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The Impact of Economic Growth and Trade Openness on Environmental Degradation: Evidence from A Panel of ASEAN Countries

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Abstract: Global warming and climate change show a decrease in environmental quality. The main cause of global warming is the emission of carbon dioxide (CO2). This study aims to analyze the effect of economic growth and economic openness on environmental quality in ASEAN countries from 2010 to 2019. This research uses a panel data analysis method. The analysis results show that the variable economic growth has a negative and significant effect on carbon dioxide emissions. Meanwhile, the variables used for economic openness are exports, imports, and FDI. Export and FDI variables have a positive and significant effect on CO2 emissions, but there is no effect on imports. This study also used population variables as control variables and the result is there is no effect on CO2. Based on the results, it is necessary to have a carbon emission reduction policy for ASEAN countries using environmentally friendly technology.

Keywords: CO2 Emissions; Economic Growth; Environmental Quality; Trade Openness

JEL Classification: F18; F64; O44; P18; Q56

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Introduction

The quality of the environment is deteriorating due to climate change and global warming. Changes in environmental quality have become a global issue in the last few decades. According to Ghosh (2010), the main cause of global warming is the emission of carbon dioxide (CO2). Global warming is caused by rapid economic growth. It increases industrial growth, which impacts air pollution and affects the decline in environmental quality (Candra, 2018). The Environmental Protection Agency (2020) explained that CO2 contributes greatly to global warming. It contributes 56%, while NH4 and N2O only contribute 18% and 6%. The amount of CO2 in the atmosphere is the effect of greenhouse gases, resulting in global warming. Greenhouse gases have a Global Warming Potential (GWP) whose measurement is relatively between CO2 gas and a value of 1. The large GWP value indicates that it is increasingly destructive (Sugiyono, 1997).

The Intergovernmental Panel on Climate Change (IPCC) explained that Southeast Asia is predicted to have serious climate change because most of its economic growth still relies on natural resources and the agricultural sector. Kolstad and Krautkraemer (1993) also stated that economic growth can cause negative impacts on the environment in the long term.

It is further clarified by Kuznets's theory, which explains a positive relationship between economic growth and environmental quality (Panayotou, 2003; Hamori & Kume, 2018; Nguyen & Darsono, 2022). Therefore, according to Todaro et al. (2009), the development does not only focus on the economic sector but also on environmental quality.

In addition, rapid population growth will lead to increased demand for food, energy, water, and other resources. It can lead to pressure and excessive exploitation of the environment. Bran and Popa (2009) explained that the relationship will become more complex because of the dependence of the population on natural resources. This condition will have the potential to worsen environmental damage and potentially cause natural disasters. At the beginning of the 20th century, the world population fluctuated by about 6 billion. 80% are from developing countries and the majority are from ASEAN countries. Indonesia has the largest population among ASEAN countries (Nazeer & Furuoka, 2017).

This study hypothesizes that there is a significant effect between economic growth, economic openness, population, and energy consumption on carbon dioxide (CO2) emissions in 10 ASEAN countries. Only a few studies discuss economic activity and environmental quality. Meanwhile, the relationship between economic growth and environmental quality is closely related, which is explained through Kuznets's theory. In addition, the ASEAN Energy Center also estimates that greenhouse gases in the ASEAN countries will increase by 34-147% between 2017 and 2040 (ASCCR, 2021). The impacts of climate change will inevitably increase due to the accumulation of global emissions in the atmosphere over time (ASCCR, 2021).

Kuznets (1955) explains the damaged environment experienced in developing countries. Most of them are countries with low per capita income. This happens because industrialization growth is still in its early phase, which is still focused on economic development and employment. Meanwhile, environmental issues have not received special attention. Thus, in this phase, there is a positive correlation on economic growth with changes in environmental quality. However, when the economic goals have been achieved which means that per capita income has increased, the level of awareness of environmental quality begins to develop (Spilker, Koubi, & Bernauer, 2017).

Ehrlich and Holdren (1972) in their theory of Impacts of Population, Affluence and Technology (IPAT) explain that income and population are the main factors that can affect the environment. It will decrease along with the development of technology. The research that uses panel data conducted by Halkos (2011) explains the influence between economic development and the level of pollution (CO2 emissions). He stated that a policy could overcome this problem. Horii and Ikefuji (2014) explain that only the scale of production can be achieved in an expanding economy. There are three negative impacts, namely local and global pollution and environmental degradation. In addition, research related to economic openness is found in Jugurnath and Emrith (2018), which stated that foreign direct investment (FDI), population, dummy crisis, and technology positively and significantly impact environmental degradation. Meanwhile, FDI and trade have a significant negative effect on environmental degradation.

