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Determinants of Carbon Emissions Levels in Indonesia

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Abstract

This study aims to analyze the effect of population growth, economic growth, energy consumption, and growth in the number of vehicles on carbon emissions in Indonesia. This study uses data in Indonesia in 1986—2019. The method used is multiple linear regression analysis with Error Correction Model (ECM) approach. The results of this study indicate that in the short term there is no independent variable that has a significant effect on carbon emissions. In the long term, population growth has a significant negative relationship with carbon emissions. Economic growth and energy consumption have a significant positive relationship to carbon emissions, meanwhile growth in number of vehicles has no significant relationship to carbon emissions.

Keywords: ***Carbon Emissions, Population Growth, Economic Growth, Energy Consumption, Growth in Number of Vehicles***

Abstrak

Penelitian ini bertujuan untuk menganalisis pengaruh dari pertumbuhan penduduk, pertumbuhan ekonomi, konsumsi energi, dan pertumbuhan jumlah kendaraan terhadap emisi karbon di Indonesia. Penelitian ini menggunakan data di Indonesia pada tahun 1986—2019. Metode yang digunakan adalah analisis regresi linier berganda dengan pendekatan berupa Error Correction Model (ECM). Hasil dari penelitian ini menunjukkan bahwa dalam jangka pendek tidak ada variabel independen yang berpengaruh signifikan terhadap emisi karbon. Dalam jangka panjang, pertumbuhan penduduk memiliki hubungan negatif signifikan dengan emisi karbon. Pertumbuhan ekonomi dan konsumsi energi memiliki hubungan positif signifikan terhadap emisi karbon, sedangkan pertumbuhan jumlah kendaraan memiliki hubungan yang tidak signifikan terhadap emisi karbon.

Kata Kunci: Emisi Karbon, Pertumbuhan Penduduk, Pertumbuhan Ekonomi, Konsumsi Energi, Pertumbuhan Jumlah Kendaraan

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INTRODUCTION

Recently, climate change has become increasingly massive and has become an endless issue for discussion. When compared to when the steam engine was first invented in the 18th century, it was the beginning of the industrial revolution. The industrial revolution is the origin of science and technology created by humans, developing rapidly.

The first industrial revolution produced many inventions, innovations in goods and services, the creation of new jobs that had never existed before, the industrial revolution was the origin of science, but the first industrial revolution did not produce only positive things, where with the development of the machine, experts have developing various energy sources ranging from coal to the discovery of petroleum extracted from the bowels of the earth.

The start of the industrial revolution resulted in many changes that positioned humans with their technology to increasingly "master" nature. The global environmental crisis is occurring as a result of increasing development (Baiquni, 2009). Not only the first industrial revolution, the second, third, and fourth industrial revolutions also caused many negative things to the world's climate. With advances in technology and changing consumption patterns, various environmental problems have emerged, including global warming and climate change.

The increasing temperature of the earth means that the earth is experiencing global warming which is a major factor in climate change (NASA, 2014). Many things are caused by climate change in the world, such as drought, extreme rainfall, the loss of many animal and plant species, melting of ice in the Arctic and South Pole, rising sea levels, shrinking mountain glaciers, and others (Buis, 2021).

One of the things that causes global warming is the greenhouse effect. According to NASA (2019) the greenhouse effect is the obstruction of the process of bouncing sunlight out of the earth. The sun's heat that wants to come out is blocked by greenhouse gases such as carbon dioxide produced by the earth so that the sun's heat is trapped in the earth's atmosphere and causes an increase in the temperature of the earth.

According to the United States Environmental Protection Agency, the largest contributors to carbon emissions are modes of transportation at 28 percent, energy at 27 percent, and industry at 22 percent (in 2017). While the remaining 22 percent was donated by residential, commercial and agriculture. Population growth is one of the main contributors to carbon emissions. Since 1986 the population has increased from year to year, although the rate of population growth is not always the same.

