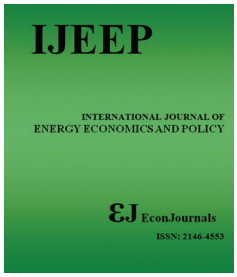

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Energy Consumption, Carbon Emissions and Economic Growth in Indonesia and Malaysia

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ABSTRACT

The main objective of this study is to examine the relationship between energy consumption, carbon emission and economic growth in the case of Indonesia and Malaysia. As every type of energy may has different impact on carbon emission and economic growth, the aggregate and disaggregate energy consumption are applied in the analysis. For the model of aggregate energy consumption, this study employs total energy consumption per capita and CO_2 emission per capita based on the total of energy consumption. Meanwhile, the disaggregate models use derivatives of variable energy consumption, namely, oil, coal, and gas. Some methodologies of econometrics such as unit root, cointegration, Granger causality, and error correction model are employed in the analysis. The short and long-run relationship are exist in both countries, the increase in aggregate consumption of energy source will increase produce CO_2 emission, while the increase in income also leads to the increase of CO_2 emission. Moreover, gas consumption is less polluting compared with other source of energy. In addition, there is a negative relationship between income and carbon emission which indicate that the carbon emission can be reduced by using gas as source of energy without preventing economic growth.

Keywords: Carbon Emission, Oil, Coal, Gas, Energy Consumption, Gross Domestic Product
JEL Classifications: K32, P18, Q43, Q48

1. INTRODUCTION

In the last few decades, environmental damage is increasingly threatening the lives of all living things on earth. The cases like natural damage, greenhouse effect and pollution are some of the factors that play an important role in contributing to environmental damage (Salahuddin and Alam, 2015). Among greenhouse gases, CO_2 contributes the greatest portion with 60% of total greenhouse gases. The CO_2 is mostly produced by energy consumption in factories, transportation, and households. Energy is the engine for industrial development and the trigger of economic growth. Energy is also the engine of the industry and all economic activity, thus it is definitely clear that to achieve the high industrial production which will trigger the high economic growth, a country needs to consume energy in the great amount. However, the large amount of energy consumption particularly fossil energy produce CO_2 as large as the fossil energy consumed and adversely affects the environment (Mercan and Karakaya, 2015).

Several studies have shown that the relationship between energy consumption and environmental pollution follows an inverted U-shaped pattern, which is commonly known as the environmental Kuznets curve (EKC) (Hao et al., 2015). The hypothesis argues that at the beginning of development, environmental degradation and pollution will increase. However, at a certain level of income per capita, the trend will reverse and the increasing economic growth will lead to environmental improvement. Several studies have shown that high economic growth also requires a large level of energy consumption. However, because the world is still heavily dependent on fossil energy that is not environmentally friendly high energy

consumption also causes high carbon emissions that adversely affect the environment and ultimately lead to global warming and climate change that threatens the survival of life on earth.

This issue has become a worldwide concern. The UN has taken action to prevent the ongoing destruction of nature, one of them by way of Kyoto Protocol declaration that has been agreed by almost all countries in the world. This declaration requires commitment from countries around the world to jointly reduce the greenhouse effect by reducing CO_2 emissions. Therefore, as one of the largest countries in Asia, Indonesian and Malaysian should be involved in the program to promote sustainable development while fighting climate change (Fatai et al., 2004).

Indonesia and Malaysia are the oil-based economies where almost all economic sectors like industry, transportation until house-hold activity rely on fossil energy generally and oil energy particularly (Azam et al., 2015). Therefore, this study aims to predict the existence of EKC in Indonesia and Malaysia. As two developing countries in Asia and have the vision to transform into a developed country with a high level of fossil energy consumption, it is important to know that if Indonesia and Malaysia become developed countries with high economic growth, does the consumption of fossil energy that causes environmental damage will decrease gradually in-line with EKC or even the existence of EKC does not exist and economic growth will cause worse natural damage (Lean and Smyth, 2010).

This study chooses Indonesia and Malaysia as the case study based on the reality that both countries experienced a rapid increase in energy consumption and carbon emission in the past few decades as a consequence of the high industrial and economic growth. The policy that should be taken by both governments to protect the environment by preserving the energy resources has important implications for the sustainable development of the countries. Some previous literature advises that any policy to increase economic growth should consider the dynamic nature of the relationships among energy, the environment, and growth and should have a long-run vision. Therefore, understanding the nature and dynamic relationship between economic growth, energy consumption and carbon emission are very important to produce the effective policy.

