



## Determinants of Carbon Emissions in 10 ASEAN Countries

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### Article Information Abstract

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Rapid economic development in ASEAN countries from many aspects of the global economy and energy outlook. Increased consumption of fossil fuels leads to an increase in CO<sub>2</sub> emissions (ACE, 2021). The problem of increasing CO<sub>2</sub> caused by economic development in ASEAN needs to be studied more deeply what variables will in the economic development affect the increase in CO<sub>2</sub> emissions. The purpose of this study is to test and obtain empirical evidence on determinants of carbon emissions in 10 ASEAN Countries (Brunei Darussalam, Indonesia, Cambodia, Lao PDR, Myanmar, Malaysia, Philippines, Singapore, Thailand, Vietnam) during 2010-2018. Some of the factors that were taken in this study, there are Gross Domestic Product (GDP), total population (PDDK), and industrial growth (MANF). This study uses panel data (time series and cross section). In using the method of regression of panel data is performed uji chow and uji hausman, and elected, namely the fixed effect model. Results of the study proved that all independent variables (GDP, total population, industrial growth) have a significant effect on carbon emissions. The conclusion is that by looking at all the independent variables in this study that affect the increase in CO<sub>2</sub> emissions, it must be considered in the future how to control these variables in order to reduce CO<sub>2</sub> emissions. The findings of this study are that the variables of GDP, total population and industrial growth cause an increase in CO<sub>2</sub> emissions, this is in accordance with the theory

## INTRODUCTION

According to Todaro in Candra (2018) Environmental quality issues are not only a problem for developed countries or developing countries, but have become a problem for all countries in the world. Environmental quality problems can occur due to the amount of pollution from factories, smoke from motor vehicles, and also forest fires that can result in decreased environmental quality. Therefore, the development of environmental quality is needed apart from development in the economic sector.

Sources of emissions CO<sub>2</sub> is mostly large (80%) caused by the activities of humans or referred to anthropogenic emission, namely fossil fuels burning while the rest (20%) comes from the activities of deforestation and degradation of forests (Sukadri, 2012).

ASEAN as an association collection of Part of a great country developing with a high population and fast growth. ASEAN is predicted an residents of its 700 million people in the year 2030 will provide contributions great for the growth of emissions of CO<sub>2</sub> as a whole (OECD, 2011). Driving factor emissions of CO<sub>2</sub>, in Dietz, T., & Rosa (1997) caused by many factors anthropogenic, for example : (1) a resident; (2) economic activities; (3) technology; (4) political and economic institutions; (5) attitudes and beliefs. From the five factors mentioned, population, income, and technology is considered as the driving principal of the emission of CO<sub>2</sub>.

Suparmoko (1998) argues that with the increasing number of population will increase the demand for goods and services that must be provided to fulfill the needs of the population. So it will have an impact on the number of production sources of nature to fulfill of the consumption of energy residents. As a result, the resources of nature is getting decreased and pollution of the environment is getting increased along with the growth of population. This causes the Gas House Greenhouse (GHG) thinned.

Factor two, namely activities economy which is reflected from economy growth (GDP).

Each country will always trying to improve the economy growth and make economy growth as a target economy and the success of the economy of a country in long term. Economy growth is as a measure of achievement the country from a period to next period to produce goods and services. Economic growth is needed and one of the sources of increasing the standard of living of a population whose numbers continue to increase.

ASEAN is the region that contributes the largest producer of CO<sub>2</sub> emissions, this is because almost the average asean country has industries that produce CO<sub>2</sub> emissions. The power generation industry is the main source that produces CO<sub>2</sub> emissions by accounting for as much as 37% of global CO<sub>2</sub> emissions. According to Frieler et al in general, CO<sub>2</sub> emission levels can be caused by the growth of industrialization. The rapid growth of industrialization has created major challenges for the environment, particularly in terms of energy consumption and CO<sub>2</sub> emissions (Candra, 2018). The year in this study started from 2010 - 2018 due to limited data at the latest World Bank until 2018.

