$$CO_2 = f(GDP, PPL, FDI, X, ENERGY) \ldots\ldots(1)$$

This essentially states that CO_2 is a function of economic growth formation (GDP), population growth (PPL), foreign direct investment (FDI), exports (X), energy consumption (ENERGY).

The values of all variables are expressed in natural logarithmic form so that all variables can be expressed in the same unit. The specification of the testing model in this study are as follows:

$$\Delta CO_{2t} = \alpha_{10} + \sum_{i=1} L11\alpha_{11i}\Delta CO_{2t-1} + \sum_{j=1} L12\alpha_{12j}\Delta GDP_{t-j} + \sum_{k=1} L13\alpha_{13k}\Delta PPL_{t-k} + \sum_{l=1} L14\alpha_{14l}\Delta FDI_{t-1} + \sum_{m=1} L15\alpha_{15m}\Delta X_{t-m} + \sum_{m=1} L16\alpha_{16m}\Delta ENERGY_{t-m} \quad \alpha_{16}\varepsilon_{t-1} + \varepsilon_{1t} \ldots\ldots(2)$$

$$\Delta GDP_t = \alpha_{20} + \sum_{i=1} L21\alpha_{21i}\Delta GDP_{t-1} + \sum_{j=1} L22\alpha_{22j}\Delta CO_{2-j} + \sum_{k=1} L23\alpha_{23k}\Delta PPL_{t-k} + \sum_{l=1} L24\alpha_{24l}\Delta FDI_{t-1} + \sum_{m=1} L25\alpha_{25m}\Delta X_{t-m} + \sum_{m=1}$$

$L26\alpha_{26m}\Delta ENERGY_{t-m} + \alpha_{27}\varepsilon_{t-1} + \varepsilon_{2t}$ ………………………………………….(3)

$$\Delta PPL_t = \alpha_{30} + \sum_{i=1} L31\alpha_{31i}\Delta PPL_{t-1} + \sum_{j=1} L32\alpha_{32j}\Delta CO_{2t-j} + \sum_{k=1} L33\alpha_{33k}\Delta GDP_{t-k} + \sum_{l=1} L34\alpha_{34l}\Delta FDI_{t-1} + \sum_{m=1} L35\alpha_{35m}\Delta X_{t-m} + \sum_{m=1} L36\alpha_{36m}\Delta ENERGY_{t-m} + \alpha_{37}\varepsilon_{t-1} + \varepsilon_{3t} \quad (4)$$

$$\Delta FDI_t = \alpha_{40} + \sum_{i=1} L41\alpha_{41i}\Delta FDI_{t-1} + \sum_{j=1} L42\alpha_{42j}\Delta CO_{2t-j} + \sum_{k=1} L43\alpha_{43k}\Delta GDP_{t-k} + \sum_{l=1} L44\alpha_{44l}\Delta PPL_{t-1} + \sum_{m=1} L45\alpha_{45m}\Delta X_{t-m} + \sum_{m=1} L46\alpha_{46m}\Delta ENERGY_{t-m} + \alpha_{47}\varepsilon_{t-1} + \varepsilon_{4t} \quad (5)$$

$$\Delta X_t = \alpha_{50} + \sum_{i=1} L51\alpha_{51i}\Delta X_{t-1} + \sum_{j=1} L52\alpha_{52j}\Delta CO_{2t-j} + \sum_{k=1} L53\alpha_{53k}\Delta GDP_{t-k} + \sum_{l=1} L54\alpha_{54l}\Delta PPL_{t-1} + \sum_{m=1} L55\alpha_{55m}\Delta FDI_{t-m} + \sum_{m=1} L56\alpha_{56m}\Delta ENERGY_{t-m} + \alpha_{57}\varepsilon_{t-1} + \varepsilon_{5t} \quad (6)$$

$$\Delta ENERGY_t = \alpha_{60} + \sum_{i=1} L61\alpha_{56i}\Delta ENERGY_{t-1} + \sum_{j=1} L62\alpha_{62j}\Delta CO_{2t-j} + \sum_{k=1} L63\alpha_{63k}\Delta GDP_{t-k} + \sum_{l=1} L64\alpha_{64l}\Delta PPL_{t-1} + \sum_{m=1} L65\alpha_{65m}\Delta FDI_{t-m} + \sum_{m=1} L66\alpha_{66m}\Delta X_{t-m} + \alpha_{67}\varepsilon_{t-1} + \varepsilon_{6t} \quad (7)$$

Where the subscript t=1,…,t denotes the time period (time frame is 1981-2017), and α_1 indicates the coefficient of the lag of each variable, and ε_t denotes error at time t.