There is no country-level study in the case of Indonesia and Malaysia which focuses on the aggregate and disaggregates analysis of energy consumption, economic growth and carbon emission. Therefore, the main purpose of this study is to evaluate the relationship between energy consumption for aggregate and disaggregate economic growth and carbon emission as well as the existence of the EKC in the case of Indonesia and Malaysia. From the perspective of aggregate analysis, this study employs total energy consumption per capita, CO_2 emission and economic growth. Meanwhile, for disaggregate energy consumption, this study employ three main fossil energies namely oil, coal and gas with CO_2 emission and economic growth. The analysis finally will try to conclude whether the two countries can achieve their goal in realizing the sustainable economic growth but environmentally friendly.

The remainder of this study is organized as follows. Section two discusses a brief literature review on the relationship among economic growth, carbon emissions and energy consumption. Section three discusses the data and model methodology used in this study. Section four presents the empirical results, while conclusion and policy implications are included in section five.

2. LITERATURE REVIEWS

In the last few decades, the study of the relationship between energy consumption, economic growth, and environmental pollution has grown enormously. This chapter will describe previous literature studies along with its growth stages and scope of study. The first segment discusses the studies which investigate the relationship between energy consumption end economic growths. These studies exhibit that there is a significant relationship between energy consumption and economic growth as the high economic growth requires greater energy consumption. The studies in this area also discussed the impact of the implementation of energy conservation policy by using cointegration and granger causality methodology.

The literatures concern about the causality between energy consumption and economic growth presents four different results. The first result is when the unidirectional causal relationship running from energy consumption to economic growth which also known as growth hypothesis. There some study which support this hypothesis among others for the case of Croatia (Borozan, 2013), Greece (Dergiades et al., 2013) and China (Wang et al., 2011). The second result presents if there is unidirectional causal relationship running from economic growth to energy consumption, this condition called as a conservation hypothesis. This hypothesis argues that in this condition, the economic growth of the country is not depending on energy consumption. Some literature review which in-line with this result was conducted by Azis (2011) for Malaysia and Ocal and Aslan (2013) for Turkey. The remaining two hypothesis clarify the bidirectional and no causality between the variables and namely as feedback and neutrality hypothesis respectively. The feedback hypothesis argues that two causality running between energy consumption and economic growth while neutrality argues that there is no causality running between the variables. Some literature showing results of feedback hypothesis conducted by Zhang (2011) and Balibey (2015) while Payne (2009), Shaari et al. (2012) were conducted the studies with neutrality hypothesis result.

The second segment of the literature focused on the studies discussed the nexus between environmental pollution and economic growth. The studies in this area involved the investigation about the existence of EKC. The issue of EKC was first initiated and tested by Grossman and Krueger (1991) in the case of USA and then some studies also provided extensive review surveys related with the issues of EKC among others Kivyiro and Arminen (2014), Al-Mulali et al. (2016b), and Jammazi and Aloui (2015).

The third segment of the literature is the mix approach of the two methods. These studies investigate the dynamic relationship between energy consumption, economic growth and environmental pollution. Several studies related to this topic among others

conducted by Shahbaz et al. (2016), Saidi and Hammami (2015), Al-Mulali et al. (2016a), and Wang et al. (2016).

In the previous literature, the relationship between CO_2 emissions and energy consumption was also associated with several macroeconomic variables such as foreign direct investment (FDI) and confirm that FDI as one of variable that affects positively to CO_2 emission (Balibey, 2015; Hong et al., 2017). Contradictory opinions are shown in the Turkish case where Bozkurt and Akan (2014) concluded energy consumption and economic growth have a positive impact on CO_2 emissions while Magazzino (2016) argues that there is no causal relationship between energy consumption, economic growth and CO_2 emissions. The empirical literature of Indonesia concluded the neutrality hypothesis where oil and gas do not contribute significantly to economic growth as well as CO_2 emission (Bimanatya and Widodo, 2018; Nugraha and Osman, 2019). Energy consumption and economic growth were identified to affect CO_2 in Malaysia especially in the long-run (Tan and Tan, 2015) and mostly contributed by the transportation sector (Mustapa and Bekhet, 2015).