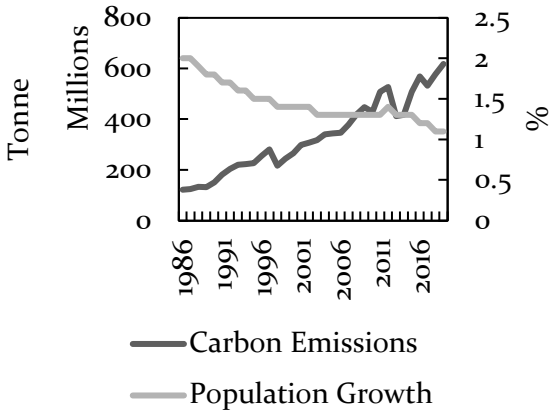

Figure 1. Comparison of Carbon Emissions with Population Growth
Source: Data Processed, 2021

It can be seen from figure 1 that since 1986-2019 population growth tends to decrease, but the level of carbon emissions tends to increase in 1986-2019. In 2014 and 2015 where population growth tended to decline, however, the level of carbon emissions increased quite drastically. However, this is not in accordance with the existing theory, namely when population growth increases, the level of carbon emissions increases, and vice versa.

Likewise with the research of Safriwan (2020) and Noormalitasari (2021) who found that population density has a positive relationship with carbon emissions. Population size is a factor that increases carbon emissions (Fan & Lei 2016), while according to Cheng et al (2018) the population scale significantly increases optimal carbon emissions. Population size played a positive role in increasing transportation-related carbon emissions over the years (Zhu & Li, 2017). Q. Zhu & Peng (2012) said urbanization increases carbon emissions. In a study conducted by Alam et al (2016) concluded that CO2 emissions and population growth have a statistically significant relationship for India, Brazil and have an insignificant relationship for China and Indonesia in both the short and long term.

According to Dong et al (2018) population size has a significant positive effect on carbon emissions, but in a study conducted by Begum et al (2015) population growth rate does not have a significant impact on CO2 emissions per capita, but some say that population is not the main cause increasing carbon emissions in Pakistan (Nasir & Rehman, 2011).

Figure 2 is a comparison between the level of carbon emissions and Indonesia's economic growth. It can be seen from the graph that in 1987 economic growth decreased by 1 percent but carbon emissions increased from the previous year. In 2009 economic growth decreased from the previous year but the level of carbon emissions increased in the same year. In 2012, economic growth decreased by 0.2 percent from 2011, while in 2012 carbon emissions increased from the previous year.

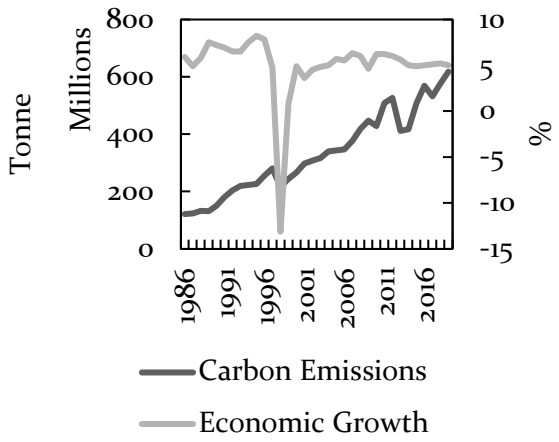

Figure 2. Comparison of Carbon Emissions with Economic Growth
Source: Data Processed, 2021

This is not in accordance with the theory put forward by Kuznets in the Environmental Kuznets Curve which states that economic growth has a positive relationship with environmental degradation. Likewise with research conducted by Cheng et al (2018) GDP per capita significantly increases the potential level of optimal GDP loss, it significantly reduces optimal carbon emissions.

In the long term, economic growth could adversely affect CO2 emissions in Malaysia (Begum et al, 2015). Economic growth plays a positive role in increasing transportation-related carbon emissions (Zhu and Li, 2017). According to Fauzi (2017) DP per capita has a positive effect on CO2 emissions. According to Zhang & Zhang

(2018) economic development has an effect on carbon emissions, which is explained by the proven EKC.

GDP has a unidirectional causality to carbon emissions, so that if output their economic continues to increase, carbon emissions will not decrease in the near future (Kasman & Duman, 2014), Yet Nasir & Rehman (2011) said the causality of economic growth to carbon emissions is relatively small. in Pakistan. Mazzarino (2000) who said that the main driver of variation in CO_2 emissions is economic growth.