The gap in this research is that the results of this study state that the GDP variables, namely GDP and Total Population, have a positive relationship or have a significant effect on increasing CO<sub>2</sub> emissions. While in other studies, namely research from Begum R A, Sohag, Abdullah S M S (2015), it states that if the results also demonstrate that both per capita energy consumption and per capita GDP has a long term positive impacts with per capita carbon emissions, but population growth rate has no significant impacts on per capita CO<sub>2</sub> emission. However, the study suggests that in the long run, economic growth may have an adverse effect on the CO<sub>2</sub> emissions in Malaysia.

Based on the background behind the above, the authors are interested to know the effect of gross domestic product, total population, and industrial growth to carbon emission in the 10 ASEAN countries in 2010-2018.

## RESEARCH METHODS

This study uses research descriptive methods with quantitative approach, research descriptive is used to determine the effect of gross domestic product, total population, and industrial growth on the carbon emissions. While the quantitative approach emphasizes more on measurement theories with numerical variables and data analysis. The data used in this research is secondary data. Data obtained from the World Bank and several articles of the journal are related. The data used in this study, among others: gross domestic product, total population, industrial growth and carbon emissions in 2010-2018. This study took 10 ASEAN countries (Brunei Darussalam, Indonesia, Cambodia, Lao PDR, Myanmar, Malaysia, Philippines, Singapore, Thailand, Vietnam) due to the limited availability of data in the World Bank.

Dependent variable on this study is carbon emissions (CO<sub>2</sub>), measured in Metric Tons per capita. While the first independent variable is gross domestic product (GDP), measured in current US\$. The second independent variable is total population (PDDK), measured in person. The third independent variable is industrial growth (MANF), measured in current US\$. The analytical tool used is the panel method. There are 3 methods used to work with panel data, namely: Pooled Least Square (PLS), Fixed Effect Model (FEM), Random Effect Model (REM) (Gujarati, D. and Dawn C, 2009). In this panel data, a Chow test is carried out to determine whether an appropriate model for this study is the Chow test. The Chow test looks at the right common effect or fixed effect model to determine panel data. Furthermore, the Hausman test is used to determine the appropriate estimation model, whether Fixed Effect or Random Effect will be selected. The Hausman test follows a Cross-section random assessment, so the decision to choose the suitability of the model can be decided correctly. Next, the lagrange multiplier test is used to determine the right estimation model whether random effect or

common effect will be selected. In this study, the lagrange multiplier test was not carried out because the results on the Chow and Hausman tests were consistent with the selected fixed effect model. This study modifies Akram (2012) model so that it becomes:

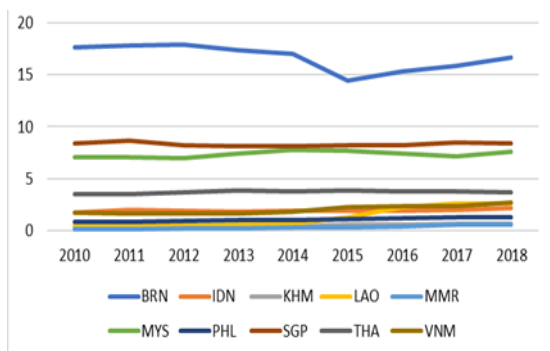
$$CO2_t = \alpha_1 + \sum_{j=1}^k \beta_{11}GDP_{t-j} + \sum_{j=1}^k \beta_{12}PDDK_{t-j} + \sum_{j=1}^k \beta_{13}MANF_{t-j} + \varepsilon_t \dots\dots\dots(1)$$

Where CO<sub>2</sub> is the carbon emissions; GDP is Gross Domestic Product, PDDK is total population; MANF is an industrial growth; α is constant ; t is time; j is countries; β is coefficient of each variable; and ε is the error term.