The novelty of this study is that it specifically discusses carbon dioxide (CO2). There have been limited studies regarding carbon dioxide (CO2). Other studies discuss the environmental quality index which does not discuss further details. This study also focuses on using independent variables in the form of economic and economic growth. Moreover, this study uses the most recent data from 10 ASEAN countries. This research introduces the idea that high economic growth, international trade activities, population levels, and energy consumption will increase the value of carbon dioxide emissions, which impact global warming and a decrease in environmental quality. Therefore, the purpose of this study is to analyze the influence of economic growth and openness on CO2 emissions.

Research Method

This study used a quantitative method approach that aimed to analyze the changes of environmental quality caused by economic growth and trade openness. The data used was annual data from 2010 to 2019 in 10 ASEAN member countries (Indonesia, Thailand, Myanmar, Vietnam, Malaysia, Myanmar, Singapore, Cambodia, Laos, and the Philippines) obtained from World Bank data sources. The variables that were used in this empirical research are shown in Table 1.

Table 1 Variable Identity

Variable	Definition	Sources
CO2 emissions	CO2 emissions (metric tons per capita)	World Bank (2021)
Economic growth	Total GDP per capita (constant) in millions of US dollars	World Bank (2021)
Population	Total population in 10 ASEAN countries	World Bank (2021)
Trade openness	Total exports and imports of goods and services in 10 ASEAN countries	World Bank (2021)
Foreign direct investment	Net foreign investment rate	World Bank (2021)

The data analysis method used was quantitative analysis using panel data regression. This research used panel data regression to determine the differences between individuals or in each ASEAN country. Panel data can be used to avoid the limited number of observations because a large number of observations will increase the degree of freedom. In addition, this estimation can reduce the existence of collinearity between independent variables (Gujarati, 2012). The advantage of using panel data estimation is suitable for describing the dynamics of change. Panel data can detect and measure the impact and minimize the bias that might result in the regression (Baltagi, 2005).The general equation for panel data is as follows:

$$Y_{it} = \beta_{it} + \beta_{it}X_{it} + \varepsilon_{it} \qquad (1)$$

In this equation, *Y* is the dependent variable, β is the regression parameter, *X* is the independent variable and ε is the stochastic disturbance variable. Meanwhile, *i* and *t* show the observation and time. In this study, the model used as an approach to analyze the

relationship between economic growth and trade openness with CO2 emissions is as follows:

$$CO2_{it} = a_{it} + \beta_1 Growth_{it} + \beta_2 POP_{it} + \beta_3 NP_{it} + \beta_4 FDI_{it} + \varepsilon_{it} \quad (2)$$

Where CO2 is the CO2 emissions or carbon dioxide produced, Growth is economic growth, *Pop* is the total population, *NP* is the trade balance, *FDI* is foreign investment. The trade balance and FDI are indicators used as an indicator of the openness of the economy. Meanwhile, ε_{it} is the coefficient of confounding.

The estimation of this research panel data used several stages of testing which were the selection of the best model and the classical assumption test. In selecting the best model, there are three stages of testing, namely Chow test, Hausman test, and LM test. The three models that will be regressed are the common effect, fixed effect, and random effect models. Furthermore, in the classical assumption test, it is necessary to carry out three stages of testing, namely heteroscedasticity test, autocorrelation test, and multicollinearity test. The three tests must be met so that the data used can be tested for validity.

Result and Discussion

This study used a quantitative method approach that aimed to analyze the environmental Kuznets curve hypothesis and analyze changes in environmental quality caused by economic growth and openness. The data used were 10 ASEAN countries (Indonesia, Thailand, Myanmar, Vietnam, Malaysia, Myanmar, Singapore, Cambodia, Laos, and the Philippines) from 2010 to 2019. The data used started from 2010 aimed to examine the relationship between growth and economic openness to environmental quality in the last ten years. In general, this empirical research used secondary data taken from the World Bank in 2021. This study used CO2 emission variables, economic growth, population, trade openness, and foreign direct investment.