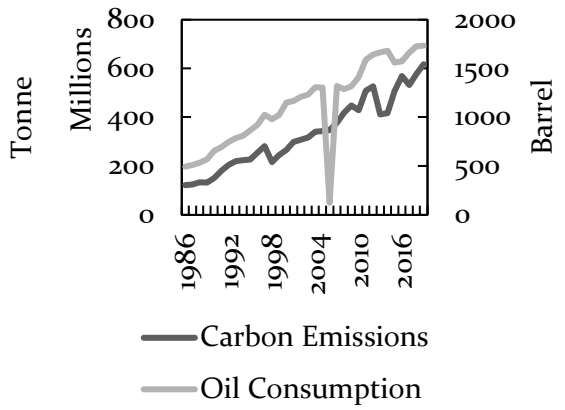

Figure 3. Comparison of Carbon Emissions with Oil Consumption
Source: Data Processed, 2021

It can be seen from figure 3 that in 2006 oil consumption decreased quite drastically but carbon emissions in the same year increased although not significantly. In 2008 oil consumption decreased from 2007, but carbon emissions increased in the same year. This is not in accordance with previous research, in a study conducted by Fauzi (2017) who said that energy consumption has a positive effect on carbon emissions.

Energy consumption contributes to carbon emissions in the long term in a positive and significant way, energy consumption also contributes to emissions through several non-economic activities, such as the domestic and transportation sectors (Nasir & Rehman, 2011). The elasticity of carbon emissions to total oil consumption and transportation sector oil consumption is positive and significant (Alkhathlan & Javid, 2015).

Begum et al (2015) said that energy consumption per capita has a long-term positive impact on per capita carbon emissions. CO_2 emissions have increased statistically significantly with increasing energy consumption (Alam et al, 2016). Energy consumption has a unidirectional causality to carbon emissions (Kasman & Duman, 2014), then coal consumption has a significant causality relationship to the level of carbon emissions (Bimanatya & Widodo, 2018).

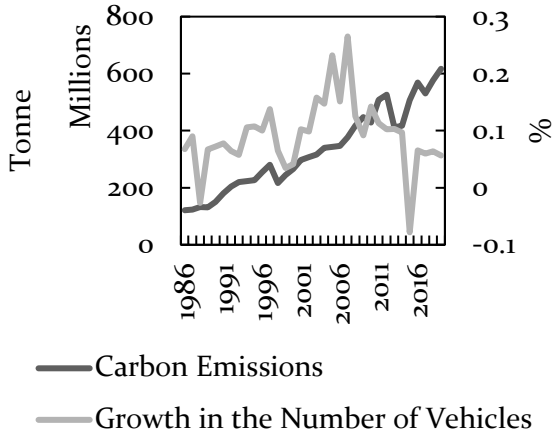

Figure 4. Comparison of Carbon Emissions with Growth in the Number of Vehicles
Source: Data Processed, 2021

It can be seen from figure 4 that in 1988 the growth in the number of vehicles decreased drastically from the previous year, but carbon emissions continued to increase in the same year. In 1991-1993 growth in the number of vehicles decreased by 0.02% while carbon emissions in the

same period increased. This is not in accordance with the theory which states that if the number of vehicles increases, the level of carbon emissions will also increase, and vice versa.

This can happen because the more vehicles, the more pollution generated will also increase. This is supported by research conducted by Zhu & Li (2017) who says that the transportation sector is the largest emitter of greenhouse gases and the fastest growing sector in terms of energy consumption in China. Meanwhile, according to the United States Environmental Protection Agency, the largest contributor to carbon emissions is the mode of transportation by 28 percent (in 2017).

Transport plays an important role in carbon dioxide (CO_2) emissions. Cross-roads are one of the main sources of carbon emissions that cause climate change (Zhang et al, 2019). On average, private vehicles globally consume around 36 million barrels of oil per day which emits about 17 billion tons of carbon dioxide every day (Reisinger & Emadi, 2013).

This research refers to the theory of Environmental Kuznets Curve (EKC) and Pollution Haven Hypotheses. EKC said that initially economic growth will be accompanied by environmental degradation, as the economic sector shifts to the service sector, economic growth will be accompanied by an improving environment (Halton, 2021). The Pollution Haven Hypotheses explain the relationship between industry and carbon emissions in a country.