The next step is to test the statistical determination (R<sup>2</sup>), t test, F test. The coefficient of determination (R<sup>2</sup>) is essentially to measure how far the the model's ability to explain the dependent variable. T test is used to see whether or not each independent variable is significant to the dependent variable. The F test is carried out to see whether or not the independent variable is simultaneously (overall) significant to the dependent variables (Kuncoro, 2011). After panel data regression and the selected model was taken, the classical assumption test was carried out which included normality test, test multicollinearity, and heteroskedasticity test.

## RESULTS AND DISCUSSION

Carbon emissions produced by 10 ASEAN countries during 2010-2018, the highest is Brunei Darussalam country of 14-17 metric tons per capita. 95 percent of Brunei Darussalam's total exports are petroleum and gas commodities. Despite this, the country is still working on an energy transition. Energy transition is an inevitability that cannot be ignored. Because energy transition efforts can have an impact on environmental recovery. The second largest is Singapore by 8 metric tons per capita, then the third largest is Malaysia by 6-7 metric tons per capita. While the smallest carbon emissions production is the Myanmar country of 0,1-0,6 metric tons per capita.



**Figure 1.** Carbon Emissions in 10 ASEAN Countries (Metric Tons Per Capita ).

Source: Data Processed, 2022

The regression result of panel data in this study, the value of R2 is 0.997757. This shows that independent variables together are able to explain dependent variables by 99%.

From the regression results it is also known that the probability of F is 0.000000. When compared to the 5% alpha sign, the probability of F is less than the level of alpha significance. This indicates that all independent variables together have a significant effect on dependent variables.

**Table 1.** The results of panel data regression with the selected fixed effects model (FEM)

Variable	Coefficient	t-statistic	Prob
C	1.295898	2.167514	0.0333
GDP	4.40E-05	2.246140	0.0276
PDDK	3.57E-08	3.582536	0.0006
MANF	-4.98E-12	-2.163149	0.0336
R-squared	0.997757		
Adjusted R-squared	0.997408		
F-statistic	2854.799		
Prob(F-statistic)	0.000000		
Durbin-Watson stat	1.032067		

Source: Data Processed, 2022

To see the effect of each independent variable on the dependent variable by using the test t. Probability of test result t compared to 5% alpha significance rate. From the output results in table 1, this indicates that the probability of a variable GDP is 0.0276, where the value is less than the alpha of 5%. This means that the GDP variable has a significant effect on carbon

emissions. Next is the probability of a total population variable (PDDK) of 0.0006, where the value is less than the alpha significance level of 5%. This means that total population variable (PDDK) have a significant effect on carbon emissions. The last is an industrial growth variable (MANF) with a probability of 0.0336, which is less than the alpha significance level of 5%. This means that industrial variables have a significant effect on carbon emissions.

Discussion

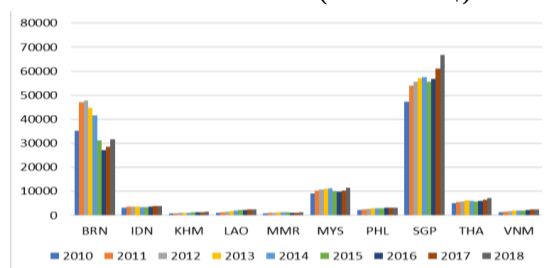
From the results of panel data regression with the Fixed Effect Model, the following regression equation is obtained:

$$CO2it= 1.295898 + 4.40E-05GDPit + 3.57E-08PDDKit - 4.98E-12MANFit + Uit \dots (2)$$

The further discussion of the factors that affect the carbon emissions is explained below:

- Effect of Gross Domestic Product (GDP) on Carbon Emissions. The highest GDP during 2010-2018 was Singapore, second is Brunei Darussalam, third Malaysia, fourth Thailand, fifth Indonesia, sixth philippines. GDP growth in Vietnam and Lao PDR is narrowly proportional, as well as Cambodia and Myanmar countries. Below is a chart of GDP growth in 10 asean countries.

**Figure 2.** Gross Domestic product (GDP) in 10 ASEAN Countries (current US\$)



Source: Data Processed, 2022

The results of this study indicate that when gross domestic product (GDP) increases by 1 percent, it will increase carbon emissions by 4.40E-05 percent. According to the Environmental Kuznets Curve (EKC) hypothesis, economic development represented by Gross Domestic Product (GDP) per capita, in the early stages of industrialization will be accompanied by increased damage environment.

