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THE EFFECT OF POPULATION, GDP, OIL CONSUMPTION, AND FDI ON CO2 EMISSIONS IN ASEAN 5 DEVELOPING COUNTRIES

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Abstract

Carbon dioxide emissions (CO_2) is a kind of gas that caused Global Warming. Intergovernmental Panel on Climate Change (IPCC) reported that CO_2 is resulted by human activities such as economic activities. This study aims to examine the effect of population, Gross Domestic Product (GDP), oil consumption, and Foreign Direct Investment (FDI) to CO_2 emissions in ASEAN 5 developing countries that are Malaysia, Indonesia, Thailand, Philippines, and Vietnam from 1985 to 2017. The data generated from the World Bank and British Petroleum. Due to the greater number of time series rather than cross-section, this study employed the Fixed-Effects model to estimate panel data. However, the Hausman test also revealed that Fixed-Effects is statistically preferable. The Fixed-Effect estimation results revealed that population, GDP, and oil consumption affect CO_2 emissions positively significant at 5% level. Meanwhile, FDI affects CO_2 emissions negatively significant at 10% level. The negative relationship between CO_2 emissions and FDI confirmed The Halo Effect hypothesis. Low carbon technologies should be utilized as a policy recommendation to reduce CO_2 emissions.

Keywords: CO_2 emissions, population, GDP, oil consumption, FDI

1. Introduction

Global warming has been a threat in the last few decades. One of the factors that caused global warming is the greenhouse effect. This effect occurred when gases in the atmosphere trap the heat of the sun. It makes the earth warmer and comfortable to live in. However, this condition also has a negative impact. The higher earth temperature can melt snow and ice that resulted in the rise of sea level. It contributes to extreme weather and generates climate change. The greenhouse effect is caused by the higher water vapour concentration (H_2O), carbon dioxide (CO_2), methane (CH_4), and nitrogen oxide (N_2O).

Intergovernmental Panel on Climate Change (IPCC) reported in 2014 that CO_2 is the highest gas resulted by human activities such as industrial activities and fossil fuel combustion. Thus, CO_2 has the highest contribution to the global warming problem (Kojima, 2019). British Petroleum reported that the CO_2 emission in the world is increased at 3.82% in the past 53 years. The world CO_2 emission is increased from 11,193.9 million tonnes 33,890.8 million tonnes from 1965 to 2018. For that reason, carbon dioxide emission has been an international issue in scientific

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research currently. Many papers not only studied about how to solve the problem but also studied about the determinant of CO_2 emissions.

As mentioned before, the determinants of CO_2 emissions not only from the natural process but also from human activities, especially economic activities. Table 1 below shows that the increasing population by 15.75% is followed by the increasing GDP by 34.85% in the period of 2008-2018. The increasing population and GDP also followed by increasing oil consumption and CO_2 emissions by 10.9% and 11.7% respectively. Population growth increases along with the primary needs such as foods and goods. Not only produce foods and goods, but the production process also yields pollution that threatens the environment. One of the pollutants is carbon dioxide emissions (CO_2). Carbon dioxide emissions are one of the gases that cause global warming and leads to climate change.

Table 1. Population, GDP, Oil Consumption, and CO_2 Emission in the World

Year	Population (million)	Gross Domestic Product (GDP) (million US $)	Oil Consumption (million tonnes)	CO_2 (million tonnes)
2008	6,757,887,172	63,616,067,321,080.9	4027.6	30,336.74
2018	7,594,270,356	85,790,820,876,816.1	4662.1	33,890.84
Growth	15.75%	34.85%	10.9%	11.7%
Growth p.a	1.57%	3.48%	1.09%	1.17%
Source:	World Bank & British Petroleum, 2019			

There are many studies about CO_2 with a different method, datasets, and research object. Thus, the results are varied. This paper examined the effect of population, GDP, oil consumption, and FDI on CO_2 emissions in ASEAN 5 developing countries that are Malaysia, Indonesia, Thailand, Philippines, and Vietnam in the period between 1985 to 2017.