Industry players will tend to choose to build factories in developing countries, because of the difficulty of regulations in developed countries to build factories. This is because developed countries have produced a lot of carbon emissions, so that newcomers will find it difficult to manage regulations and meet the requirements for the carbon emission thresholds produced, therefore industrial players tend to choose developing countries as their place to build factories (Taylor, 2005).

This study aims to determine and analyze the effect of population growth, economic growth, energy consumption, and growth in the number of vehicles on the level of carbon emissions in the short and long term in Indonesia in 1986-2019.

RESEARCH METHODS

This research is quantitative research. The analytical method used in this study is multiple linear regression with an approach in the form of Error Correction Model (ECM). The data used is data from 1986—2019. The data used in this study is data on carbon emissions and population growth sourced from Our World in Data, then economic growth data sourced from the World Bank, then energy consumption data sourced from CEIC, while data on vehicle growth is sourced from BPS.

The ECM model or often referred to as the error correction model is a Dynamic Linear Model (MLD) which is used to solve problems in the estimation of a model, time series namely blunt regression (Basuki & Prawoto, 2016).

The ECM model can also solve the problem if between the variables studied there is a long-term relationship but there is no short-term relationship, this happens if the variable is cointegrated but not stationary or undergoes a spurious regression. The ECM method is used as an econometric tool aimed at identifying the existence of short-term and long-term relationships that occur due to cointegration between the variables studied (Basuki & Prawoto,

2016). The regression equation of this study is as follows:

$CO2_t = \beta_0 + \beta_1 POP_{1t} + \beta_2 GDPG_{2t} + \beta_3 ENC_{3t} + \beta_4 VEC_{4t} + \varepsilon$..(1)

Where CO2 is Carbon Emissions, POP is Population Growth, GDPG is Economic Growth, ENC is Energy Consumption, VEC is Growth in Number of Vehicles, t is Time Period, $\beta 0$ is Constanta, $\beta 1$ $\beta 2$ $\beta 3$ $\beta 4$ is Coefficient, and ε is Error

RESULTS AND DISCUSSION

The discussion conducted by comparing the results of the study with the theory used, namely the environmental kuznets curve and pollution haven hypotheses and previous research. In the short-term estimation model, this study uses an error correction model approach in order to explain the techniques for correcting short-term imbalances towards long-term equilibrium.

Short-term and long-term dynamic behavior can be explained by long-term equilibrium. In the short-term model, it can be seen from the estimated value of the error correction model. As for the long-term model, it can be seen from the estimated value of ols (ordinary least square). He following is an analysis of the short-term and long-term estimation results.

Based on the short-term estimation results, population growth does not significantly affect the level of carbon emissions, but in the long-term estimation population growth has a significant negative effect on the level of carbon emissions. With a coefficient value of -371.937.013 with a probability of 0.0000. So that every 1 percent increase in population growth will reduce the level of carbon emissions by 371,937,013 tons with the assumption of ceteris paribus.

The insignificant effect of population growth on the level of carbon emissions in the short-term estimation is thought to be due to population growth not having an effect on the level of carbon emissions in the short term. This is in line with research conducted by Alam et al (2016) who says that population growth has an insignificant relationship for china and indonesia in the short term.

Table 1. The ECM short-term estimation results

Variables	Coefficient	T-Statistics	Probs.
D (POPG)	80010678	0.661365	0.5140
D (GDPG)	2630292.	1.771564	0.0878
D (ENC)	37899.10	1.619567	0.1169
D (VEC)	-1.42E+08	-1.399523	0.1730
ECT (-1)	-0.299438	-2.426777	0.0222
C	15202139	2.212270	0.0356
R-Squared	0.309090		
Adjusted R-Squared	0.181144		
F-Statistics	2.415783		

Source: Data Processed, 2021

The results of the long-term estimation of this study are not in line with several previous studies such as the study of Safriwan & Idris (2020) who found that population density has a positive relationship with carbon emissions. Population size is also a factor that increases carbon emissions (Fan & Lei, 2016). When talking about urbanization, it also increases carbon emissions (Zhu & Peng, 2012).