It has to do with behavior and needs society to improve the level of the economy regardless of the impact on long-term sustainability. After reaching a certain point of GDP per capita, the economy will transition to a service sector that requires the exploitation of resources less accompanied by increased public environmental awareness, resulting in damage the environment will decrease (Candra, 2018). The results of this study are the same as those of Lean, H H. and Smyth (2010): The results from the Granger causality tests suggest that in the long-run there is unidirectional Granger causality running from electricity consumption and emissions to economic growth.

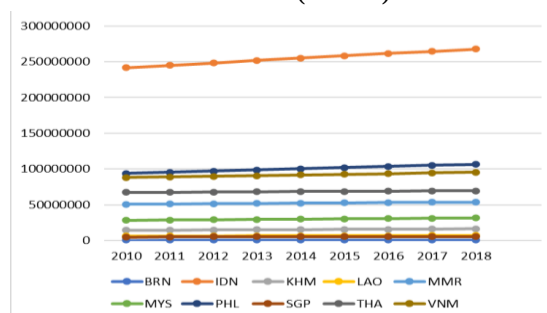
This research is also the same as other research, namely from Pejovic, Karadzic, Dragasevic (2021): (1) two-way relationship between gross domestic product and CO2 emissions, (2) two-way negative relationships between CO2 emissions and energy consumption from renewable sources, (3) no causality has been established between gross domestic product and energy consumption from renewable sources (4) the sign of the relationship in the direction from gross domestic product to CO2 emissions is negative, while in the opposite direction is positive.

This study is in line with Mohsin, M. Naseem, S. Sarfraz, M. and Azam (2022) research on investigating the relationship between environmental sustainability and economic growth in European and Central Asian countries using the 1971-2016 annual data series. The result a significant negative relationship for the long run and a positive relationship for the short-run between CO2 emission and GDP authorizes the worsening of environmental sustainability is because of economic growth for a longer term.

During the research period, the largest population is Indonesia was about 240 million to 260 million people, followed by the Philippines of about 93 million to 106 million people. The three countries with the most population, Vietnam between 87 million and 95 million people, followed by Thailand, Myanmar, Malaysia, Cambodia, Lao PDR, Singapore, and

the least populated Brunei Darussalam is about 380 thousand to 420 thousand people.

**Figure 3.** Total Population in 10 ASEAN Countries (Person)



Source: Data Processed, 2022

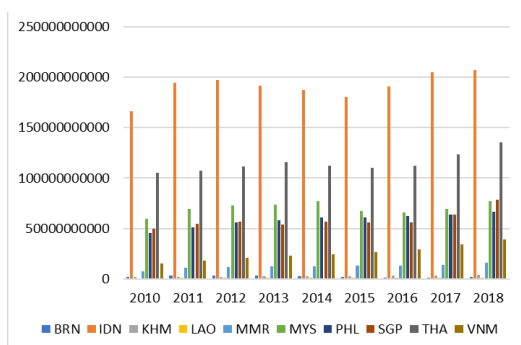
Regression panel data shows that total population has a significant effect on carbon emissions. The coefficient of the total population variable is 3.57E-08 with a probability of 0.0006 explaining that a 1% increase in total population will be followed by an increase in carbon emissions of 3.57E-08 percent. In general, pollution caused by CO2 emissions comes from 2 (two) activities, namely: natural and human (anthropogenic) such as CO2 emissions from transportation, waste, and consumption of household (domestic) electrical energy. usually CO2 emissions resulting from human activities (anthropogenic) are relatively high in concentration so that it will disrupt the balance system in the air and in the end can damage the environment and human welfare. The increasing population causes human activities to increase as well. Human activities are inseparable from energy consumption, both electrical energy and others, the use of fuel for cooking for the community, both from LPG, oil soil and firewood, this is a pollutant source of increased emissions of carbon dioxide (CO2) gas.

