

ENVIRONMENTAL DEGRADATION IN INDONESIA AND MALAYSIA: THE EFFECT OF ENERGY CONSUMPTION, ECONOMIC GROWTH, POPULATION, AND FOREIGN DIRECT INVESTMENT (FDI)

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ABSTRACT

The main objective of this study is to examine how energy consumption, economic growth, population, and foreign direct investment (FDI) affects CO₂ emissions in Indonesia and Malaysia. This study uses the longest and most updated annual data during the period 1960-2018. To get a deeper analysis, this study employs disaggregate of CO₂ emissions and energy consumption data namely, oil, coal and natural gas. The ordinary least square which preceded by unit root test and classical assumption test are employed. The results show that all type of energy consumption affect positively to CO₂ emission. Economic growth is identified as the variable with greatest influences on CO₂ emissions in oil and natural gas model, while CO₂ emissions from coal consumption are mainly affected by populations. The study concludes that economic growth of both countries relies heavily on fossil fuel. CO₂ emission sourced from coal mostly affected by population due to the high demand of electricity from household fulfilled by power generation which use coal as the fuel. The EKC hypothesis is confirmed in the model of gas, indicate that natural gas is the most appropriate source of energy to be used at the certain level. Using natural gas is effectively decrease the CO₂ emission while in the same time increase the economic growth. Natural gas is also found as the most environmentally friendly fossil fuel due as it produces less CO₂ emission compared to oil and coal. The findings have important implications for policy makers in determining policy and business decisions especially to enhance environmentally friendly energy uses for the benefit of the economy.

Keywords : energy consumption, oil, coal, gas, economic growth, population, urbanization, trade openness

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INTRODUCTION

Carbon dioxide (CO₂) emissions is a major factor causing some worldwide environmental damage. The increasing of CO₂ emissions in the earth's atmosphere cause global warming which then increases the temperature of the earth, melting the polar ice which than raise the level of sea water, and climate change. The raise of CO₂ emissions mainly caused by the burning of fossil fuel consumption in various sectors including industry, transportation, and household. In 2018, the International Energy Agency (IEA) recorded 33.4 Gt of CO₂ emissions in the world, where 65% of CO₂ emission is sourced from fossil fuels and industrial process (EPA, 2018). This is very worrying level because it could endanger the survival of living things in the world.

The CO₂ emissions mostly produced from burning fossil fuels namely oil, coal, and natural gas. Table 1 reveals that the combustion of three fossil fuels produces different level of CO₂ emissions where coal produces the most CO₂ emission followed by oil and natural gas. In addition, deforestation also supports the raise of CO₂ emissions. Forest area which is drastically reduced every year diminish the earth's ability to process CO₂.

Table 1.
Pound of CO₂ Produced from Various Types of Fossil Fuels

No	Fuels	Pounds of CO ₂ Emitted per Million British Thermal Units (Btu) of Energy
1	Coal (anthracite)	228.6
2	Coal (bituminous)	205.7
3	Coal (lignite)	215.4
4	Coal (subbituminous)	214.3
5	Diesel fuel and heating oil	161.3
6	Gasoline(without ethanol)	157.2
7	Propane	139.0
8	Natural gas	117.0

Source: Energy Information and Administration (EIA) 2018

In the mission to reduce CO₂ emissions, several studies have been investigated the root of the problem that causes increased of CO₂ emissions in the world (for example, Zhu and Peng, 2012; Saboori and Sulaiman, 2013; Waluyo and Terawaki, 2016; Zhang and Tan, 2016; Zhou and Liu, 2016). These studies confirm that there are several factors triggered the increasing of CO₂ emissions in the various countries in the world. The consumption of fossil energy and economic growth are found as the most common factors causes the rising of CO₂ in various countries. In addition, population and FDI are also confirmed as an internal and external factor that triggers the increasing of CO₂ emissions in various countries.

Although many previous studies have confirmed that those variables contribute significantly to increase CO₂ emissions in various countries, references that exploring the case studies of Indonesia and Malaysia are still limited. In addition, most of the literatures only count total CO₂ emissions to measure the emission that are resulted from all type of energy sources. In other words, those studies do not analyze in detail how energy consumptions, economic growth, population and FDI, determine CO₂ emission resulted from the each sources of energy, namely, oil, coal, and natural gas.