Table 2 Descriptive Statistics

	CO2	LGDP	LPOP	LIMPORT	LEXPORT	FDI
Mean	0.586145	2.520011	62886087	1.470011	1.610011	-6.220009
Median	0.498823	2.050011	41275308	1.210011	1.110011	-2.090009
Maximum	1.668606	1.200012	2.710008	5.870011	6.910011	9.910009
Minimum	0.135738	7.130009	388634.0	3.520009	2.520009	-6.990010
Std. Dev	0.351386	2.820011	73697451	1.520011	1.760011	1.190010
Skewness	1.276024	1.684638	1.684060	1.108904	1.301752	-2.903089
Kurtosis	4.154009	5.539986	5.086143	3.734152	4.222439	14.08515
Jarque-Bera	32.68619	74.18145	65.40095	22.74023	34.46913	652.4678
Probability	0.000000	0.000000	0.000000	0.000012	0.000000	0.000000
Sum	58.61451	2.520013	6.290009	1.610013	1.470013	-6.220011
Sum Sq. Dev.	12.22377	7.870024	5.380017	3.080024	2.280024	1.400022
Observations	100	100	100	100	100	100

Table 2 shows the descriptive statistics for all of the variables used in the study.The observations made in this study were 100. The average of CO2 is 0.58, and the maximum and the minimum value of CO2 are 1.66 and 0.13. While the average of LGDP is 2.52, the maximum value is 1.20 and the minimum value is 7.13. Then for LPOP variable, the mean value is 628, the maximum and the minimum value are 412 and 2.71. Variable of LIMPORT has a similar average with the variable of LEXPORT, it is 1.47 and 1.61. The maximum and the minimum of LIMPORT are 5.87 and 3.52. In contrast, the maximum and the minimum of LEXPORT are 6.91 and 2.52. Furthermore, the FDI variable has an average value of -6.22, the maximum value is 9.91 and the minimum value is -6.99.

The data analysis was carried out using the panel data regression method which is a combination of cross section and time series for the level of ASEAN countries. In panel data regression, the best model used in this study is the fixed effect model. It is based on the best model selection test using the Chow test and Hausman test. Chow test was used to determine the best model between the Common Effect Model (CEM) and Fixed Effect Model (FEM). Meanwhile, the Hausman test was used to determine the best model between the Fixed Effect Model and the Random Effect Model (REM) by considering the probability of cross-section value (Susanti & Nidar, 2016).

In panel data, the classical assumption test is optional. Some researchers ignore classical assumptions. According to Gujarati (2012), panel data has complexity regarding the behavior that is in the model. Therefore, panel data does not require classical assumption tests. Thus, the superiority of panel data regression implies that there is no need for classical assumption tests (Verbeek, 2000; Gujarati, 2012). Table 3 shows the results of testing panel data consisting of the common effect model, fixed effect, and random effect model.

Table 3 Panel Data Model Estimation Results

Variable	Probability		
	Common Effect	**Fixed Effect**	**Random Effect**
C	0.0156	-1.995007	-2.670087
LGDP	0.0000***	-0.386154	-0.341169
LPOP	0.0020***	0.113513	0.061382*
LEXPORT	0.4886	0.371680	0.394691
LIMPORT	0.5079	0.050738**	0.044890**
FDI	0.0072***	1.21E-12	2.61E-12
R-squared	0.300920	0.962263	0.138494
Adjusted R-squared	0.267310	0.956702	0.097076
F-statistic	8.953394	173.0319	3.343777
Prob(F-statistic)	0.000000	0.000000	0.007680
*Note: *p<0.1. **p<0.05, ***p<0.01*			

Based on the estimation results, the best model is selected. The results of the chow test are shown in Table 4.

Table 4 Chow Test Result

Effects Test	Statistic	d.f.	Prob.
Cross-section F	169.659308	(9,95)	0.0000

Table 4 shows the probability value of the cross-section F < (0.05) which means that the Fixed Effect Model (FEM) is the best model compared to the Common Effect Model (CEM) in analyzing the environmental quality of 10 ASEAN countries. The next test is the Hausman test, which selects the best model between the Fixed Effect Model (FEM) and the Random Effect Model (REM). The results of the Hausman test show that the probability value of chi-square < (0.05). The more appropriate model to use is the Fixed Effect Model (FEM) (see table5).

Table 5 Hausman Test result

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	21.226750	5	0.0007

The results of the two best model tests show that the Fixed Effect Model is the best model to be used in this study. Therefore, the LM test does not need to be continued. The estimation results from the Fixed Effect Model are are shown in Table 6.