This study is in line with research Gao, C. Tao (2021). The results illustrate that the carbon emission situation due to trade in China is partly shaped by inter-provincial migration at the national level. While the contribution of migration varies widely across subregions due to regional economic development and unequal carbon intensity, migration-focused emission control strategies should be discriminatory

scaled up to better understand China's shared energy conservation and emission reduction policies. It can be concluded if the population density increases in an area it will increase carbon emissions. This study is also in accordance with Yeh, J, C., Liao, C (2017) research, stated that population size and age structure greatly affect energy consumption which will ultimately increase carbon dioxide (CO<sub>2</sub>) emissions in Taiwan during the 1994-2014 period. This research is also the same as other research, namely from Fao, Zhou, Zhang, Shao (2021): The results show that urban population aging increases urban household carbon emissions at levels both below and above 0.083, while this positive impact is comparatively smaller when urban population aging is above 0.083.

During the research period, the country that had the highest industrial growth was Indonesia, followed by Thailand, then Malaysia, followed by the Philippines and Singapore. The country with the slowest industrial growth is Lao PDR.

**Figure 4.** Industrial Growth in 10 ASEAN Countries (current US\$)



Source: Data Processed, 2022

The results show that the value of industrial growth has significant effect on carbon emissions. The MANF variable coefficient of -4.98E-12 with a probability of 0.0336 explains that every 1% increase in industrial growth, it will decrease carbon emissions by 4.98E-12 percent, and it can be interpreted that the growth variable of the industry has a significant relationship but has a negative impact on the carbon emissions variable. The results of this study are in accordance with the kuznet theory. Based on kuznets view, severe environmental damage will

be prone to occur in developing countries. This happens because in the early phases of industrialization growth. It focuses only on how the economy is growing rapidly and absorbing a lot of labor. Environmental issues have not been high on the agenda and the government has not been heavily involved in the effort improvement of the market system. The negative externalities that arise are environmental degradation by various indicators, namely increasing emissions of carbon dioxide (CO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO), ozone (O<sub>3</sub>), and particulate matter (dust) (Arief, 2016)

The results are in line with Rahman, M M and Kashem (2017) research on Carbon emissions, energy consumption and industrial growth in Bangladesh from 1972 to 2011. Where the results of his research are the industrial production and energy consumption have significant positive impact on the carbon emissions both in the short and long-runs.

This study is the same as the results of research from Yu Y (2018) that CO<sub>2</sub> emissions will have an upward trend in the future. As a result, speeding up construction of the sanatoria industry as well as adjusting of the energy and industry structures is proposed as effective ways to control CO<sub>2</sub> emissions. This research is the same as the research from Raza (2022): the manufacturing sectors' technological progress has a positive impact while the industrial sectors' technological progress has mix impact on CO<sub>2</sub> emissions. This study is also the same as the results of research from Hu Y, Yu Y (2021) and research from (Li, 2022).

The findings of this study are that all independent variables such as GDP, Total Population and Industrial Growth have an influence on increasing CO<sub>2</sub> emissions, which means that if each variable increases by 1%, CO<sub>2</sub> emissions will also increase by 1% and this is in accordance with the existing theory.

## CONCLUSION

In this research discusses the effect of variables such as GDP, total population, and industrial growth on carbon emissions in 10 ASEAN countries (Brunei Darussalam,

Indonesia, Cambodia, Lao PDR, Myanmar, Malaysia, Philippines, Singapore, Thailand, Vietnam). The results of this study show that all independent variables such as GDP, total population, and industrial growth have a significant effect on carbon emissions. So if the amount of GDP, total population and industrial growth increases, it will increase carbon emissions in 10 ASEAN countries during the research period.

Based on the results of the study, the implication is that the government must pay attention to environmental aspects, especially the problem of environmental damage or degradation caused by human activities and economic activities such as industrial growth that causes increased carbon emissions. For that it needs government policies in controlling carbon emissions, for example such as controlling population growth, boost the implementation of environmentally friendly industries, etc.

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