Indonesia and Malaysia is interesting case study as both countries are experienced high economic growth. In addition, the increase of population and urbanization will stimulate the aggregate demand of the country, escalate total transactions and finally elevate the economic growth as confirmed by some studies conducted by Wang *et al.* (2016) and Ding *et al.* (2015). In addition, trade openness also escalates economic growth in a different way by encouraging export and import. Although there is a risk if the net import is greater than net export will make the deficit trade of balance, the trade openness basically still supports economic growth from the perspective of aggregate consumption (Ding *et al.*, 2015) All effort of government to increase those variables is basically to stimulate the economic growth which need the great consumption of energy. If Indonesian and Malaysian government seeks to realize a high economic growth with low levels of energy consumption, then the government should anticipate what will happen to some macroeconomic variables.

Therefore, the main objective of this study is to examine the effect of energy consumption, economic growth, population, and FDI to the disaggregate CO₂ emissions, namely, oil, coal and natural gas. EKC is also one of the objectives in this study. Finding the existence of EKC allows this study to identify which energy sources are most environmentally friendly and can reduce CO₂ emissions without hampering economic growth in both countries. The remaining of this study consists of literature review at section two, discusses the data and model methodology at section three, presents the empirical results at section four, and conclusion and policy implications are included in section five.

LITERATURE REVIEW

Energy Consumption and CO₂ Emission

Research and discussion on how the level of energy consumption affects CO₂ in the atmosphere has occurred in a long time. In general, the hypothesis reveals that increasing energy consumption is in line with the increase in CO₂ in the atmosphere, which also means that it is in line with the increasing damage to nature and climate change. This is because countries in the world still depend on fossil energy as the main fuel that produces large amounts of CO₂ such as coal and oil. This phenomenon occurs in several countries, especially developing countries, as stated by Alam *et al.* (2012) in his study on the relationship between energy consumption and CO₂ emissions in the case of Bangladesh. The study confirms that Bangladesh's economic growth relies heavily on energy consumption, especially electricity, which will then increase CO₂ emissions and air pollution. Even though electricity is environmentally friendly energy, power plants still use fossil fuels like coal and oil as the main fuel. The study advises Bangladesh to looking for alternative energy that is more environmentally friendly as the main fuel for electricity generation.

Alam *et al.* (2016) observed the case of India by using dynamic modeling confirmed that there is a strong relationship between energy consumption and economic growth in the long-run. The similar results of the study were also obtained by Wang *et al.* (2016) in the case of China, Shahbaz (2012) in the case of Portugal as well as Alkhatlan and Javid (2015) for the case of Saudi Arabia. Several studies have attempted to conduct comparative studies in several countries related to the issue of the relationship between energy consumption and CO₂ emissions. Acheampong (2018) informed in his study that increasing of carbon emission in the Middle East and North Africa (MENA) countries are positively caused by energy consumption especially oil. The result of Acheampong (2018) supported by the study conducted by Gorus and Aydin (2019) by using the different methodology that is panel frequency domain analysis.

Population and CO₂ Emissions

Population is one of the variables considered to contribute to the increase of CO₂ emissions in the atmosphere. High population growth, especially in developing countries such as India, China and Indonesia are considered to increase CO₂ emissions produced by the household sector (Zhang and Tan, 2016). This statement also strengthened by the study of Zhou and Liu (2016) in the case of China. High population growth causes increased CO₂ emissions both directly and indirectly. Directly, the population stimulates an increase in CO₂ emissions through burning fossil fuels in the transportation sector and household needs. The household sector needs fuel for daily needs such as cooking and water heating. In addition, the higher the population, the higher the transportation needs to support community mobility from one place to another place either near or far. The high household and transportation need of energy supply will increase CO₂ emissions directly and significantly. Although the household sector has used natural gas which produces less of CO₂, the transportation sector which needs more fuel is still dominated by fossil fuels, especially oil (Zhu and Peng, 2012). Indirectly, the population increases CO₂ emissions through the demand for electrical energy where the power plant uses fossil energy as the main fuel.