1.1 Review of Literature

Previous studies about environmental economics, especially CO_2 emissions, revealed different results. The results have differed on the method, research object, dataset, and variables. Population and GDP are considered as one of the significant drivers of CO_2. A study by Begum et al. (2015) revealed that in Malaysia, the effect of population growth on CO_2 emissions is positive but insignificant. It implies that in Malaysia population growth was not the main factor that affects CO_2 emissions. Meanwhile, per capita GDP affect per capita CO_2 emissions negatively in Malaysia from 1970 to 1980. It means that the increasing per capita GDP decrease per capita CO_2 emissions. However, from 1980 to 2009, per capita, CO_2 affect GDP positively. It implies that per capita GDP increased along with per capita CO_2 emissions.

Another study by Alam et al. (2016) examined the relationship among per capita CO_2 emissions, population, and GDP per capita growth in Brazil, China, India, and Indonesia using linear and quadratics model. The results are different between the models and for each country. Population growth affects per capita CO_2 emissions significantly positive in India by using a linear model.

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Meanwhile, in the case of Brazil, population growth affected per capita CO_2 emissions significantly negative by using a linear model in the long run but showed significant positive result by using quadratic models in the short run. In Indonesia, GDP per capita showed a positively significant effect on per capita CO_2 emissions. The same result happened in Brazil that GDP per capita affect per capita CO_2 emissions positively significant. Meanwhile, in China, per capita, CO_2 emissions would eventually decline with the increase of GDP in the long run. A study by Asumadu-Sarkodie & Owusu (2016) revealed that population affect CO_2 emissions positively in Ghana. A 1% increase in population leads to an increase of CO_2 emissions by 1.72% in Ghana.

The increasing population tend to induce massive economic activities due to the higher needs of goods and services. Thus, oil consumption getting higher because of the production process. A study by Alkhathlan & Javid (2015) revealed a positive relationship between oil consumption and CO_2 emissions in Saudi Arabia. A 1% increase in total oil consumption will lead to an increase in CO_2 emissions by 87%.

Foreign Direct Investment (FDI) also considered as one of the factors affecting CO_2 emissions. In this globalization era, FDI has increased from the 1980s to 1990s. The increasing FDI brings positive impact on host countries such as capital, skill transfer, technology transfer, market access, and export promotion (Acharyya, 2009). These impacts imply the increasing economic activities that lead to economic growth. The increasing economic activities not only yield goods and services but also waste such as air pollution that can degrade the environment. However, the impact of FDI on CO_2 emissions is still arguable. A study by Linh & Lin (2015) revealed that FDI affects CO_2 emissions positively significant in the 12 most populous countries in Asia. The study confirms the Pollution Haven Hypothesis. This hypothesis explains that foreign companies invest in the host country with cheap labour and resources but not along with sustainable technology. This condition leads to environmental degradation, in this case, the higher CO_2 emissions.

A study by Guzel & Okumus (2020) revealed that the increase of FDI leads to the higher CO_2 emissions per capita in ASEAN-5 countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand). The result also confirmed the Pollution Haven Hypothesis. Meanwhile, a study by Zhu et al. (2016) revealed that FDI affects CO_2 emissions negatively in ASEAN-5 countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand. The study employed panel quantile regression to estimate panel dataset from 1981 to 2011. The result confirmed a study by Shao (2018). The study revealed that FDI affects carbon intensity (the ratio of CO_2 and GDP in a certain period) in 188 countries from 1990 to 2013 negatively. It implied that FDI would reduce the carbon intensity of the host country. This result supported the Halo Effect hypothesis. Halo effect hypothesis is when the foreign companies utilized new technologies and improved management services to provided cleaner technology to the host country. It implies that FDI not only as a factor to boost host country economics but also pay attention to the environment.