However, in a study conducted by Begum et al (2015) said otherwise, the rate of population growth does not have a significant impact on co2 emissions per capita. Nasir & Rehman (2011) say that population is not the main cause of increasing carbon emissions in pakistan. In his

research, Shi (2003) said that the impact of population growth on carbon emissions is more pronounced in developing countries than in developed countries. In developing countries, the elasticity of the relationship between population growth and carbon emissions is close to 2. While in developed countries the elasticity of the relationship between population growth and carbon emissions is less than 1.

The negative relationship in the long-term estimate between population growth and carbon emission levels is thought to be caused by a decline in growth rates. Population in indonesia from 1986 to 2019 and there are also some residents who are suspected of not producing carbon emissions. Although the population continues to increase, the population growth rate has a declining trend from year to year. This can be seen in the following curve:

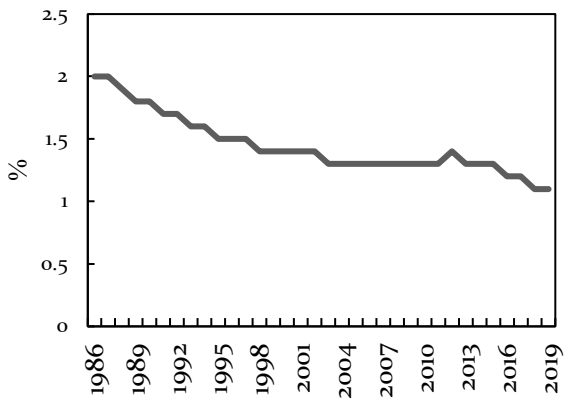

Figure 5. Population Growth in Indonesia in 1986-2019
Source: Our World in Data, 2020

From fsigure 5 it can be seen that from 1986 population growth in indonesia has a downward trend, the increase in population in t is less than year t-1. This is the alleged cause of the negative relationship between population growth and the level of carbon emissions. There is another assumption that people living in remote areas do not produce carbon emissions, but the growth of the village population continues to occur every year. According to data taken from worldometers, the village population in indonesia in 2019 reached 45 percent, so it can be assumed that the village population continues to increase every year but does not produce carbon emissions.

Table 2. The ECM long-term estimation results

Variables	Coefficient	T-Statistics	Probs.
POPG	-3.72E+08	-5.128857	0.0000
GDPG	7196023.	2.451290	0.0205
ENC	133102.6	3.461250	0.0017
VEC	-3.24E+08	-1.881243	0.0700
C	7.13E+08	4.899762	0.0000
R-Squared	0.867629		
Adjusted R-Squared	0.849371		
F-Statistics	47.52039		

Source: Data Processed, 2021

Based on the results of short-term estimates, economic growth does not significantly affect the level of carbon emissions, but in the long-term estimation of economic growth has a significant positive effect on the level of carbon emissions. With a coefficient value of 7196,023 with a probability of 0.0205. So that every 1 percent economic growth will increase carbon emissions by 7,196,023 tons with the assumption of ceteris paribus.

The insignificant effect of economic growth on the level of carbon emissions in the short-term estimation is thought to be caused by the absence of a significant effect between economic growth on carbon emissions in indonesia in the short term. This is in line with research conducted by Kasman & Duman (2014) who says that gdp has a

unidirectional causality with carbon emissions, so that if output their economic continues to increase then carbon emissions will not decrease in the near future.

In pakistan, things like this also happen where economic growth in the short term does not have a significant effect on carbon emissions, so it can be said that the EKC (environmental kuznets curve) only applies in long-term phenomena in pakistan (Nasir & Rehman, 2011). Economic growth has a significant positive effect on carbon emissions, it is suspected that economic growth will initially cause environmental degradation to increase due to growth in consumption and mass production, the structure of the economy changes from rural to urban and from the agricultural stage to the industrial stage.

Then, along with changes in the regional or national economic structure from heavy energy-based industries to advanced technology-based industries and services. This may decrease over time. This is said by the ekc theory presented by kuznets. This is in line with several studies such as research conducted by Safriwan & Idris (2020) who found that economic growth has a positive relationship with environmental degradation, which means that if economic growth increases, carbon emissions will also increase.