Populations increase CO₂ emissions through electricity and housing needs. The higher the population, the higher the need for household electricity used for lights, televisions, refrigerators and other household electrical appliances. According to the theory of economic development, one of the positive contents of a high population is it will stimulate high transactions and economic activities which will encourage high economic growth. But the high economic activity also requires a large supply of energy, especially electricity for lighting, air conditioning and others. Thus, in addition to the housing sector, electricity demand for offices needs also becomes large in line with high economic activity. The problem faced later is the high demand for electrical energy filled by power plants that use

fossil energy that is oil and coal as fuel. The power plants then produce large amounts of CO₂ along with the high demand for electrical energy from the public due to high population. Through this stage, the high population contributes to increasing CO₂ emissions indirectly (Begum *et al.*, 2015).

Foreign Direct Investment (FDI) and CO₂ Emissions

The relationships between FDI and carbon dioxide emissions have been a subject of debate in empirical and theoretical literature for the past two decades. Some studies claim that FDI does not cause CO₂ emissions while others state that FDI has a significant impact on CO₂. The impact of CO₂ emission by FDI, in this case, is more focused on the host-country, not home-country. There are two conflicting hypotheses related to the impact of FDI on the host country's environment which has been presented in the previous studies that are pollution haven hypothesis and the halo effect hypothesis. The halo effect hypothesis argues that foreign investors will bring many positive effects to the environment of host country (Albornoz *et al.*, 2009). It is because the multinational companies have more advanced and more environmentally friendly technologies that will be implemented in host country countries (Görg and Strobl, 2005). Meanwhile, the pollution haven hypothesis stated that multinational companies will tend to invest in countries with non-strict environmental regulations. This will make it easier for them to use the cheapest technology and fuel without having to consider the impact on the environment (Cole and Elliott, 2005). This strategy can endanger the environment in the host country if the problem is not taken seriously (Cole, Elliott and Fredriksson, 2006). This is supported by evidence that many foreign MNCs are relocating their industries from developed countries where environmental regulations are very strict towards developing countries with lax environmental regulations (Copeland and Taylor, 2004). Therefore, to answer the question of whether FDI can cause more emissions in the host countries, it depends on the MNCs motivations. The study conducted by Hassaballa (2014) has provided justification for using GHG emission variables, especially CO₂, as a proxy for general pollution. The study also indicated that CO₂ is a primary source of global warming. The variable also has a close relationship with local pollutants such as nitrogen oxide and Sulphur dioxide.

There is no doubt that developing countries need FDI to stimulate their economic growth. Developing countries, as host-countries, also become the main destination of developed countries, as home-countries, to invest. Therefore, studies that discuss the effect of FDI on the environment make developing countries as the main subject of the case studies. The studies conducted are based on the income of the country which grouped into low, middle and high-income countries in order to compare whether FDI only gives the impact to host countries (developing countries) or also there is some impact for the home countries

(developed countries). The study of Shao (2018) argues that FDI has proven to have a very large impact on host-countries than home-countries, especially in increasing environmental damage caused by CO₂. FDI is also indicated to cause environmental damage through investment in the manufacturing sector, while FDI non-manufacturing investment is not indicated to increase environmental damage in developing countries (Fauzel, 2017). FDI is also detected to have a very significant effect on CO₂ emissions in middle-income countries rather than in low-income countries. Investors tend to invest in middle-income countries due to infrastructure readiness as well as the stability of the economy and political condition (Hoffmann *et al.*, 2005).

Environmental Kuznet Curve (EKC)

The issue of EKC has been observed by many studies in the various study case countries. The latest study conducted by Gill, Viswanathan and Hassan (2018) concluded that too many resources are needed, and costs could not be absorbed to actualize the EKC. This study recommends the government to tighten fossil fuel consumption with taxes and increase alternative energy consumption. Meanwhile, Al-Mulali and Ozturk (2015) argue that EKC hypothesis only occurs for developed countries and not detected in developing countries. Meanwhile the study also claims that energy consumption, urbanization, and trade openness increase the environmental degradation for all countries case study. Balibey (2015) confirm the EKC in the case of Turkey but economic growth leads to environmental degradation. The study of Caviglia-Harris, Chambers and Kahn (2009) also found the evidence of EKC. Conversely, Ali *et al.* (2017) shows that the existence of EKC is not confirmed in Pakistan.