2. Method

This study observed ASEAN 5 developing countries between 1985 to 2017. This study utilized CO_2 as a dependent variable, while the independent variables are Gross Domestic Product

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(GDP), oil consumption, and Foreign Direct Investment (FDI). This study transformed the data to approximately conform to normality. Below is the variable specification of the study:

Table 2. Variable Specification

No	Variable	Variable Specification	Source
1	lnCO2	Carbon dioxide emission, measured in a million tonnes	British Petroleum
2	lnPop	The population in a country each year	World Bank
3	lnGDP	The Gross Domestic Product (GDP) in a country each year, measured in a million US dollar	World Bank
4	lnOil_const	The oil consumption in a country each year, measured in a million tonnes	British Petroleum
5	lnFDI	The Foreign Direct Investment (FDI) in a country each year, measured in a million US dollar	World Bank

To estimate the effect of population, GDP, oil consumption, and FDI to CO_2 emissions, this study employed a panel regression model. Usually, there are two-panel regression models that commonly used, they are Fixed-Effects and Random-Effects. The fixed-Effects model relies on the time series variations. Thus, the variables do not change over time and cannot be identified. Meanwhile, Random-Effects relies on a weighted average of the within and between variables.

$$lnCO_2 = (\alpha_0 + \lambda_i) + \alpha_1 lnPop_{it} + \alpha_2 lnGDP_{it} + \alpha_3 lnOil\_const_{it} + \alpha_4 lnFDI_{it} + \varepsilon_{it} \quad (1)$$

$$lnCO_2 = \beta_0 + \beta_1 lnPop_{it} + \beta_2 lnGDP_{it} + \beta_3 lnOil\_const_{it} + \beta_4 lnFDI_{it} + \lambda_i + \varepsilon_{it} \quad (2)$$

The (1) equation is the Fixed-Effects model, and the (2) is a Random-Effects model. The (1) model is named Fixed-Effect model because the individual-specific effects are assumed to be individual specific intercepts. The (2) model is called the Random-Effects model because the λ_i is a random variable with zero mean value and variance. The λ_i also more crucially uncorrelated with the regressor. The two models have their assumption and estimation. The researcher often confuses which model is preferable. Judge et al. (1982) explained that if the number of time series data is greater than the number of cross-sectional units, Fixed-Effect model is preferred. However, there is also a statistical test to choose between Fixed-Effect and Random-Effect, which is preferable. The statistical analysis named as Hausman-Test since it developed by Hausman in 1978. From the variables, method, and dataset, this paper is the first paper estimating the effect of population, GDP, oil consumption, and FDI in ASEAN 5 developing countries from 1985 to 2017 using the Fixed-Effects model.

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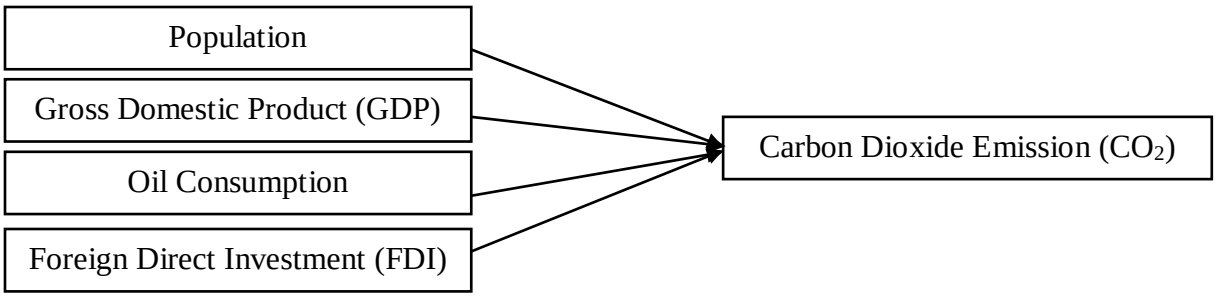
2.1 Research Framework

Below is the research framework of this study:



2.2 Hypotheses

The hypotheses formulated in this study are as follow:

H1: Population affect CO_2 emissions positively in ASEAN 5 developing countries from 1985 to 2017