3. DATA AND METHODOLOGY

3.1. Data and Model

This study employs annual time series data of Indonesia and Malaysia from 1971 to 2014. The data of oil (tones), gas and coal (million tons of oil equivalent) consumption for Indonesia and Malaysia are retrieved from British petroleum statistical review 2017. Meanwhile, data for total energy consumption (kg of oil equivalent per capita), gross domestic product (GDP) (constant local currency unit) as the reflection of economic growth, total CO_2 emission (metric tons per capita), CO_2 emission from oil, coal and gas (kilo tones) of Malaysia and Indonesia are sourced from World Development Indicators – World Bank 2017.

The model in this study consists of two approaches: Aggregate and disaggregate, that are differentiated by the type of energy consumption variable and CO_2 emission source. The model for aggregate approach of Indonesia and Malaysia are as follows:

$$IDCOT_t = \alpha_0+\alpha_1 IDEC_t+\alpha_2 IDGDP_t+\varepsilon_t \quad (1)$$

$$MYCOT_t = \beta_0+\beta_1 MYEC_t+\beta_2 MYGDP_t+\varepsilon_{2t} \quad (2)$$

Where COT_t is a total CO_2 emission metric ton per capita, EC_t is total energy fossil consumption, GDP_t is the GDP and ε_t is error term. The characters of *ID* and *MY* reflect the countries that are Indonesia and Malaysia respectively. Afterward, to evaluate the separate effect of these types of energy consumption on economic growth and CO_2 emissions and on the basis of Eq. (1) and (2), this study employ the disaggregates model of total energy consumption into oil, coal and gas consumption along with their respective CO_2 emissions as follows.

a. The model for oil consumption in Indonesia and Malaysia is as follows:

$$IDCOO_t = \gamma_0+\gamma_1 IDOIL_t+\gamma_2 IDGDP_t+\varepsilon_{3t} \quad (3)$$

$$MYCOO_t = \delta_0+\delta_1 MYOIL_t+\beta_2 MYGDP_t+\varepsilon_{4t} \quad (4)$$

Where $IDCOO_t$ is CO_2 emission per capita from the consumption of oil of Indonesia, $IDOIL_t$ is per capita oil consumption of Indonesia, $IDGDP_t$ is economic growth of Indonesia and ε_{3t} is the error term. $MYCOO_t$ is CO_2 emission per capita from the consumption of oil of Malaysia, $MYOIL_t$ is per capita oil consumption of Malaysia, $MYGDP_t$ is economic growth of Malaysia and ε_{4t} is the error term.

b. The model for coal consumption in Indonesia and Malaysia is as follows:

$$IDCOC_t = \eta_0+\eta_1 IDCOAL_t+\eta_2 IDGDP_t+\varepsilon_{5t} \quad (5)$$

$$MYCOC_t = \gamma_0+\gamma_1 MYCOAL_t+\gamma_2 MYGDP_t+\varepsilon_{6t} \quad (6)$$

Where $IDCOC_t$ is CO_2 emission per capita from the consumption of coal of Indonesia, $IDCOAL_t$ is the per capita coal consumption of Indonesia and ε_{5t} is the error term. $MYCOC_t$ is CO_2 emission per capita from the consumption of coal of Malaysia, $MYCOAL_t$ is the per capita coal consumption of Malaysia and ε_{6t} is the error term.

c. The model for gas consumption in Indonesia and Malaysia is as follows:

$$IDCOG_t = \theta_0+\theta_1 IDGAS_t+\theta_2 IDGDP_t+\varepsilon_{7t} \quad (7)$$

$$MYCOG_t = \rho_0+\rho_1 MYGAS_t+\rho_2 MYGDP_t+\varepsilon_{8t} \quad (8)$$

Where $IDCOG_t$ is CO_2 emission per capita from the consumption of gas of Indonesia, $IDGAS_t$ is per capita gas consumption of Indonesia and ε_{7t} is the error term. $MYCOG_t$ is CO_2 emission per capita from the consumption of gas of Malaysia, $MYGAS_t$ is per capita gas consumption of Malaysia and ε_{8t} is the error term. The next sub-chapter will explain some methodology use in this study.

3.2. Methodology

The data used in this study is the annual time series data. Generally, the time series data is not stationer at the level. If this happens, then the stationer condition can only be realized by differentiating the data one or even 2 times. If the time series data is stationer at the level, it is called as integrated of order zero or I (0). In another case, if the data is stationer at the first-difference level, then it is called as integrated of order one or I (1). The analysis using ordinary least square (OLS) can only be conducted if all of data is stationer, either the dependent or independent data. Therefore, if the OLS analysis technique is employed using non-stationer data either one or all of the data, then the phenomenon of spurious regression will occur.