A Brief Literature from the Case of Indonesia

The studies related with EKC in the case of Indonesia have been analyzed by Waluyo and Terawaki (2016) which supports the existing of inverted-U relationship between carbon emission and GDP. Meanwhile, Santosa, Okuda and Tanaka (2008) argues that Indonesia is one of the largest energy fossil consumption country must actively encourage restrictions on fossil energy consumption in order to reduce the impact of global climate change. Indonesia is recognized as having enormous energy potential, both fossil and renewable energy, but this potential cannot be optimally implemented. Therefore, there is a need for cooperation between government and non-government institutions to promote renewable energy to achieve safe and environmentally friendly energy resources (Hasan, Mahlia and Nur, 2012). Shahbaz *et al.* (2013), identified that economic growth and energy consumption are proven to increase carbon emissions in Indonesia. This study also encourages the role of financial institutions and trade to contribute improving the quality of the environment. Meanwhile, Jafari, Othman and Nor (2012) explained that there is no relationship between economic

growth, carbon emissions and other variables. Therefore, the implementation of energy conservation policies is predicted not to have any significant impact to the macroeconomic activities in Indonesia.

A Brief Literature from the Case of Malaysia

Saboori and Sulaiman (2013) confirmed the absence of an inverted U-shaped relationship (EKC) in the case of Malaysia when used aggregate energy consumption. However, the EKC is confirmed when the study used disaggregate energy consumption, the study also supported by the study of Mugableh (2013). Some macroeconomic variables that is Foreign Direct Investment (FDI) and trade openness are included in the model by Lau, Choong and Eng (2014) to get more detail analysis. The study confirmed the existence of EKC between energy consumption and CO₂ emission in the short-run while in the long-run, the study also confirmed the EKC after including another two variables that is FDI and trade openness. Conversely, the EKC was not found in the study conducted by Azlina, Law and Mustapha (2014). Therefore, this study advises the government to reduce and limit fossil energy consumption strictly.

RESEARCH METHODS

Data and model

The current study uses secondary data in order to achieve the goal of the study and answer the questions of the research problem. The data are retrieved from World Development Indicator (WDI) – World Bank during the period 1960 to 2017. Some missing data during the observation period are interpolated by using trend analysis method.

The mathematical model uses to analyze the data for the case of Indonesia are as follow:

$$COOID_t = \alpha + OCID_t + GDPID_t + GDPID_t^2 + POPID_t + FDIID_t + \varepsilon_t \dots\dots\dots (1)$$

$$COCID_t = \beta + CCID_t + GDPID_t + GDPID_t^2 + POPID_t + FDIID_t + \varepsilon_t \dots\dots\dots (2)$$

$$COGID_t = \gamma + GCID_t + GDPID_t + GDPID_t^2 + POPID_t + FDIID_t + \varepsilon_t \dots\dots\dots (3)$$

While model for Malaysia are written as follow:

$$COOMY_t = \delta + OCMY_t + GDPMY_t + GDPMY_t^2 + POPMY_t + FDIMY_t + \varepsilon_t \dots\dots\dots (4)$$

$$COCMY_t = \varphi + OCMY_t + GDPMY_t + GDPMY_t^2 + POPMY_t + FDIMY_t + \varepsilon_t \dots\dots\dots (5)$$

$$COGMY_t = \theta + OCMY_t + GDPMY_t + GDPMY_t^2 + POPMY_t + FDIMY_t + \varepsilon_t \dots\dots\dots (6)$$

Where COOID is CO₂ emission from oil consumption of Indonesia; COOMY is CO₂ emission from oil consumption of Malaysia; COCID is CO₂ emission from coal consumption of Indonesia; COCMY is CO₂ emission from coal consumption of Malaysia; COGID is CO₂ emission from gas consumption of Indonesia; COGMY is CO₂ emission from gas consumption of Malaysia; OCID is oil consumption of Indonesia; OCMY is oil consumption of Malaysia;

CCID is coal consumption of Indonesia; CCMY is coal consumption of Malaysia; GCID is gas consumption of Indonesia; GCMY is gas consumption of Malaysia; GDPID is gross domestic product of Indonesia; GDPMY is gross domestic product of Malaysia; POPID is population of Indonesia; POPMY is population of Malaysia; FDIID is foreign direct investment of Indonesia; FDIMY is foreign direct investment of Malaysia. Descriptive statistic of the variables are presented in Table 2.