H2: GDP affect CO_2 emissions positively in ASEAN 5 developing countries from 1985 to 2017

H3: Oil consumption affect CO_2 emissions positively in ASEAN 5 developing countries from 1985 to 2017

H4: FDI affect CO_2 emissions positively in ASEAN 5 developing countries from 1985 to 2017

3. Result and Discussion

This study examined the effect of population, Gross Domestic Product (GDP), oil consumption, and Foreign Direct Investment (FDI) in ASEAN 5 developing countries that are Malaysia, Indonesia, Thailand, Philippines, and Vietnam. This study used CO2 as the dependent variable and four independent variables that are population, Gross Domestic Product (GDP), oil consumption, and Foreign Direct Investment. The data generated from British Petroleum and World Bank from 1985 to 2017.

3.1 Fixed-Effects and Random-Effects

Generally, two models often employed to estimate panel data. The models are Fixed-Effect and Random-Effect model. Table 3 below presented the estimation result of the Fixed-Effect and Random-Effect model. The Fixed-Effects and Random-Effects model showed a slightly different result. Population, GDP, and oil consumption affect CO_2 emissions positively significant at 1% level. The fixed-Effects result revealed that FDI affects CO_2 emissions negatively significant at 1%. Meanwhile, Random-Effects estimation showed that FDI affects CO_2 emissions positively significant at 5% level.

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Table 3. Data Estimation Result

Variable	FE	RE
lnPop	0.595	-0.008
	(0.000)***	(0.000)***
lnGDP	0.213	0.281
	(0.000)***	(0.000)***
lnOil_const	0.772	0.639
	(0.000)***	(0.000)***
lnFDI	-0.021	0.028
	(0.000)***	(0.012)**
_cons	-13.384	-4.873
	(0.000)***	(0.000)***
Number of Observation	159	159
R^2 within	0.98	0.97

*** = significance at 1% level; ** = significance at 5% level ; *= significance at 10%

Source: Data estimation result, 2020

3.2 Hausman-Test

This study employed Hausman-Test to determine which model are preferable between Fixed-Effect and Random-Effect model. The Hausman-Test estimation result is presented in Table 4 below.

Table 4. Hausman Test Result

Chi square statistic (chi2)	Prob
11.53	0.02

Source: Data estimation result, 2020

The Hausman test showed the probability value of 0.02, which < 0.05 (5%). The results indicated that Random-Effects is not appropriate. Thus, the Fixed-Effects model is preferable. This paper conducted classical assumption test before further analysis. The classical assumption tests utilized in this paper are the multicollinearity test and heteroscedasticity test.

3.3 Multicollinearity Test

Multicollinearity defined as a linear relationship between the independent variables (Frisch, 1998). This study utilized VIF mean value to detect multicollinearity problem in the model. If the mean value of VIF is greater than 10, it means that the multicollinearity problem exists. Table 5 below showed the VIF mean value of 3.43 that is < than 10. It implied that the model does not have a multicollinearity problem.

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Table 5. VIF Value Estimation Result

Variable	VIF	1/VIF
lnPop	1.21	0.824
lnGDP	5.43	0.184
lnOil_const	5.10	0.196
lnFDI	1.96	0.509
Mean VIF	3.43	

Source: Data estimation result, 2020

3.4 Heteroscedasticity Test

This study employed a Modified Wald Statistic to detect the heteroskedasticity problem. If the probability value is < 0.05, it means that the variances are not constant. It implied that there is a heteroscedasticity problem.

Table 6. Heteroscedasticity Test Result

Chi-Square Statistic	Prob
30.11	0.000

Source: Data estimation result, 2020

Table 6 showed the probability value of 0.000, and it means that the model has a heteroscedasticity problem. This study utilized "robust" command in STATA 14 to weight the standard error robust.

