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THE INFLUENCE OF ENERGY CONSUMPTION, RENEWABLE ENERGY AND ECONOMIC GROWTH ON CO_2 EMISSION IN MALAYSIA AND INDONESIA

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Abstract: The main objective of this study is to analyse linkages between carbon dioxide emissions, consumption of energy resources and economic growth in Malaysia and Indonesia between 1980 and 2011. With a motivation to recognize the potential effects of energy consumption and economic growth in driving the climate change pressure, it further aims to examine the Environmental Kuznet Curve hypothesis. Annual data over 1980-2011 period were used to examine the long-run relationship and the causality between the variables. The findings revealed the presence of long-run relationship among variables. In addition, analysis on causality tests suggests that there is a causality run from energy use to renewable energy in Malaysia. The results also provide evidence of causality running from renewable energy to carbon dioxide emissions and to economic growth in Indonesia. However, the results of the Environmental Kuznet Curve hypothesis show no evidence in favor to this hypothesis for both countries. The implication of this study is that in order to reduce emission without sacrificing economic growth, policies should be aimed at promoting renewable energy and energy efficiency.

Keywords: Carbon dioxide emissions, energy resources, economic growth, Environmental Kuznet Curve, sustainable consumption.

Introduction

It is widely recognized that energy resources are vital to the world's economic development. They are essential ingredients in most of the sectors of existing economies. Energy is demanded as one of the products that a consumer (individuals, households, producers or firms) decides to buy for utility maximization. For instance, energy provides the consumer with heat and electricity for lightning and domestic appliances in the residential sector, and to power manufacturing products in the industrial sector. Furthermore, energy is considered as important factor for production on top of other inputs such as labor, materials and capital (Stern, 2010). However, a negative outcome of energy consumption is the emission of carbon dioxide (CO_2) through mainly from industrial activities, economic growth and increase in the world population. To date, issues on increased level for CO_2 emissions are well discussed by most countries in the world because it has become a major contributor to the problem of climate change (Sebri & Ben-Salha, 2014, Al-Mulali *et al.,* 2013).

Economic growth in Association of Southeast Asian Nations (ASEAN) countries have been well progressing in recent years. Up to now, Singapore ranked the highest per capita income among the ASEAN countries, followed by Malaysia and Indonesia (World Bank, 2015). As a developing country, Malaysia has experienced outstanding growth in economic progress for the past three decades. As a leading exporter of commodities such as natural gas and palm oil in the world, economic activities in Malaysia are globalized and there is a connection between energy consumption and economic development that contribute to environmental problems, which can be translated to the emission of carbon dioxide. Besides, there are structural changes in the economy which is undergoing an economic transition from different sectors. For instance, a change from agriculture to industry sector, and then to services sector which served a significant role for emerging growth in energy consumption. The industry sector is the leading energy user compared to other sector and its energy consumption is very high indeed (Energy Information Administration, 2017). Therefore, industry sector contributes considerably to the CO_2 emissions. As reported by Carbon Dioxide Information Analysis Centre (2012), a statistics of CO_2 production in 2009 shows that Malaysia, with an estimate of 198,348 (Kt), ranked 24th from 188 countries in the world.

On another side, Indonesia, which is the most populous country in Southeast Asia, is also experiencing strong economic growth that has headed to a surge in the total energy consumption throughout the country (World Bank, 2014). International Energy Agency (2015) reported in 2014, Indonesia ranked at the 7th place as the largest exporter for natural gas and was the main exporter of coal in the world. Oil, gas, and coal are the three major resource wealth that contribute to domestic growth and foreign exchanges earning. Economic activities in Indonesia are also heavily dependent on energy consumption and this inevitably contributes to the CO_2 emissions. In 2008, CO_2 emission in Indonesia was reported at 406,028.58 (Kt) (World Bank, 2014). As a result of being seen as a major contributor of CO_2 emissions, Indonesia has committed to decrease the greenhouse gases (GHG) emissions ranging from 41% to 26% (Copenhagen Accord, 2009).