Table 2.
Descriptive Statistic

Variables	Min	Max	Mean	Std Dev	Variables	Min	Max	Mean	Std Dev
LCOOID	9.596	12.764	11.255	0.913	LCOOMY	3.977	5.066	4.521	0.328
LCOCID	5.203	12.755	8.978	2.376	LCOCMY	0.985	5.354	3.169	1.307
LCOGID	7.601	12.008	9.991	1.281	LCOGMY	1.326	5.746	3.536	1.353
LOCID	1.735	4.356	3.206	0.898	LOCMY	0.303	1.747	1.025	0.432
LCCID	0.041	4.157	1.534	1.523	LCCMY	4.954	8.298	6.631	1.161
LGCID	0.013	3.759	2.222	1.344	LGCMY	1.001	5.588	4.205	1.469
LGDPID	15.473	17.448	16.462	0.588	LGDPMY	3.639	4.627	4.135	0.292
LPOPID	18.246	19.421	18.926	0.341	LPOPMY	6.911	7.541	7.229	0.184
LFDIID	21.833	23.947	22.518	0.621	LFDIMY	7.973	10.179	9.118	0.721

The study employs ordinary least square as an analysis tools to examine the effect of energy consumption, economic growth, population, and FDI to the CO₂ emission in the case of Indonesia and Malaysia. A model in the OLS should fulfill some classical assumption to ensure that the model is valid and suitable for forecasting. The classical assumption consisting of the test of normality, heteroskedasticity, autocorrelation, and multicollinearity.

Unit Root Test

The regression of non-stationer time series data will result the spurious regression. It is the condition where a regression that does not reveal the truth, the independent variable seems to influence the dependent variable significantly, even though the relationship occurs only because the two variables have the same trend and the resulting regression becomes meaningless. Therefore, a model must be free of spurious regression before it is regressed by ensuring the absence of the unit root in the variable. Therefore, in the first step the stationery test procedure will be conducted to examine the stationary level of each variable.

Ordinary Least Square (OLS)

Ordinary least square is an approach to determine the effect of independent variables on the dependent variable. Ordinary least square method will produce the best estimate compared to other methods if all classical assumptions are met. Conversely, if the classical assumptions are not met will produce an invalid estimator. OLS method is estimates a regression line by finding a minimum value for the number of squares of error between the predicted value and

the reality value. OLS is a regression method that minimize the squared error. The linear regression model with OLS method should fulfill the classical assumption as known as best linear unbiased estimation (BLUE).

Classical Assumption

The first classical assumption is the normality test. Normality test is a statistical test conducted to find out how the distribution of the data. The classical assumption requires the residual of a model should be normally distributed before further analysis conducted. The test of normality can be done by using test of Jarque-Berra. The residual can be detected as normally distributed if the probability of Jarque-Berra is higher than $\alpha = 10\%$ and vice versa.

The second assumption that should be fulfilled by an OLS model is multicollinearity where there is a violation of OLS assumptions where there is a significant relationship between independent variables in a system of structural equations. The multicollinearity can be indicated slightly from the high value of determination coefficient (R^2) but many independent variables are not significant. While specifically, the multicollinearity can be detected by finding the correlation value between the independent variable and compare it with R^2 . The correlation value which is less than R^2 indicates that the variables is free from multicollinearity and vice versa.

The third classical assumption is heteroskedasticity, it is a condition where the error term variance of the model is always changing. Whereas OLS assumes an error term of a model must have a constant variance or called homoscedasticity. Detecting the heteroskedasticity in an OLS model can be done by conducting test of white heteroskedasticity (no cross term) if there is only one independent variable and test of white heteroskedasticity (cross term) if the independent variable is more than one. The assumption whether the error term is homoscedasticity or heteroscedasticity can be concluded by comparing the value of F test white heteroskedasticity. If the probability of F greater than $\alpha = 5\%$, it can be concluded that the error term is homoscedasticity. Otherwise, the error term will detect as heteroskedasticity.