RESULTS AND DISCUSSION

The results of this study started by performing the unit root test. If all variables are stationary at the level it will use VAR but if stationary in first or second difference then it will be followed by cointegration test to determine whether the data has cointegration or not have cointegration, in this research stationary test is using Augmented Dickey-Fuller.

Table 1. Unit Root Test

Variable	Level	1st Difference	2nd Difference
CO_2	0.002	0.851	0.005
GDP	0.988	0.008	0.000
PPL	0.278	0.959	0.000
FDI	0.331	0.001	0.000
X	0.403	0.000	0.000
ENERGY	0.000	0.557	0.001

Source : Data processed, 2019

And supposing the ADF test results is known not stationary therefore do a difference non stationary processes. And if in the form of the ADF test result level the data is not stationary, it is necessary to transform the data in the form of degrees derived first (first difference). Furthermore, if the data is still not stationary, the transformation returns from the first degree to the second derivative degree (second difference). Then proceed to the next step when the data is stationary.

From Table 1 shows the root unit test result not stationary at the level but the data stationary at second-difference.

Before the cointegration test is carried out, it is necessary to determine the length of the lag, the goal is to see the behavior and relationships of each variable in the system. Optimum lag is a test carried out in VAR/VECM method, as the assumption of a variables does not directly but requires a period of time. Optimum lag used 5 lag criteria Likehood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), Hannan-Quinn Information Criterion (HQ). Optimum lag that will used is optimum lag with the most lag on criteria test result.

Table 2. Lag Optimum Test

Lag	LR	FPE	AIC	SC	HQ
0	NA	3.03E+23	71.09	71.37	71.19
1	113.63	3.19E+22	68.80	70.72	69.44
2	69.02	1.03E+22	67.42	70.99	68.60
3	59.12*	2.26e+21*	65.11*	70.34*	66.85*

Notes: * indicates lag order selected by the criterion.
Source : Data processed, 2019

From the Table 2 shown that this research use 3 lag as lag optimum because of the result that 5 criteria shows lag optimum on lag 3, the best lag read by mark with (*) every criteria.

Table 3. Johansen Cointegration Test

Hyphotesized No. of CE(s)	Trace Statistic	Critical Value	Probability	Max Eigen Stat
r = 0*	227.85	95.75	0	89.19
r ≤ 1*	138.66	69.82	0	48.38
r ≤ 2*	90.28	47.86	0	34.96
r ≤ 3*	55.32	29.80	0.00001	23.20
r ≤ 4*	32.12	15.50	0.00008	18.65
r ≤ 5*	13.47	3.84	0.00024	13.47

Source : Data processed, 2019

The cointegration test is done to see if inter-variable research has relationship or not in the long-term. If there is a long term relationship it will use the VECM method. If there is no found cointegration then it will using the VAR unrestricted method. Johansen cointegration test by comparing the maximum eigenvalue statistics and trace statistics with their respective critical values.

The result on Table 3 indicate that at least there are 5 cointegration between variables, that result can be seen on table 3 that trace value statistic 227,85 is greater than critical value 95,75 and maximum eigenvalue 89,19 is greater than critical value 0. Therefore since the variables in model have a long-term relationship the research uses the VECM method. VECM is used to determine short-term behavior towards its long-term value. VECM can also be used to calculate short-term relationships between variables through standardized coefficients and estimate long-term relationships using residual lags from cointegrated regression (Ajija et al, 2011).

After all the requirements have been tested, the results showed that the research could be analyzing with the VECM method. By using VECM, it can be seen that the relationship between short and long term behavior between the existing variables converges into a cointegration relationship but still allows for dynamic changes in the short-term. The VECM model uses the t-table value as determinant to determine the results of hypothesis test. If t-statistic value is greater than the t-table then there can be concluded there is significant affect. Otherwise t-table is greater than t-table then there can be concluded there is insignificant affect.