Energy use has been identified as one of the factors that contributes to the CO_2 emission which subsequently gives a negative impact to the environment. The dependency on fossil fuels in energy consumption is driving the continued rise in CO_2 emissions thus leading to climate change. As can be shown from Figure 1 and 2, there is an increasing trend of energy consumption for both countries. The figures also reveal that over time, CO_2 emissions increase continuously. In general, when energy consumption increases, CO_2 emissions increase dramatically. A rapid increase in energy use will increase CO_2 emissions which subsequently gives a negative impact to the environment. Prior studies have confirmed that energy use was associated to economic development and leads an upsurge in CO_2 emissions as evidenced by Jalil and Mahmud (2009) and Chang (2010) in the case of China; Ghosh (2010) in the case of India; Azlina and Nik Mustapha (2012), Chandran and Tang (2013), Begum *et al.* (2015) in the case of Malaysia; Chandran and Tan (2013) in the case of both China and India and Tang and Tan (2015) in the case of Vietnam.

Since economic development may have a contrary effect on the climate change in the long term, the negative impact on the burning of fossil fuel on the environment is slowly shifting the world economies towards using renewable energy (Jamaluddin *et al.,* 2013). In recent years, renewable energy, such as wind, hydropower, geothermal, biomass and solar have been used as alternatives for non-renewable energy resources. In fact, ASEAN countries as a whole are rich not only in fossil fuels which are not renewable such as coal, natural gas and petroleum but also the vast potential in renewable resources (Lidula *et al.,* 2006). Climate change concerns coupled with energy scarcity and an increasing cost of energy are strong impetus behind increased demand of global renewable energy resources. Renewable energy offers the opportunity for climate mitigation, contributing to sustainable development.

Over the past centuries, studies on the Environmental Kuznets Curve (EKC) revealed that environmental degradation occurs in tandem with economic growth. The EKC hypothesis suggests that in the early stages of economic growth degradation and pollution increases, but beyond a certain level of income per capita, which will vary for different indicators, the trend tend to reverse, so that at high income levels economic growth leads to environmental improvement (Stern, 2004). Current literature on EKC hypothesis shows that there are linkages between environmental degradation and economic growth. A previous study by Azam and Khan (2016) provided further support to the EKC hypothesis which proposed that in the event of increases in income, it will also results in increases in pollution up to a certain level and then decreases. In addition, the study by Jebli *et al.* (2016) provided more proof to the EKC hypothesis in which the findings supported the causal relationship between income and carbon dioxide emissions. In fact, the increase in energy consumption increases carbon dioxide emissions both in the short run and the long run. The extension study of economic growth-environmental pollution causality nexus and energy consumption-economic growth causality nexus has convinced economists to understand the role of economic growth and energy consumption in climate change. Therefore in this study, it is necessary to analyze EKC hypothesis between economic growth, energy consumption, CO_2 emissions and renewable energy to determine the effects of energy consumption, renewable energy, and economic growth on CO_2 emissions.

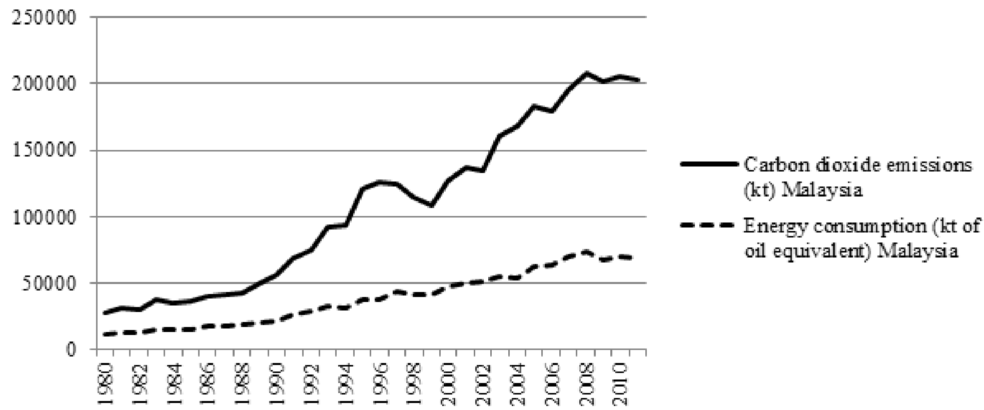

Figure 1: Carbon dioxide emissions per capita and energy consumption per capita in Malaysia, 1980-2011 (Source: World Bank, 2014)