Dong et al (2018) also say that economic growth has a significant positive effect on carbon emissions. GDP per Capita has a positive long-term effect on carbon emissions in malaysia (Begum et al, 2015). Fauzi (2017) says that GDP per Capita has a positive effect on carbon emissions.

Based on the short-term estimation results, energy consumption has no significant effect on the level of carbon emissions, but in the long-term estimation, energy consumption has a significant positive effect on the level of carbon emissions. With a coefficient value of 133.102.6 with a probability of 0.0017. So that every a barrel increase in energy consumption will increase carbon emissions by 133,102.6 tons with an assumption ceteris paribus.

The insignificant effect of energy consumption on carbon emission levels in short-term estimates is thought to be due to the short-term energy consumption has not had a significant effect in increasing carbon emissions levels, this occurs because energy consumption has no direct effect on carbon emissions, energy consumption takes time to affect carbon emissions. This is in line with the research conducted by Nasir & Rehman (2011) who said that energy consumption has no significant effect on carbon emissions in the short term in Pakistan.

The increase in carbon emissions caused by increased energy consumption in the long term is thought to be due to the consumption of energy producing carbon emissions. According to climate communication, fossil fuel consumption accounts for 8% of the world's carbon emissions. The results are in line with several studies such as a study conducted by fauzi (2017) who said that energy consumption has a positive influence on significant levels of carbon emissions in 6 asean countries including indonesia. Begum et al (2015) also say that energy consumption per capita has a long-term positive impact on per capita carbon emissions. The elasticity of carbon emissions to total oil consumption and transportation oil consumption is positive and significant (Alkhathlan & Javid, 2015).

Based on the results of both short- and long-term estimates, the growth in the number of vehicles did not have a significant effect on carbon emission levels. This is evidenced by a

probability value lower than the real level of 0.05 in both short-term and long-term estimates. This is not in line with several studies such as Sasmita (2015) says that the amount of carbon emissions that can be reduced by cfd activities is 236.486 Kg CO_2.

L. Zhang et al. (2019) says that road traffic is one of the main sources of carbon emissions that cause climate change, while Barth & Boriboonsomsin (2008) say that carbon emissions can be reduced by optimizing the transportation system in an area, such as by reducing traffic jams. The study found that the growth in the number of vehicles had an insignificant influence on Indonesia's carbon emission levels in 1986-2019. This is thought to be due to various policies set by the government in the suppression of carbon emissions, especially in the transportation sector.

As is the policy of Sistranas (national transportation system) which contains that the transportation system must pay attention to the environment, so that the carbon emissions of the transportation sector can be suppressed. It is also supported by the concept of sustainability transportation by the ministry of environment (Rahmayanti, 2007).

Sustainable transport is transportation that has a low impact on the environment and considers the transportation system for the future. There are allegations that cause insignificant relationships in the number of vehicles to the level of carbon emissions, namely due to the development of technology in modern vehicles. This can happen because there are canister emissions that serve to reduce carbon emissions produced by a vehicle (Leanse, 2016). If these results are linked to pollution haven hypotheses, the growth in the number of vehicles is related because the vehicles themselves are produced by several factories in Indonesia.

Taylor (2005) said the relocation of factories to developing countries, such as indonesia does not always have an impact on the increase in carbon emissions, because factories relocated from developed countries have more effective and environmentally friendly technologies. In this case, developing countries can use the technology to minimize the carbon emissions produced.

CONCLUSION

Based on the results of research on the effect of population growth, economic growth, energy consumption, and the growth of vehicle numbers on carbon emission levels in Indonesia in 1986-2019, it can be concluded that population growth has no significant effect on carbon emission levels. In long-term estimates population growth has a significant negative influence on carbon emission levels.

Based on the results of short-term estimates, economic growth has no significant effect on carbon emission levels. In long-term estimates economic growth has a significant positive influence on carbon emission levels. Based on short-term estimates, energy consumption had no significant effect on carbon emissions levels. In long-term estimates energy consumption has a significant positive influence on carbon emission levels. In both short- and long-term estimates, the growth in the number of vehicles has not had a significant effect on carbon emissions levels.

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