Before conducting regression analysis using time-series data, the test of stationary should be conducted for all variables involved in the system to ensure whether the variables are stationer or not. This test is conducted using unit root test to find whether the unit root exists in the data or not. The presence of the unit root in the data indicates that the data is not stationer and vice versa. Determination of integration ordo is also performing by using unit root test to ensure how many times the data should be differentiated. There are several methodologies to test the presence of unit root, the two most popular methodologies that

are currently widely used are Dickey–Fuller and Phillips–Perron (PP) unit root test. The illustration of Dickey–Fuller unit root test is by following the process of autoregression of first order auto regressive (AR) (1) as follow:

$$y_t = \rho y_{t-1} + \mu_t \qquad -1<\rho<1 \tag{9}$$

Where μ_t is a white noise. In the case of unit root, if the $\rho = 1$ then Eq. (9) is become a random walk model without drift which as known as a non-stationary process. If the absolute value of ρ is more than one, then the series of y_t is become explosive. In order to make a stationary series become possible, then the absolute value of ρ should be less than one. By deducting y_{t-1} at both side of the equation, then the above equation can be written as follow:

$$y_t - y_{t-1} = \rho y_{t-1} - y_{t-1} + \mu_t$$

$$= (\rho - 1)\, y_{t-1} + \mu_t \quad \text{Or it can be written as}$$

$$\Delta y_t = \delta y_{t-1} + \mu_t \tag{10}$$

Where $\delta = \rho - 1$ and Δ are the representation of first-order AR process. The test of unit root by using Dickey–Fuller test is the test of hypothesis H_0 and H_1. The detail hypothesis is as follow:

a. Zero hypothesis: H_0: $\delta = 0$ meaning that there is a unit root or the time-series data is not stationer.
b. Alternative hypothesis: H_1: $\delta < 1$ meaning that there is no a unit root or the time-series data is stationer.

The result of Dickey–Fuller unit root test then should be compared with critical value if McKinnon on the 1%, 5% and 10% level of significant. If the t-statistics value if larger than t–table value, then H_0 hypothesis is rejected and meaning that data is stationer. On the contrary, if the result is accept H_0 hypothesis, meaning that the data is not stationer.

The test of Dickey–Fuller is assumed that the error term is not correlated μ_t. However, there is a condition where the error term μ_t is correlated. To cover this condition, Dickey–Fuller also prepared another test namely Augmented Dickey–Fuller (ADF) test. Specifically, the equation of ADF test can be written as follow:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta y_{t-i} + \varepsilon_t \tag{11}$$

Where ε_t is error term of white noise and

$\Delta y_{t-1} = (y_{t-1} - y_{t-2})$
$\Delta y_{t-2} = (y_{t-2} - y_{t-3})$ etc.

Another way to test the root unit is by using the PP method, this method is the expansion of the ADF method which allows the assumption of the error distribution. The ADF test assumes that the error is homogeny and independent. However, the PP test allows the error dependent and distributed heterogeneously or known as heteroskedasticity.

In addition, the difference between ADF and PP tests is in the ADF test, firstly we have to determine the lag to be used because the mistake in determining the lag will affect the test results. However, by using the PP test the mistake can be avoided because the lag has been determined based on the range of data. The last step for ADF and PP test is to compare the result of t-statistic value with the result of critical value in the 1%, 5% and 10% level of significance.

The concept of cointegration is basically to find out the presence of long–run equilibrium between the variables in the system. In many cases, the variables which are not stationer or following the random walk pattern at the level have a linear combination between the variables, this condition can also identify as stationary condition. In this case, it can be said that the variables are cointegrated. There are few tests which can be used to perform cointegration test that are Engle and Granger (1987), Johansen and Juselius (1990) and Johansen (1991).

The null hypothesis of cointegration test is declared that there is no cointegration between the variables while the alternative hypothesis indicates the presence of cointegration between the variables. The null hypothesis can be accepted if the critical value of 1%, 5% and 10% are larger than Trace Statistic or Max-Eigen Statistic. Otherwise, the hypothesis should be rejected if the critical value of 1%, 5% and 10% are lower than Trace Statistic or Max-Eigen Statistic which indicates the presence of cointegration between the variables.