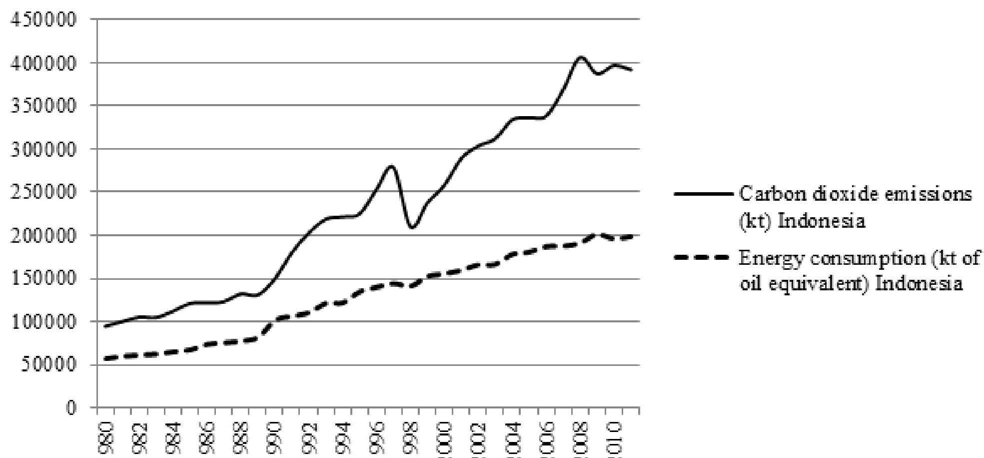

Figure 2: Carbon dioxide emissions per capita and energy consumption per capita in Indonesia, 1980-2011 (Source: World Bank, 2014)

Thus, this study refers to two major research problems as a motivation for investigating the empirical links between CO_2 emissions, energy resource consumption and economic growth. Firstly, as ASEAN has experienced spectacular economic development in recent years, then industrialization and services plays an essential role for the emerging development in energy consumption. Since Malaysia and Indonesia are developing countries in which most electricity sectors are particularly dependent on energy consumption such as electricity use; this sector contributes to the emission of greenhouse gas. As a consequence, due to the existence of causality between energy use and economic growth, the growing use of energy particularly affects economic growth while considerably contributes to environmental degradation. Hence, this study finds it is noteworthy to focus on causality between CO_2 emissions along with energy resource which comprise of renewable and non-renewable energy consumption and economic growth, given the fact that energy consumption is increasing with both economic growth and CO_2 emissions. So, as to assume the lower of CO_2 emissions was a result of increasing use of renewable sources, the current study considers the renewable energy consumption as one of the efforts to avoid environmental pollution. An analysis of renewable energy use and carbon dioxide emissions nexus proposes that the relationship between the two can either be a positive or a negative relationship. A positive relationship suggests the higher renewable energy use will increase the carbon dioxide emissions while a negative relationship indicates that the higher renewable energy use will lower the carbon dioxide emissions. Besides that, it is also essential to examine the EKC hypothesis because an increase in income per capita may have a significant contribution to environmental degradation. For that reason, testing EKC hypothesis is needed given the remarkable growth rate for these particular ASEAN countries. The findings are anticipated to provide an imperative reference in formulating long term energy policies.

Furthermore, with the growing concern about GHG emissions and climate change, a number of developing economies have started to explore the use of renewable energy as an alternative to the current energy sources and to reduce the environmental problem as well. In fact, countries in ASEAN region are richly endowed with renewable energy sources. Renewable energy sources are a good alternative for electricity generation in ASEAN region. ASEAN countries as a whole are rich in energy sources ranging from the oil reserved, natural gas, and coal to the large potential in renewable energy (Lidula *et al.,* 2006). Among the renewable energy sources available in the region are wind, hydro, and geothermal. Therefore, this study also takes a look at renewable energy use in the attempt to analyze the impact of renewable energy on carbon dioxide emission. This approach is of interest because most of previous literature still paid less attention to the renewable energy use as a variable that might affect the findings of this study.