The critical value of t-table on 1%, 5% and 10% respectively were 2,750; 2,042; and 1,697.

This research can be said significant with a confidence rate of 95%.

The CO_2 variable as the endogenous variable is affected by an exogenous variables. Table 4 explain that CO_2 emissions, economic growth, population growth, and exports has a positive and significant effect on emissions CO_2 in the short-run. If there is an increase of CO_2 emissions by one percent in the previous year, it will increase CO_2 emissions in the current year by 6,84 points. Increase in GDP rate one percent will increase CO_2 by 0,10 point. This result accordance with the theory, where in theory increase economic growth can increase the emissions CO_2.

The CO_2 variable as the endogenous variable is affected by an exogenous variables. Table 4 explain that CO_2 emissions, economic growth, population growth, and exports has a positive and significant effect on emissions CO_2 in the short-run. If there is an increase of CO_2 emissions by one percent in the previous year, it will increase CO_2 emissions in the current year by 6,84 points. Increase in GDP rate one percent will increase CO_2 by 0,10 point. This result accordance with the theory, where in theory increase economic growth can increase the emissions CO_2

Population growth has positive relationship and significant affecting to emissions CO_2. Increase in PPL rate one percent will increase CO_2 by 1953 point. The relationship is in accordance with the theory if the population growth is increasing it will causes increasing emissions CO_2.

Foreign direct investment has negative relationship and significant affecting emissions CO_2, when FDI increase one percent will decrease CO_2 to 12,94 point. The result not accordance with the theory, where in theory increase foreign direct investment will occur causes of emissions CO_2.

Exports have positive relationship and significant affect to emissions CO_2. When there is increase of X will increase the CO_2. The result accordance with the theory, when exports increase would increasing the emissions CO_2.

Energy consumption has negative relationship and significant affecting emissions CO_2, when ENERGY increase one percent it will decreasing CO_2 about 8,71 point. The result is not accordance to the theory, when energy consumption increasing it will affecting the emissions CO_2 increasing also.

Table 4. VECM Estimation

Variable	Coefficient	t-statistic
	Short-run	
CointEq1	-11.026206	[-10.8019]
D(D_CO_2 (-1))	6.841342*	[9.41832]
D(D_CO_2 (-2))	3.536022*	[8.21700]
D(D_GDP(-1))	0.105558*	[4.41573]
D(D_GDP(-2))	0.028357	[1.18807]
D(D_PPL(-1))	-624.557820	[-0.95467]
D(D_PPL(-2))	1953.58323 *	[2.87796]
D(D_FDI(-1))	-12.945140*	[-6.27600]
D(D_FDI(-2))	-2.784661	[-1.61205]
D(D_X(-1))	0.000000*	[-7.72387]
D(D_X(-2))	0.000000*	[-5.13014]
D(D_ENERGY (-1))	-18.947046*	[-9.60681]
D(D_ENERGY (-2))	-8.710121*	[-5.87238]
C	-0.361146	[-0.17690]
	Long-run	
D_CO_2 (-1)	1.0000000	
D_GDP(-1)	0.01299***	[1.90294]
D_PPL(-1)	-17.19817	[-0.55990]
D_FDI(-1)	-1.56083**	[-2.60887]
D_X(-1)	0.00000*	[-5.79581]
D_ENERGY(-1)	-2.65502*	[-37.1237]

Notes: ***, **, and * denote significance level at 1%, 5% and 10%, respectively.

Source : Data processed, 2019

Furthermore, in the long-run it is known that the variables GDP, FDI, X, and ENERGY have a significant effect on CO_2. While the PPL variable has no effect on CO_2. Economic growth, and exports variable has positive and significant effect on CO_2 emissions. If there was an increase in economic growth by one point in the previous year, it would increase CO_2 emissions by 0,01. Table 4 shows if there is an increase of exports by one point in the previous year, it will increase CO_2 emissions by 0,00 points. Foreign direct investment and energy consumption has negative and significant effect on CO_2 emissions. If there is an increase in FDI by one point in the previous year, it will reduce CO_2 emissions by 17,2 points. If there is an energy consumption increasing of one point in the previous year, it will reduce CO_2 emissions by 2,65 points.