The long-run elasticity of the model will be obtained from the coefficient of cointegration while short-run elasticity will be obtained from the coefficient of error correction model (ECM). ECM is a model used to correct the regression equation between variables that are not stationary individually to return to their equilibrium value in the long run, with the main condition being the existence of cointegration relationships among the constituent variables. Granger causality test will also performed in this study to measure the strength relationship between the variables as well as the direction of causality whether *X* cause *Y*, *Y* cause *X*, *X* and *Y* causing each other or there is no cause between *X* and *Y*. Mathematically, the equation of granger causality can be written as follows:

$$Y_t = \sum a_i Y_{t-i} \sum b_j X_{t-j} + v_t; X \to Y \text{ if } b_j > 0 \tag{12}$$

$$X_t = \sum a_i Y_{t-i} \sum b_j X_{t-j} + u_t; X \to Y \text{ if } b_j > 0 \tag{13}$$

4. EMPIRICAL RESULTS AND DISCUSSION

The first step of the methodology is to test the stationary through unit root test by using ADF and PP test.

The existence of unit root test indicates that the variable is not stationer and basic hypothesis can be rejected if the t-statistics value is higher than 1%, 5% or 10% critical value. Table 1 presents the result of ADF and PP test of stationary for the variables uses in the system in level and first difference and focus with trend and intercept assumption. According to the ADF and PP test at Table 1, the result shows the presence of unit root for almost all variables at the level except several variables which are already

stationer at level. However, the basic hypothesis can be rejected at the first difference level and indicates that all variables are stationer. Due to not all variables are stationer at the level, therefore the cointegration test should be performed to find out the long-run relationship between the variables. The present of cointegration confirm that variables are stationer and avoid from spurious regression.

The Johansen and Julius test of cointegration has been conducted in this study to find out the presence of long-run relationship between the variables in every system. Table 2 displays the Johansen-Juselius cointegration test results for eight systems. Based on the table, the test of cointegration for all models clearly reject the null hypothesis of there is no long-run relationship between the variables. It means that the cointegration exists for all system both in the case of Indonesia and Malaysia or for aggregate and disaggregate model.

The test of cointegration confirms the presence of long-run relationship between the variables and also indicates that there is Granger causality between the variables at least one direction. However, this test cannot predict which direction of causality. Therefore, the Granger causality test should be performed to indicate the direction of causality. Table 3 shows the result of the Granger causality test for all models of Indonesia and Malaysia. The result reveals that there are close causal relationships between the variables for all models in both countries.

The estimated short-run and long-run elasticity are reported in Tables 4 and 5 respectively. Some models are showing the significance value based on the t-statistic. The variables are indicated as significant if the t-statistics is higher than t-table.

There are five interesting finding appear from the empirical finding of short-run and long-run elasticity of the models. The first one is the long-run income elasticity estimates of per capita carbon emission is higher than the short-run income elasticity estimates of per capita carbon emission for all models of Indonesia and three of four model of Malaysia. This result designates that in the

Table 1: ADF and PP unit root test

Variable	ADF				PP			
	Level		1st Diff.		Level		1st Diff.	
	Intercept	Trend and intercept	Intercept	Trend and intercept	Intercept	Trend and intercept	Intercept	Trend and intercept
IDCOT	−2.42	−2.39	−7.31*	−7.22*	−2.37	−2.34	−7.45*	−7.35*
IDEC	−1.07	−1.26	−6.68	−6.74*	−1.13	−1.26	−6.70*	−6.80*
IDCOAL	1.79	−2.92	−10.93*	−11.82*	2.75	−2.96	−10.81*	−12.32*
IDCOC	−0.77	−1.58	−5.41*	−5.39*	−0.78	−1.86	−5.35*	−5.32*
IDCOG	−3.93*	−1.35	−10.01*	−11.98*	−3.02**	−0.95	−9.49*	−12.94*
IDCOO	−1.51	−3.54**	−6.90*	−6.98*	−2.07	−3.41***	−8.32*	−9.28*
IDGAS	−5.30*	−3.49	−4.02*	−5.37*	−5.85*	−1.39	−9.85*	−19.17*
IDGDP	−0.76	−2.54	−4.86*	−4.81*	−0.76	−2.19	−4.88*	−4.78*
IDOIL	−4.01*	−2.07	−5.22*	−6.62*	−4.19*	−2.08	−5.30*	−6.62*
MYCOT	−0.81	−2.02	−7.92*	−7.85*	−0.81	−2.10	−7.86*	−7.84*
MYEC	−1.10	−1.83	−6.93*	−7.03*	−1.64	−1.83	−7.14*	−9.91*
MYCOAL	1.80	−1.23	−4.48*	−5.09*	1.33	−1.28	−4.47*	−5.09*
MYCOC	−0.66	−3.24***	−10.47*	−10.49*	−0.55	−3.39***	−10.59*	−11.43*
MYCOG	−1.24	−1.23	−3.65*	−3.66**	−1.26	−1.69	−5.03*	−5.02*
MYCOO	0.96	−2.11	−8.09*	−8.02*	−0.94	−2.02	−8.09*	−8.02*
MYGAS	−1.26	−1.19	−6.61*	−6.76*	−1.69	−0.97	−6.66*	−11.47*
MYGDP	−1.60	−2.22	−5.62*	−5.70*	−1.56	−2.32	−5.62*	−5.70*
MYOIL	−2.27	−1.30	−5.79*	−6.19*	−2.19	−1.48	−5.89*	−6.21*