Table 6 Fixed Effect Model Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.995007	2.762051	-0.722292	0.4719
LGDP	-0.386154	0.105087	-3.674599	0.0004***
LPOP	0.113513	0.227642	0.498647	0.6192
LEXPORT	0.371680	0.068025	5.463848	0.0000***
LIMPORT	0.050738	0.040829	1.242684	0.2170
FDI	1.21E-12	6.27E-13	1.935037	0.0560**
		Effect Specification		
R-squared	0.962263			
Adjusted R-squared	0.956702			
S.E. of regression	0.108484			
F-statistic	173.0319			
Prob(F-statistic)	0.000000			

Based on Table 6, the statistical tests were carried out which included individual parameter significance tests (t statistical tests), joint significance tests (f statistical tests) and R^2 determinant coefficient tests. The t-statistic test aims to examine the influence of each independent variable individually in explaining the variation of the dependent variable.

The estimation results show that the LGDP variable has a t-count of -3.674599 and a probability value of 0.0004, the LPOP variable of 0.498647 and the probability value of 0.6192, the LEXPORT variable of 5.463848 and the probability value of 0.0000. While the

LIMPORT and FDI variables have t-counts of 1.242684 and 1.935037 and probability values of 0.2170 and 0.0560. Furthermore, the F test determines the independent variables on the dependent variable as a whole. The probability value of the *f-statistic* is 0.000000 which means it is smaller than the alpha value of 0.05. These results conclude that the independent variables LGDP, LPOP, LEXPORT, LIMPORT, and FDI affect the independent variable of environmental quality in 10 ASEAN countries. Furthermore, the estimation results show an R^2 value of 0.962263 or 96.22% which means that the LGDP, LPOP, LEXPORT, LIMPORT, and FDI variables can explain the environmental quality variable in 10 ASEAN countries by 96.22%. The remaining 3.78% can be explained by the variables outside the research variables.

Based on the results of panel data regression using the fixed-effect *model*, the following equation can be obtained:

$$CO2_{it} = -1.995007 - 0.386\, LGDP_{it} + 0.113\, LPOP_{it} + 0.371\, LEXPORT_{it} + 0.050\, LIMPORT_{it} + 1.210\, FDI_{it} + u_{it} \quad (3)$$

According to the equation, the constant coefficient is -1.995007, meaning that other systematic variables also affect the quality of the environment in 10 ASEAN countries but are not included in the study. Furthermore, LGDP has a coefficient of -0.386. Increasing 1 percent economic growth will reduce CO2 by 0.386 percent in the 10 ASEAN countries. The results of the panel data output show that the probability value of LGDP is 0.0004. It is smaller than the alpha value of 0.05, so that LGDP has a negative and significant effect on CO2 emissions.

The next variable is LPOP which has a coefficient of 0.113. It indicates that the increase of 1 percent, will increase CO2 by 0.113 percent. However, the estimation result of LPOP has a probability value of 0.6192. It is greater than the alpha value of 0.05, so that LPOP has a positive and insignificant effect on CO2 emissions in 10 ASEAN countries. This also occurs in the LIMPORT variable which has a coefficient value of 0.050 with a probability value of 0.2170. It indicates that LIMPORT has a positive and insignificant effect on CO2.

Furthermore, the LEXPORT variable has a coefficient value of 0.371. The increase of 1 percent exports will increase CO2 emissions by 0.371 percent. This is further supported by the probability value of 0.0000 (alpha value <0.05). It indicates that LEXPORT has a positive and significant effect on CO2 in 10 ASEAN countries. Furthermore, the FDI variable has a coefficient value of 1.210 and a probability of 0.056. It indicates that FDI has a positive and significant effect on CO2 and the increase of 1 percent FDI will increase CO2 emissions by 1.210 percent.

Based on the estimation results of the fixed-effect model, the LGDP, LPOP, LEXPORT, LIMPORT and FDI variables have a significant effect on CO2 emissions in 10 ASEAN countries. However, partially not all of the independent variables affect CO2 emissions in the 10 ASEAN countries.

LGDP or economic growth has a negative and significant impact on CO2 emissions in the 10 ASEAN countries. When a country's economy grows, it will reduce the level of CO2 emissions. This means that when CO2 emissions decrease, the quality of the environment in that country increases. This is in accordance with the Environmental Kuznets Curve (EKC) theory which explains that the higher the economic growth of a country, the lower the level of environmental damage in the long term.Indonesia is one of the ASEAN countries where they have a program as its determination to control greenhouse gases as stated in the NDC document in Law Number 16 of 2016. Indonesia has a target of reducing gas emissions by 29% on its own and then by 41% with international assistance. The higher the level of economic growth of a country, the higher the level of awareness in each country of its concern for the environment, especially CO2 emissions. This study is in line with that conducted by Arouri, Hossain, and Badrul Muttakin (2014), Ali, Soemarno, and Purnomo (2015), Ibrahiem (2016), and Nikensari, Destilawati, and Nurjanah (2019).