Table 5. The Results of Granger Causality Test

Variable	CO_2	GDP	PPL	FDI	X	ENERGY
CO_2	-	0.86	0.34	0.89	0.16	0.00
GDP	0.00	-	0.14	0.47	0.00	0.05
PPL	0.01	0.53	-	0.42	0.72	0.01
FDI	0.00	0.85	0.45	-	0.02	0.00
X	0.00	0.92	0.81	0.40	-	0.00
ENERGY	0.00	0.90	0.47	0.92	0.49	-

Source : Data processed, 2019

In analysis, the VECM model is used quite often along with the Granger Causality test thus this approach is often referred to as VECM Granger Causality. The causality test is performed to determine whether an endogenous variable can be treated as an exogenous variable. Also the granger causality test is a test to analyze causality and see the direction of relationships between variables in research. If there are two variables y and z, then whether y causes z or z causes y or applies both or there is no relationship between the two. The y variable causes the z variable, meaning how much z value in the current period can be explained by the z value in the previous period and the y value in the previous period.

The result show there is one-way causality relationship that economic growth, population growth, foreign direct investment, exports affect emissions CO_2. Furthermore there is two-way relationship between energy consumption and emissions CO_2. It follows that the results here are consistent with a recent studies on this subject by Omri and Kahouli (2014) and Shahbaz et al., (2013).

Before using impulse response and variance decomposition there is need to know the model is stable or not. If all roots have a modulus of less than one and are inside the unit circle, the model is stable. This model can be said stable because the modulus in table 5 and figure 6 has shown that the roots have a modulus of less than one and are within the unit circle. So it is known can analyze with impulse response function (IRF) and variance decomposition (VD).

Table 6. Stability Test

Root	Modulus
-0.278321 - 0.800019i	0.847050
-0.487313 - 0.687335i	0.842557
-0.637043 - 0.477986i	0.796426
-0.610565 - 0.100785i	0.618827
-0.286477 - 0.436274i	0.521924
0.342423	0.342423

Source : Data processed, 2019

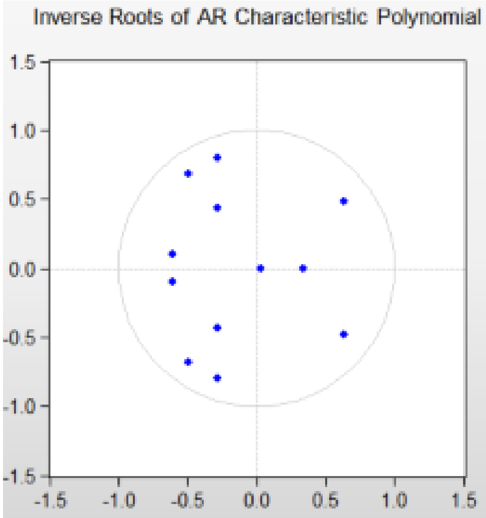

Figure 6. Stability Test
Source : Data processed, 2019

Estimation of the impulse response function is carried out to examine the shock response of a variable to changes in one standard deviation of the variable itself or other variables until several periods after the shock occurs. If the impulse response shows a movement that is getting closer to the equilibrium point (convergence) or returns to the previous balance, it means that the response of a variable due to a shock will disappear over time therefore the shock does not leave a permanent effect on the variable.

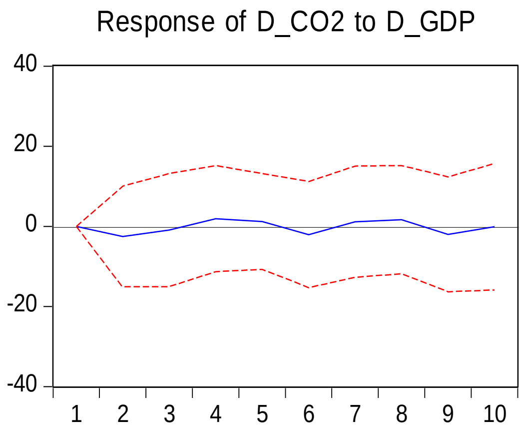

Figure 7. CO_2 Response to GDP
Source : Data processed, 2019

From figure 7 shown the response emissions CO_2 to economic growth starts in the 2nd period which tends to fluctuate because the response is negative in the 2nd period until the 4th period. Then the response is positive in the 5th to 8th periods, and again negative in the 9th period. The position of balance (convergence) is reached in the 10th period.