*.**.***denotes significant at 1%, 5% and 10% level of significant respectively. ADF: Augmented Dickey–Fuller, PP: Phillips–Perron

Table 2: Cointegration test result

Systems	Null hypothesis			Systems	Null hypothesis		
	None	At most 1	At most 2		None	At most 1	At most 2
(1) Aggregate energy consumption Indonesia				**(5) Aggregate energy consumption Malaysia**			
Trace	52.32*	13.12	2.32	Trace	33.53*	12.35	1.76
Max	39.20*	10.79	2.32	Max	21.17*	10.58	1.76
(2) Oil consumption Indonesia				**(6) Oil consumption Malaysia**			
Trace	75.52*	24.60*	5.07*	Trace	52.06*	13.97	3.78
Max	50.91*	19.53*	5.07*	Max	38.08*	10.19	3.78
(3) Coal consumption Indonesia				**(7) Coal consumption Malaysia**			
Trace	60.01*	13.26	3.81	Trace	47.14*	9.10	0.27
Max	46.74*	9.45	3.81	Max	38.03*	8.83	0.27
(4) Gas consumption Indonesia				**(8) Gas consumption Malaysia**			
Trace	57.54*	19.47*	4.78*	Trace	33.43*	11.02	0.81
Max	38.06*	14.69*	4.78*	Max	22.40*	10.21	0.81

The system lag order is selected based on SIC

Table 3: Granger causality

Indonesia				Malaysia			
Total energy consumption	**IDCOT**	**IDEC**	**IDGDP**	**Total energy consumption**	**MYCOT**	**MYEC**	**MYGDP**
IDCOT	–	0.96	0.42	MYCOT	–	0.68	0.08
IDEC	0.53	–	0.76	MYEC	0.09	–	0.60
IDGDP	0.04*	0.30	–	MYGDP	0.03*	0.01*	–
Oil consumption	**IDCOO**	**IDOIL**	**IDGDP**	**Oil consumption**	**MYCOO**	**MYOIL**	**MYGDP**
IDCOO	–	0.61	0.98	MYCOO	–	0.30	0.66
IDOIL	0.01*	–	0.66	MYOIL	0.03	–	0.66
IDGDP	0.01*	0.26	–	MYGDP	0.03*	0.46	–
Coal consumption	**IDCOC**	**IDCOAL**	**IDGDP**	**Coal consumption**	**MYCOC**	**MYCOAL**	**MYGDP**
IDCOC	–	0.01*	0.24	MYCOC	–	0.11	0.37
IDCOAL	0.82	–	0.19	MYCOAL	0.65	–	0.55
IDGDP	0.03*	0.02*	–	MYGDP	0.01*	0.04*	–
Gas consumption	**IDCOG**	**IDGAS**	**IDGDP**	**Gas consumption**	**MYCOG**	**MYGAS**	**MYGDP**
IDCOG	–	0.03*	0.28	MYCOG	–	0.62	0.45
IDGAS	0.01	–	0.98	MYGAS	0.03*	–	0.31
IDGDP	0.01*	0.20	–	MYGDP	0.24	0.65	–