The linkage between energy use and economic growth has attracted a considerable body of literature over the past century. This linkage is closely associated not only to analyze the causality between the two variables, but also helps to examine the existence of the EKC. In order to examine economic growth-energy consumption nexus, previous studies agreed to propose that there are four main hypotheses related to the nexus. First, is the 'Growth hypothesis' - the validity of this hypothesis is confirmed when causality is found to run from energy use to economic growth, which implies energy use is vital in economic development. In this situation, limitations on energy use could affect economic growth negatively. In contrast, an increase in energy use could provide benefits to the development of economics. Under this hypothesis, energy consumption plays as a controlling factor to economic development. Any shocks to the supply of energy will negatively correlated with economic development. The second hypothesis refers to 'Conservation hypothesis'. It refers to a situation where economic development contributes to energy use. It is valid if there is causality runs from economic development to energy use. Following this, a policy related to energy conservation may be executed with minimum effect on economic development. Concisely, it proposes an energy independent economy. Next is the 'Feedback hypothesis'. This hypothesis indicates a mutual relationship between economic development and energy use. The hypothesis is valid with the existence of bi-directional causality between energy use and economic development. In this regard, both variables are mutually determined and affected at the same period. For instance, reduction on economic growth may decrease energy consumption. Similarly, any changes in energy use will be transmitted to economic growth. Finally, 'Neutrality Hypothesis' is supported by the nonexistence of causality between energy use and economic development. It suggests that energy use does not affect economic development. Thus, neither conventional nor extensive policies which refer to energy use will have any influence on economic development.

Numerous empirical evidences support the growth hypothesis. This hypothesis exists in energy dependent countries as evidenced by Soytas and Sari (2003) in the case of Turkey, France, Japan and Germany, Lean and Smyth (2010) in the case of Indonesia, Malaysia, Philippines, Singapore and Thailand, Tsani (2010) in the case of Greece and Tiwari (2011) in the case of India. According to Lean and Smyth (2010), consumption of energy will results in direct and indirect effect. For instance, the direct effect of energy use from commercial and industrial sectors will generate economic growth at a higher rates, while higher consumption of electricity which a results from an increase in energy production, will generate indirect effect in energy services by creating employment and providing infrastructure.

Conversely, conservation hypothesis proposes that economic development causes energy use in one way causality. Previous studies have found the support for this hypothesis in less energy dependent economies as shown by Yoo (2006) in Thailand, Azlina *et al.* (2014), Azlina (2011) and Ang (2008) in Malaysia, Zhang and Cheng (2009) in China and Ozturk *et al.* (2010) for low income countries. According to Yoo (2006), economic development causes enlargement in main sectors such as commercial and industrial sectors. In these sectors, electricity consumption has increased because electricity served as major input in factories and large scale plants in the production process.

With respect to the feedback hypothesis, some of the evidence can be found in Chen *et al.* (2007), Ozturk *et al.* (2010) and Tang and Tan (2013). They found consistent evidence showing that when energy consumption increases, economic growth will increase while a rise in economic growth directs to an increasing dependence on energy consumption. In contrast, studies by Jobert and Karanfil (2007), Halicioglu (2009) and Soytas and Sari (2009) in Turkey and Payne (2009) in USA reported that energy use and economic development have not given an effect on each other significantly. Their findings proved that no relationship exists among energy use and economic development either in short or long run.

Methodology

Data

This study uses secondary data of carbon dioxide emissions, energy consumption, real GDP per capita and renewable energy extracted from the World Development Indicators 2014 database from World Bank (2014). The annual data covers the period from 1980 to 2011, which correspond to 32 years of data that were used in this study.