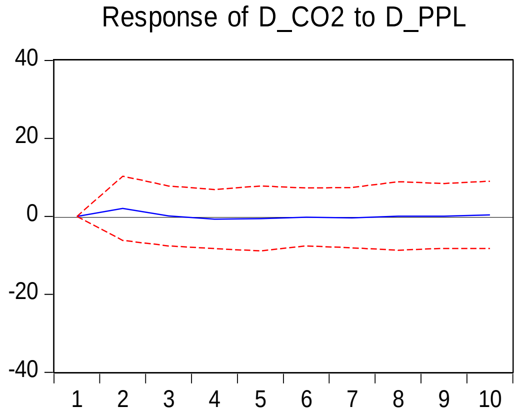

Figure 8. CO_2 Response to PPL
Source : Data processed, 2019

From figure 8 shown positive responses emissions CO_2 to population growth. The response begins and starts at the maximum point in the 2nd period. Subsequent responses begin to stabilize and head towards equilibrium in the 3rd period.

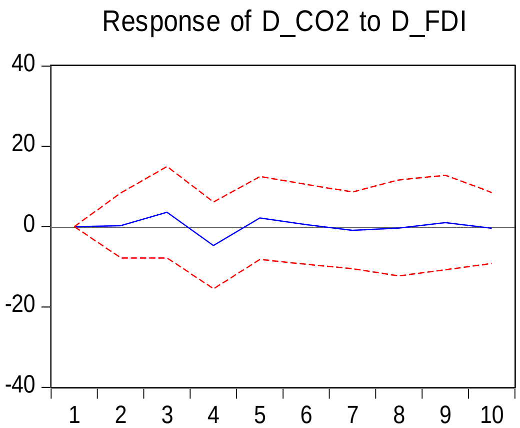

Figure 9. CO_2 Response to FDI
Source : Data processed, 2019

From figure 9 shown positive responses emissions CO_2 to foreign direct investment. The response starts from the second period which fluctuates in value until the 10th period. The response increased by one standard deviation of emissions CO_2 which reached its highest point in the 3rd period. Furthermore the response has decreased and reached its lowest point in the 4th period. After that period emissions CO_2 gradually move to equilibrium, in the 5th to the 10th periods.

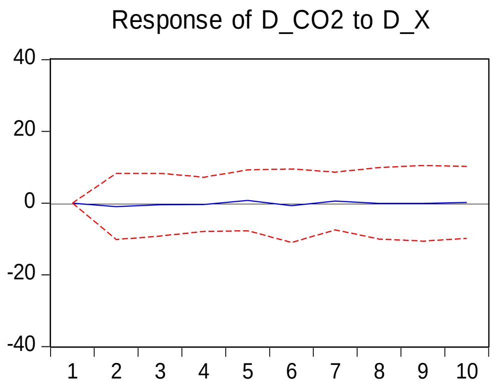

Figure 10. CO_2 Response to X
Source : Data processed, 2019

Figure 10 shown the response emissions CO_2 to exports. The response starts in the 2nd period which is negative until the 4th period. The response began to stabilize and lead to a balance in the 5th to the 10th periods.