The last assumption that should be fulfilled by a model of OLS is autocorrelation. This is a test to determine whether there is correlation between the residual of the t period with residual of t-1 period. Classical assumptions require no autocorrelation in the residuals of a model which means that the current residuals should not be influenced by previous residuals. The autocorrelation will cause the suspected parameters to be inefficient. The autocorrelation can be detected by comparing the Durbin Watson value with the Du DI value. The model will free from autocorrelation if the Durbin Watson value is between Du and 4-Du. In the case of autocorrelation found in the model, the ADF test of cointegration on residual can be done in

order to find the cointegration between the residual. When the cointegration exist between the residual, the existence of autocorrelation can be ignored, and the model is valid to be used as forecasting tools.

RESULTS AND DISCUSSION

Unit Root Test Result

The test of unit root shows that unit root exists for all variables in the level. Meaning that the variables are not stationer at level. However, all variables are shows stationer at the first difference. The result of unit root test at the level and first difference displays in the Table 3.

Classical Assumption Result

The data transformation conducted in the first step in order to change the measurement scale of original data into logarithm. In the logarithm form, all variables are in the elasticity form. Therefore, the coefficient number indicates the size of the effect of a variable to other variables.

Table 3.
Unit Root Test

Indonesia			Malaysia		
Variable	ADF Test		Variable	ADF Test	
COOID	0.440	0.000*	COOMY	0.294	0.000*
COCID	0.613	0.000*	COCMY	0.155	0.000*
COGID	0.485	0.000*	COGMY	0.457	0.000*
OCID	0.930	0.000*	OOCMY	0.631	0.000*
CCID	0.833	0.000*	CCMY	0.282	0.000*
GCID	0.270	0.000*	GOCMY	0.911	0.000*
GDPID	0.052	0.000*	GDCMY	0.640	0.000*
POPID	0.600	0.000*	POPMY	1.000	0.000*
FDIID	0.420	0.000*	FDIMY	0.144	0.000*

*denotes significant at 5% level of significant

The result of normality test shows that all model normally distributed. It is detected by the probability of Jarque-Berra which is higher than $\alpha = 10\%$. The result of normality test displays in the Table 4. The test of white heteroskedasticity shows that the probability of F is higher than $\alpha = 5\%$. The result of the test clarifies that the errors of all models are homoscedasticity. The result of white heteroskedasticity test are show at the Table 5. Furthermore, the result of correlation test for all model indicates that all correlation values are less than coefficient determination (R^2). The result concluded that multicollinearity assumption cannot found either for all models of Indonesia or Malaysia. The summary of multicollinearity test shows at the Table 6.

Table 4.
Normality Test

Country	Model	Normality Test	
		Probability (Jarque-berra)	Conclusion
Indonesia	Model 1	0.342*	Normal
	Model 2	0.558*	Normal
	Model 3	0.431*	Normal
Malaysia	Model 4	0.612*	Normal
	Model 5	0.870*	Normal
	Model 6	0.683*	Normal

$\alpha = 10\%$; *denotes probability higher then α and conclude that model normally distributed

Table 5.
Heteroscedasticity Test Result

Country	Model	Autocorrelation Test	
		Prob. (F White test)	Conclusion
Indonesia	Model 1	0.3566*	Homoscedasticity
	Model 2	0.6239*	Homoscedasticity
	Model 3	0.9896*	Homoscedasticity
Malaysia	Model 4	0.4581*	Homoscedasticity
	Model 5	0.6064*	Homoscedasticity
	Model 6	0.4422*	Homoscedasticity

$\alpha = 5\%$; *denotes probability higher then α and indicates that the error term is homoscedasticity

Table 6.
Summary of Multicollinearity Test

Country	Model	Multicollinearity Test	
		R-Square	Conclusion
Indonesia	Model 1	0.97979	Free multicollinearity
	Model 2	0.97555	Free multicollinearity
	Model 3	0.98384	Free multicollinearity
Malaysia	Model 4	0.98327	Free multicollinearity
	Model 5	0.98465	Free multicollinearity
	Model 6	0.86778	Free multicollinearity

The last assumption is the test of autocorrelation. The OLS assumption requires there is no autocorrelation in the residual of a model. The value of Durbin-Watson for all models are near to zero. Therefore, the results conclude that the model contains of positive autocorrelation. The result of autocorrelation displays in the Table 7.