Tables 1 and 2 show the descriptive statistics of the variables used in the study. CO_2 emission in metric tonnes per capita ranges from 6.32 to 42.43 in the case of Malaysia and 0.65 to 1.90 in the case of Indonesia. In Malaysia, real gross domestic product ranges from US\$1,729.18 to US\$6,512.13 while in Indonesia, it ranges from US\$555.93 to US\$1,650.63. With regards to the energy consumption per capita, it ranges from 11,883.61 to 73,023.53 kilogram of oil equivalent in Malaysia, while in Indonesia, it is between 56,251 and 201,999. Finally, the renewable energy use ranges from 1,657.93 to 3,503.61 metric tonnes of oil equivalent in Malaysia and ranges from 0.651 to 1.902 in Indonesia.

Descriptive results showed a negatively skewed distribution between all the variables with skewness values at -0.2920, -0.2622, -0.1836, and -1.3508 respectively in the case of Malaysia. Skewness is a measure of asymmetry and describes the shape of the Probability Distribution Function. If the skewness value is positive, the probability distribution function is at right or positively skewed. If it is negative, it is at left or negatively skewed. All of the variables showed suitable kurtosis since the value is not larger than 3. Meanwhile, Jarque-Bera normality test showed that CO_2, energy consumption, GDP, and renewable energy are normally distributed. With respect to Indonesia, the descriptive results showed a positively and negatively skewed distribution between all the variables. The Jarque-Bera normality test also showed that CO_2, energy consumption, GDP, and renewable energy are normally distributed.

Table 1: Summary of descriptive statistics for each series (Malaysia)

Variable	Carbon dioxide emission (CO_2) (Metric tonnes per capita)	Income per capita (GDP) (2005 constant US$)	Energy consumption (EC) (Kilogram of oil equivalent)	Renewable energy consumption (RE) (Billion Kilowatt hours)
Mean	107934.7	3896.66	38446.48	2341.781
Median	111060.6	3813.18	37532.97	2375.000
Maximum	208267.3	6512.13	73023.53	2987.000
Minimum	27997.54	1729.18	11883.61	1606.000
Std. Dev.	62465.46	1474.77	20382.34	435.6944
Skewness	0.218384	0.2087	0.250282	-0.049170
Kurtosis	1.662677	1.6856	1.682823	1.828886
Jarque-Bera	2.638931	2.9320	2.647359	1.841572
Probability	0.267278	0.2308	0.266154	0.398206

Table 2: Summary of descriptive statistics for each series (Indonesia)

Variable	Carbon dioxide emission (CO_2) (Metric tonnes per capita)	Income per capita (GDP) (2005 constant US$)	Energy consumption (EC) (Kilogram of oil equivalent)	Renewable energy consumption (RE) (Billion Kilowatt hours)
Mean	1.172	1026.636	128919.3	1.171
Maximum	1.902	1650.629	201999.0	1.902
Minimum	0.65	555.927	56251.00	0.651
Std. Dev.	0.398	312.758	49787.27	0.398
Skewness	0.756100	0.514913	-0.430252	0.626283
Kurtosis	2.887311	2.154690	1.625602	1.878681
Jarque-Bera	3.065931	2.366785	3.505915	3.768371
Probability	0.215895	0.306238	0.173261	0.151953

Model Specification

Previous studies show that the EKC hypothesis has generally been used as a baseline estimate model where it is used to find out the relationship among numerous indicators of environmental problem and income per capita. This model can be formally represented as follows:

$$CO_{2_t} = \alpha + \alpha_1 GDP_t + \alpha_2 GDP^2{}_t + \varepsilon_t \quad (1)$$

Where *t*, and *ε* denote time and error term, respectively; CO_2 is per capita carbon dioxide emission, *GDP and* GDP^2 indicate real income per capita and the squared value of real income per capita, respectively.