Meanwhile, the population in this study had a positive and insignificant effect. As the population increases, it will not affect CO2 emissions. Population growth causes energy demand which will increase CO2 gas emissions (Li & Liu, 2014). According to Mahmood (2012), population density has a positive impact on CO2 emissions. The population density is the factor that influences environmental degradation. A large population with relatively high population growth will cause an increase in the need for natural resources as inputs for goods and services (Ilham, 2021). However, in this study, population growth had no significant effect. Although the high population can increase the demand for fuel energy such as industrial generation, electric power, and transportation, the population is responsible for the environmental degradation. For example, along with the development of the times in the industrial structure, the population switched to using heavy equipment towards service-based industries and the use of advanced technology that could lead to a reduction in CO2 emissions (Banerjee & Rahman, 2012). In addition, the population living in urban areas has a higher level of awareness of the importance of maintaining environmental quality. Currently, there is control of energy consumption, especially in the transportation sector which can reduce the level of CO2 emissions (Chandran Govindaraju & Tang, 2013). This is in contrast with the research conducted by Zhao et al. (2013) that population density has a negative effect on carbon dioxide. Similarly, research conducted by Ong and Sek (2013) shows that residents in low- and middle-income countries have a negative influence on CO2 emissions. Wafiq and Suryanto (2021) also proposed that the population density has a significant negative impact on the environmental quality.

Furthermore, the export growth rate has a positive and significant impact on CO2 emissions in the 10 ASEAN countries. This shows that the higher the level of international trade activity, the higher the CO2 emissions produced. The increasing demand for exports means an increase in the productivity of a country which requires more energy consumption. Not only the need for more energy consumption, but the need for natural resources has also become more intensive to produce residues and waste that have an impact on environmental degradation (Hossain & Rao, 2014). According to Ong and Sek (2013), human activities and industrialization will increase CO2 emissions that affect global warming. This is in contrast with the import activities where in this study it was found that the activities had no effect on CO2 emissions. This is because import activities

do not require high productivity which produces a lot of waste. On the other hand, import activities have a significant impact on marine pollution, specifically in the sea transportation sector. Almost 95% of goods transportation for export and import uses sea transportation (Statistics Indonesia, 2016). However, the members of the International Maritime Organization (IMO) have agreed on a strategy to reduce greenhouse gases in shipping. This will tackle and reduce marine pollution.

There are various factors in this study which are estimated to cause an increase in CO2 emissions, namely foreign direct investment (FDI) or foreign investment. The estimation results show that FDI has a positive and significant effect on CO2 emissions in 10 ASEAN countries. The increase in FDI will reduce the quality of the environment. These results are in accordance with the research conducted by Shahbaz, Nasreen, Abbas, and Anis (2015) that high levels of FDI will cause more energy consumption to be used by a country, especially in the industrial sector where energy consumption has a significant effect on environmental quality.

Conclusion

This study aims to analyze the effect of economic growth and trade openness on the quality of the environment in ASEAN countries. This research introduces the idea that high economic growth, international trade activities, population levels, and energy consumption increase carbon dioxide emissions which have an impact on global warming and decrease the environmental quality. The data used is annual data from 2010-2020 in ASEAN countries (Indonesia, Thailand, Myanmar, Vietnam, Malaysia, Myanmar, Singapore, Cambodia, Laos, and the Philippines) and used panel data regression model estimation.

This study uses GDP as a proxy for economic growth. The result is a significant negative effect and this is in accordance with the existing theory. The proxy of trade openness in this study uses export, import, and FDI variables. The results show that exports and FDI have a positive and significant effect on CO2 emissions, while there is no effect on imports. Furthermore, this study also uses population variables as control variables and the results show that there is no effect on environmental quality. The results of this study provide the variables used contribute to CO2 emissions in 10 ASEAN countries.

The government in each country is advised to take advantage of its economic growth to make an effort to enhance environmental quality. For example, by providing funds to research technologies that can reduce CO2 emissions or improve environmental quality and provide special policies for using environmentally friendly products. The government is also advised to control export and import activities to provide solutions to the environmental quality problems. Therefore, export activities can run optimally but still maintain environmental quality. It is hoped that further research can be carried out by considering the addition of countries and periods or with other methods to perfect the research.

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