Table 7.
Autocorrelation Test

Country	Model	Autocorrelation Test	
		D-W	Conclusion
Indonesia	Model 1	0.8200	Positive Correlation
	Model 2	1.1006	Positive Correlation
	Model 3	0.8059	Positive Correlation
Malaysia	Model 4	0.8200	Positive Correlation
	Model 5	1.1007	Positive Correlation
	Model 6	0.8060	Positive Correlation

Due to the model contain of autocorrelation, therefore the ADF test of cointegration on the residual should be performed in order to find the cointegration in the residual. The results of ADF test of cointegration on the residual reveals that the cointegration found for all models, meaning that the autocorrelation can be ignored, and the model is valid for forecasting tools.

Table 8.
ADF Cointegration Test on Residual

Country	Model	Cointegration Test	
		Prob.	Conclusion
Indonesia	Model 1	0.3566*	Cointegrated
	Model 2	0.6239*	Cointegrated
	Model 3	0.9896*	Cointegrated
Malaysia	Model 4	0.4581*	Cointegrated
	Model 5	0.6064*	Cointegrated
	Model 6	0.4422*	Cointegrated

$\alpha = 5\%$, *indicates significant value at 5% level of significant and cointegration found.

Regression Result

The result of regression displays in Table 9. All independent variables in the system are found has positive impact to the CO₂ emission, it means that the increasing of all variables contributes to increase CO₂ emission and then damage the environmental in both countries. Economic growth gives the most contribution to the increasing of CO₂ emissions from oil and natural gas in both countries. This is because the two countries rely heavily on fossil fuels as an economic drive.

Meanwhile, the CO₂ emission sourced from coal is mostly affected by population in the both countries. It is because the high demand of electricity is fulfilled by the government through electric steam power plant which use coal as the fuel. Economic growth also contributes to the CO₂ emission sourced from coal consumption but with lower impact. The EKC hypothesis are found in the model of natural gas consumption of both countries. Based on the EKC hypothesis, consuming natural gas will bring the economics of both countries keep growing

and at the certain level the CO₂ emission will decrease gradually. The results reflect that natural gas is the most profitable energy sources compared with other fossil energy such as oil and coal. Therefore, consuming natural gas will realize the green economic growth of both countries.

Table 9.
Regression Result

Indonesia	C	LOCID	LCCID	LGCID	LGDPID	LGDPID ²	LPOPID	LFDIID
LCOOID	10.976* [30.933]	0.269* [6.957]	-	-	10.409* [13.722]	0.285* [15.389]	1.363* [12.000]	0.100* [17.430]
LCOCID	75.490* [10.098]	-	0.990* [38.371]	-	3.555* [3.545]	0.082* [8.053]	4.049* [10.062]	0.159* [13.013]
LCOGID	14.419* [5.105]	-	-	0.328* [2.601]	14.441* [3.943]	-0.404* [-3.856]	1.328* [3.477]	0.144* [1.945]
Malaysia	C	LOCMY	LCCMY	LGCMY	LGDPMY	LGDPMY ²	LPOPMY	LFDIMY
LCOOMY	4.061* [41.250]	0.306* [12.381]	-	-	0.721* [8.670]	0.143* [7.510]	0.025* [6.623]	0.094* [10.931]
LCOCMY	39.373* [21.359]	-	0.374* [11.198]	-	0.800* [4.901]	0.196* [5.101]	5.338* [19.870]	0.161* [3.633]
LCOGMY	9.285* [2.181]	-	-	0.341* [19.805]	12.109* [81.550]	-0.887* [-15.995]	3.233* [4.369]	0.139* [2.670]

*denotes significant at 5% level of significant

The analysis is conducted in multivariate setting by employing time series technique. Apart of looking at the aggregate energy consumption, the analysis also examines to various type of energy consumption by conducting a separate analysis for each types of energy. In other word, the paper provides both the aggregate and disaggregates perspective on the energy consumption in Malaysia. From the aggregate perspective, we find significant relations between energy consumption and other variables namely, real GDP, urbanization, population and trade openness. Real GDP has positive impact to energy consumption in the long run and further supported with the evidence from Granger causality test. Urbanization, trade openness and population also have significant impact on both aggregate and disaggregate energy consumption. However, in the short run, trade openness only significant for coal and gas energy.