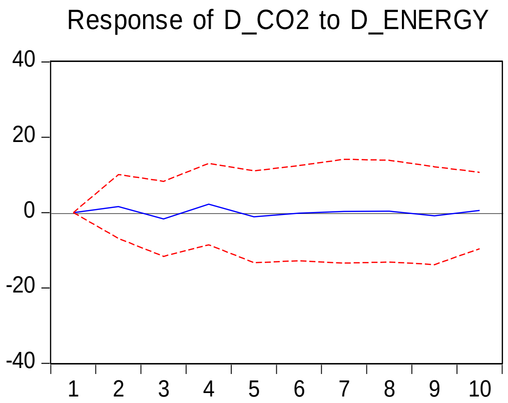

Figure 11. CO_2 Response to ENERGY
Source : Data processed, 2019

From figure 11 shown the response emissions CO_2 to energy consumptions. The response starts in the 2nd period which tends to fluctuate because the response is negative in the 2nd period until the 3rd period. The response increased by one standard deviation of CO_2 emissions which reached its highest point in the 4th period. Furthermore, the CO_2 emission response gradually leads to a position of equilibrium, which is in the 5th to the 10th periods.

The results of this impulse response found that the graph shows during 10 periods the average CO_2 emission response is positive at the beginning of the period. The movement of the response to CO_2 emissions due to shocks or variable changes in the long run is seen to be equilibrium or near zero (convergent) only on the effects of shocks from population growth, exports and energy consumption. That is, shocks or changes in these variables will still be responded by CO_2 emissions even though the effects are not permanent. Meanwhile, variables other than the three have permanent and long-term effects.

Table 7. Variance Decomposition

Per.	S.E.	CO_2	GDP	PPL	FDI	X	ENERGY
1	23.17	100.00	0.00	0.00	0.00	0.00	0.00
2	25.11	97.75	1.05	0.65	0.01	0.15	0.39
3	25.71	95.29	1.13	0.62	1.95	0.18	0.82
4	26.38	91.00	1.60	0.67	5.07	0.19	1.48
5	26.84	90.17	1.75	0.69	5.53	0.26	1.61
6	27.33	89.81	2.27	0.67	5.37	0.33	1.55
7	27.44	89.53	2.43	0.69	5.44	0.36	1.55
8	27.50	89.19	2.77	0.68	5.43	0.36	1.56
9	27.63	88.52	3.29	0.68	5.51	0.36	1.64
10	27.65	88.45	3.28	0.69	5.53	0.36	1.68

Source : Data processed, 2019

Variance decomposition explains how the shock that occurs on a variable is contributed by another variable and the variable itself. Table 6 shown the result of the first period on CO_2 caused by CO_2 itself, can be seen from the contribution 100% on the first period. In the second period the largest contribution is CO_2 itself about 97,75% also influenced by GDP about 1,05%, population growth about 0,65%, foreign direct investment about 0,01%, export about 0,15%, and last but not least energy consumption about 0,39%. The contribution of CO_2 decrease from period to period, otherwise contribution other variables increase until tenth periodThe largest contribution of fluctuation shocks in tenth period is CO_2 emission itself and followed by GDP about 3,28%, population growth about 0,69%, foreign direct investment about 5,53%, export about 0,36% and energy consumption about 1,68%.

CONCLUSION

The granger causality relationship shown in this study is that there is direct causal relationship with a strong relationship between the economic growth, population growth, foreign direct investment and exports with Energy consumption and CO_2 emissions. And there is a two-way relationship between energy consumption and CO_2 emissions.

High energy consumption causes CO_2 emissions to increase. High CO_2 emissions cause environmental degradation which makes the temperature on the surface of the earth become hot. This causes a decrease in the equality of life that results in people using technology. The technology in question such as the use of air conditioners, private cars, etc. that do not escape the need for electrical energy which is included in energy consumption.

This research proves the Kuznets environmental curve theory that economic development causes environmental degradation. Which means that the rate of economic growth determines the amount of energy consumed by the community. Thus, a country's policy to limit the energy consumption level will not reduce their economic growth. The high level of economic growth makes it possible to carry out a high enough production process that requires input, one of which is energy use, on the other hand with the determination of the energy consumption used according to the high level of economic growth, people's income also increases, therefore they are willing to pay taxes for environmental improvement purposes.

Therefore, when viewed from the direction of the overall relationship in the long run, there is a two-way relationship between the energy consumption variable on CO_2 emissions, and the variables of economic growth and energy consumption are independent of each other.

Indonesia needs to reduce consumption of fossil energy to reduce environmental degradation and immediately switch to renewable energy sources.

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