In order for the EKC to be valid, one would expect α_1 is positive and α_2 is negative. The combination of these two effects (α_1>0α_2<0) will produce the inverted U-shaped relationships between CO_2 emissions per capita and real income per capita. To assess the impact of energy consumption and renewable energy use on CO_2 emissions, the new model for testing the EKC hypothesis can be shown as follow:

$$CO_{2_t} = \alpha + \alpha_1 GDP_t + \alpha_2 GDP^2{}_t + \alpha_3 EC_t + \alpha_4 RE_t + \varepsilon_t \quad (2)$$

In this analysis, we closely follow the methodology of Azlina *et al.* (2014) which adopted three nexus into a single multivariate framework, (i) economic growth - energy use nexus (ii) economic growth - CO_2 emissions nexus, and (iii) renewable energy - CO_2 emissions nexus. The following log quadratic EKC equation is used to study the impact of economic development and energy resources consumption on CO_2 emissions.

$$\ln CO_{2_t} = \alpha + \alpha_1 \ln GDP_t + \alpha_2 \ln GDP^2{}_t + \alpha_3 \ln EC_t + \alpha_4 \ln RE_t + \mu_t \quad (3)$$

Where, EC is per capita energy consumption and RE stands for renewable energy consumption. The residuals are assumed to be normally distributed and white noise. The sign of α_3 is expected to be positive and have been found to affect CO_2 emissions, as shown by Azlina *et al.* (2014). A positive association reflects higher level of energy consumption can enhance the scale of economy and as a consequence, more CO_2 emissions will be produced. The sign of α_4 is expected to be negative because the use of renewable energy resource does not contribute to environmental degradation and are favorable to environmental quality while their consumptions are not subject to exhaustion. A negative association reveals that renewable energy consumption can reduce the emissions level.

Estimation Method

Following the established procedure, the test of the causal relationship between the series is conducted in three stages. First, a test is carried out to ascertain the order of integration in all variables. The presence of unit roots that is when the series is non-stationary in their level form can be examined by applying the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests. As noted by Granger (1987), to make sure that the procedures of classical econometrics are applied appropriately, one must ensure that the variables of interest do not exhibit unit roots because using non-stationary data to conduct an analysis can lead to spurious results. Next, having established the order of integration in the series, the cointegration test developed by Johansen and Julius (1990) is carried out to investigate the existence of long run relationship between the variables. In the third step, the Vector Error Correction Model (VECM) is estimated to assess the direction of causality between the variables. The VECM equations are shown as follows:

$$\Delta \ln CO2_t = a_1 + \sum_{i=1}^{p} \beta\, 1i \Delta \ln CO2_{t-1} + \sum_{i=1}^{p} y\, 1i \Delta \ln GDP_{t-1} + \sum_{i=1}^{p} \delta\, 1i \Delta \ln GDP2_{t-1} + \sum_{i=1}^{p} \mu\, 1i \Delta \ln EC_{t-1} + \sum_{i=1}^{p} \pi\, 1i \Delta \ln RE_{t-1} + \lambda 1ECT_{t-1} + \varepsilon_{1t} \quad (4)$$

$$\Delta \ln GDP_t = a_1 + \sum_{i=1}^{p} \beta\, 2i \Delta \ln CO2_{t-1} + \sum_{i=1}^{p} y\, 2i \Delta \ln GDP_{t-1} + \sum_{i=1}^{p} \delta\, 2i \Delta \ln GDP2_{t-1} + \sum_{i=1}^{p} \mu\, 2i \Delta \ln EC_{t-1} + \sum_{i=1}^{p} \pi\, 2i \Delta \ln RE_{t-1} + \lambda 2ECT_{t-1} + \varepsilon_{2t} \quad (5)$$

$$\Delta \ln GDP2_t = a_1 + \sum_{i=1}^{p} \beta\, 3i \Delta \ln CO2_{t-1} + \sum_{i=1}^{p} y\, 3i \Delta \ln GDP_{t-1} + \sum_{i=1}^{p} \delta\, 3i \Delta \ln GDP2_{t-1} + \sum_{i=1}^{p} \mu\, 3i \Delta \ln EC_{t-1} + \sum_{i=1}^{p} \pi\, 3i \Delta \ln RE_{t-1} + \lambda 3ECT_{t-1} + \varepsilon_{3t} \quad (6)$$