Focusing on the magnitude of the long run coefficient, we note that oil is the variable that mainly affected by the increase of real GDP, while gas energy is the type energy that the least impacted by change in GDP. The condition reflects that Malaysia's and Indonesia's economic growth rely on the supply of oil in large amount and increase every year. The failure of the government to manage the supply of oil could slow down the economic growth of both countries. This is very important to note by the government given that the

production of oil tend to decrease since 2004 and even the amount of oil consumption exceeds the production in 2011. Oil consumption continues to increase while oil production continues to decline until 2013. Although after 2013, oil production begins to increase until 2017, the level of oil production is still lower than the level of oil consumption. Therefore, the government must increase oil production to support economic growth to avoid negative growth.

In addition, gas as the least affected variable by the change of GDP indicates that the contribution of gas to the economic growth is still small compared to oil and coal consumption. However, to reduce the environmental damage and the emissions of carbon dioxide, the government should maximize the use of gas as the main fuel in all economic and household activity and subsequently projected to replace oil and coal and believe as more environmentally friendly source of energy.

However, if we look at the impact of population growth on energy consumption, gas is the type of energy that most affected by the increase of population in Malaysia and Indonesia. It is in line with the fact that gas is the main energy source of the household especially for cooking purposes. Another finding mentions that the increase in urbanization will affect mostly on oil consumption. This phenomenon is also in line with the condition that the urbanization occurred because the residents moved to the city to work. The high level of employment needs in turn will increase the need for transportations for workers and then rise the needs of oil as the main fuel of transportation. The final statement of this study concludes that fossil energy, oil, coal and gas, are still of the main factors which affect the economic growth. In addition, other macroeconomic variable particularly population and urbanization also affect the energy consumption. Therefore, government should maintain energy supplies to fulfill the needs of people as well as support economic growth at the high level. We believe that these findings are important for policy makers to ensure the energy security in the country.

CONCLUSION

The main objective of this study is to empirically analyze the effect of several macroeconomic variables to the increasing of CO₂ emission in the case of Indonesia dan Malaysia. The macro economy variables consist of energy consumption and economic growth as the main variables, population as internal factor and FDI as internal factor. In addition, the study also tries to find the existing of EKC hypothesis in the model. The main contribution of the study is through the introduction of disaggregate energy consumption and disaggregate CO₂ emission which classified by the fossil energy sources.

The study employs ordinary least square as the methodology in order to analyze the contribution of several macro economy variables to the disaggregate CO₂ emission and previously preceded by test of classical assumption and ADF unit root test. The ADF cointegration test of residual also conducted in order to find the cointegration in the residual. The results of ADF unit root test confirm that all variables are stationer at first difference. The test of classical assumptions conclude that all models are fulfilled all classical assumption except the test autocorrelation where shows that all models are contain of autocorrelation. However, as the ADF test confirm the existing of cointegration at the residual, the present of autocorrelation can be ignored, and the possibility of spurious regression can be avoided. The result of classical assumption concludes that the models are valid for use as forecasting tools.

The regression result of all model shows that all macro economy variables affects positively to the all type of disaggregate CO₂ emission. GDP is the variable with greatest contribution to the increasing of CO₂ emissions from oil and natural gas in Indonesia and Malaysia. While CO₂ emissions from coal are mostly affected by the population in both countries, this is due to the high demand of electricity especially for household sector, fulfilled by governments through power plants that use coal as fuel. In addition, the EKC hypothesis are found in the model of natural gas consumption for both countries. It means that if both countries prioritize natural gas as the main fuel, at the certain level the CO₂ emission will decrease gradually while economy will keep growing. In addition, natural gas is the most profitable fuel because consuming natural gas will increase the environmental quality and predicted can create the green sustainable economic growth.

This study provides policy recommendations to both countries based on the results of this study. Related to the energy consumption and economic growth, the study suggests the governments in both countries to implement green economic growth. This can be realized if the government in both countries prioritize natural gas as the main fuel either for transportation sector or electricity generation. In addition, the study also advises to the governments of the two countries to control the population. The population is needed to stimulate economic growth, however the high population potentially increase the demand for energy, living place, and transportation. Therefore, the population in the ideal level is needed to keep economic growth and minimize the environmental damage by reducing the demand of energy. Lastly, the current study recommends the governments to realize the green investment by making regulation to the factories to use the environmentally friendly fuel, minimizing the deforestation while constructing the plants, and encourage the company to minimize the use of electricity.

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