3.5 Fixed-Effects Estimation Result

The command "robust" in STATA to solve heteroscedasticity problem yield a new estimation result. Table 7 below, is the Fixed-Effect final estimation result. The Fixed-Effect estimation results revealed that population affect carbon dioxide emission (CO_2) positively significant at 5% level. The results confirmed hypotheses 1 (H1) that there is a positive relationship between population and carbon dioxide emission. The estimation results also confirmed that GDP affects CO_2 emissions positively significant at 5% level. It also confirmed hypothesis 2 (H2). Oil consumption affects CO_2 emissions positively significant at 5% level. It confirmed hypothesis 3 (H3).

The result emphasized that human activities, such as economic activities affect the environment. CO_2 emissions are the proxy of the environment variable. The massive economic activities endangered environmental quality by increasing CO_2 emissions. The increasing population generates the higher needs of goods and services. Thus, the production factors such as fossil fuel (oil, coal, and natural gas) are in high demand. The production process yields not only goods and services but also pollution such as air pollution. One of the air pollutants is CO_2. The result is in

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line with studies by Begum et al. (2015), Alam et al. (2016), Asumadu-Sarkodie & Owusu (2016), Alkhathlan & Javid (2015). The results implied that in developing countries, particularly, the production activities to boost economic growth do not pay attention to the environment. As a result, the environment can be degraded. It is explained by the positive relationship between GDP, oil consumption, and CO_2 emissions.

The estimation result showed that FDI affects CO_2 emissions negatively but not significant in ASEAN 5 developing countries from 1985 to 2017. The result rejects hypotheses 4 (H4). It implies that an increase of FDI leads to the decrease of CO_2 emissions. The negative relationship between FDI and CO_2 emissions confirmed Halo Effect hypothesis. It means that in the period from 1985 to 2017, the foreign investors in Malaysia, Indonesia, Thailand, Philippines, and Vietnam utilized new technology that reduces emissions from production activities. The result is in line with a study by Shao (2018).

Table 7. Fixed-Effect Estimation Result

Variable	FE
lnPop	0.595 (0.005)**
lnGDP	0.213 (0.004)**
lnOil_const	0.772 (0.000)***
lnFDI	-0.021 (0.084)*
_cons	-13.384 (0.000)*
Number of Observation	159
R^2 within	0,98
*** = significance at 1% level ; ** = significance at 5% level ; *= significance at 10%	

Source: Data estimation result, 2020

4. Conclusion and Policy Implications

As mentioned above, there are two panel regression models that often used by most studies that are Fixed-Effects and Random-Effects. This study employed Fixed-Effect model to estimate the data due to the number of time series that greater than cross-section, as stated by Judge et al. (1982). However, this study also conducted a statistical test named the Hausman Test to choose between Fixed-Effects and Random-Effects. The result revealed that the probability value of the Hausman Test is 0.02, which < 0.05. Thus, Fixed-Effects is preferable.

This study also conducted classical assumption tests that are multicollinearity and heteroscedasticity test. The result revealed that there is no multicollinearity in the model, but heteroscedasticity problem. This study utilized 'robust' command provided by STATA 14 to

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deal with the heteroscedasticity problem. The Fixed-Effects model estimation result after 'robust' revealed that population, GDP, and oil consumption affect CO_2 emissions positively significant at 5% level. This result confirmed the findings from most studies. The result explained that the growing population would lead to the high demand of goods and services as well as oil consumption as production process factor. Meanwhile, FDI negatively affects CO_2 emissions but significant at the 10% level. The result confirms the Halo Effect Hypothesis that explain a condition when a foreign investor starts to pay attention not only to the production process but also to environmental sustainability by utilizing low carbon technology. This technology is able to reduce emissions.

Government policies can be constructed to reduce CO_2 emissions. The authorities from ASEAN 5 developing countries may start to consider utilizing low carbon technology as inputs in the production process. The fossil fuel such as oil also can be replaced with another low carbon energy resources. To obtain all these aims, each country can conduct research and development to make innovation in the low carbon technologies that fit in with each country's condition. Thus, a country not only reaches the higher economic growth but also contribute to environmental sustainability.

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