*Indicates significance at 5% level of significant

Table 4: Short-run elasticity

Short-run elasticity	Indonesia				Malaysia			
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Total energy	0.27 [0.40]				1.49 [2.82]*			
Oil		1.53 [2.36]*				0.52 [2.89]*		
Coal			0.11 [0.43]				0.65 [1.09]	
Gas				–1.42 [–2.89]*				–0.51 [–2.05]*
GDP	1.57 [2.04]*	1.01 [2.76]*	0.44 [2.32]*	–0.39 [–2.41]*	0.76 [2.48]*	0.25 [2.36]*	2.94 [1.64]	–0.35 [–2.19]*

t-values are given in bracket [ ]. *denotes statistically significant at 5% level of significant. t-table=2.018, GDP: Gross domestic product

Table 5: Long-run elasticity

Long-run elasticity	Indonesia				Malaysia			
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Total energy	1.98 [4.92]*				0.28 [1.38]			
Oil		1.48 [5.77]*				2.56 [2.79]*		
Coal			1.56 [3.32]*				0.08 [0.46]	
Gas				–1.12 [–9.23]*				–1.54 [–5.60]*
GDP	1.67 [4.78]*	1.49 [3.70]*	3.21 [5.74]*	–1.15 [–2.60]*	0.87 [3.63]*	0.32 [2.05]*	4.44 [12.61]*	–1.85 [–2.58]*

T-values are given in bracket [ ]. *denotes statistically significant at 5% level of significant. t-table=2.018. GDP: Gross domestic product

long-run there is directly proportional relationship between carbon emission and per capita income in Indonesia and Malaysia which tend to increase continuously. Meaning that increasing of per capita income will lead the carbon emission. This result in-line with the condition of Indonesia and Malaysia as a country that still relies heavily on fossil fuels, especially oil as the main fuel in various sectors and fuel prices that are still subsidized by the government.

The second one is the long-run income elasticity is greater than the short-run income elasticity. This happens to all models in both countries except for coal model of Malaysia and indicates that the higher income the higher concentration of carbon emission. A proportionate relationship between income elasticity and carbon emissions would also lead to significant increases in natural damage in the long-run. In this condition, a strict government regulation is needed to anticipate the worsening of natural damage. Income as a reflection of economic growth is cannot be limited. Whereas, this variable is trigger the increasing of carbon emission. Therefore, what the government can do is to improve the things that can reduce carbon emissions without affecting income in the long-run. Such as reforestation, planting trees in the city and also planting mangrove forests.

The third one is the long-run and short-run elasticity estimates of per capita emission with respect to all sources of energy in the both countries are positive and statistically significant. This result reflects that the consumption of all energy produce carbon emission. Therefore, any increasing of all energy consumption will increase the carbon emission but with the different amount. The fourth one is that the long-run and short-run per capita elasticity estimates of per capita carbon emission with respect to per capita gas consumption are less than the long-run and short-run elasticity estimates of per capita carbon emission with respect to per capita oil, coal and gas consumption. Based on this result we can conclude that even gas also produce the carbon emission, but gas produce the lowest amount of carbon emission. Therefore it can be say that gas is less polluting than the other sources of energy.

The fifth one is one is that the short-run and long-run income elasticity of carbon emission are negative for gas model in both countries. This result implies that the economics of both countries can keep growing without increase the carbon emission. The condition is both countries must convert their fuel consumption from oil and coal to gas.

5. CONCLUSION AND POLICY IMPLICATION

The main objective of this paper is to evaluate the relationship between economic growth, carbon emission and energy consumption at the aggregate and disaggregate levels in the case of Indonesia and Malaysia during the period 1971–2015. For model disaggregate energy consumption, this study focus on the three main energies namely oil, coal and gas. This paper employed some econometrics techniques that are unit root, cointegration and granger causality as well as ECM model.

There are five main empirical findings from this study. Firstly, per capita income and carbon emission has directly proportional relationship for the both countries. This is shown by the empirical fact that long-run income elasticity estimates of per capita carbon emission is higher than the short-tern income elasticity estimates of per capita carbon emission for both countries. It means that the increasing of per capita income will lead to the increasing of per capita carbon emission. Secondly, the empirical result also shows that the higher income the higher concentration of carbon emissions in both countries. The third one is the consumption of all energy sources are produce carbon emission. However, the fourth finding indicates that the carbon emission produced by gas consumption is less than all carbon emission produced by other energy sources. The last finding shows that both countries can reduce the carbon emission by converting their energy consumption from oil and coal to gas. By doing this thing, the economy of both countries can keep growing while the carbon emission can be reduced.

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