$$\Delta \ln EC_t = a_1 + \sum_{i=1}^{p} \beta\, 4i \Delta \ln CO2_{t-1} + \sum_{i=1}^{p} y\, 4i \Delta \ln GDP_{t-1} + \sum_{i=1}^{p} \delta\, 4i \Delta \ln GDP2_{t-1} + \sum_{i=1}^{p} \mu\, 4i \Delta \ln EC_{t-1} + \sum_{i=1}^{p} \pi\, 4i \Delta \ln RE_{t-1} + \lambda 4ECT_{t-1} + \varepsilon_{4t} \quad (7)$$

$$\Delta \ln RE_t = a_1 + \sum_{i=1}^{p} \beta\, 5i \Delta \ln CO2_{t-1} + \sum_{i=1}^{p} y\, 5i \Delta \ln GDP_{t-1} + \sum_{i=1}^{p} \delta\, 5i \Delta \ln GDP2_{t-1} + \sum_{i=1}^{p} \mu\, 5i \Delta \ln EC_{t-1} + \sum_{i=1}^{p} \pi\, 5i \Delta \ln RE_{t-1} + \lambda 5ECT_{t-1} + \varepsilon_{5t} \quad (8)$$

Where symbol Δ indicates first difference, α_1 are intercepts and *p* is the lag lengths determined by the AIC statistics. The error term ($\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}, \varepsilon_{5t}$) are assumed to be sequentially independent with zero mean and fixed covariance matrix. The terms *ECT* are the error correction terms. The coefficients of *ECT* measure speeds of adjustments. These terms were derived from the long run cointegrating relationships. The VECM model was estimated with the variables in first differences and including the long run relationships as *ECT* terms in the system.

To detect the short run Granger causal relation between carbon dioxide emissions and its determinants, the F test was applied on the first difference of lagged independent variables. This test is based on the null hypothesis that there is no Granger causality. For instance, the test for Granger causality of economic growth (in equation (4)), is H01: $y1_i = 0$, which implies that economic growth does not cause carbon dioxide emissions. Therefore, equation (4) is used to test the causal relation from economic growth, renewable and non-renewable energy consumption to carbon dioxide emissions. Similarly the hypotheses in equation (5) to (8) examined the sequence hypothesis.

Results and Discussion

Unit Root Test

The results of the unit root test are shown in Table 3. The results show that the null of a unit root in both ADF and PP tests cannot be rejected in their level form, implying that all variables are non-stationary. Nevertheless, after the first difference of each variable, the test suggests that all series are stationary.

Table 3: Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root test results

Country/ Variable	Augmented Dickey Fuller (LL)		Philips Perron (BW)	
	At level	At first difference	At level	At first difference
	Intercept & Trend		Intercept & Trend	
Malaysia				
CO2	0.8289(1)	-7.1806(0)***	-0.0072(0)	-7.2570(2)***
EC	-0.9527(0)	-7.0271(0)***	-0.6829(2)	-7.0271(0)***
GDP	-0.6472(0)	-4.4293(0)***	-0.8758(2)	-4.4200(2)***
GDP2	-0.8998(0)	-4.4973(0)***	-1.1291(2)	-4.4923(2)***
TREG	-3.0656(1)	-3.7197(7)**	-2.9460(27)	-6.0549(26)***
Indonesia				
CO2	-2.9365(0)	-5.8682(0)***	-2.9679(2)	-7.5988(10)***
EC	-0.4959(0)	-6.0890(0)***	-0.4959(0)	-6.0890(0)***
GDP	-1.9022(1)	-4.0319(0)***	-1.7519(2)	-4.0319(0)***
GDP2	-1.9824(1)	-4.0053(0)**	-1.7913(2)	-4.0303(1)***
TREG	-2.9661(0)	-8.5241(0)***	-2.8802(3)	-8.8506(3)***

Note: An asterisk ***,** and * represent 1% significance level, 5% significance level and 10% significance level, respectively. LL and BW denote optimum lag length selected based on Akaike Info Criterion and the Bandwidth, respectively.

Johansen-Juselius Cointegration and Long-Run Equilibrium Relationships

Since all series are integrated of order of one, Johansen-Juselius cointegration analysis can be applied for further analysis. The results of the cointegration tests are shown in Table 4. The table reports country by country trace statistics and maximum eigenvalue statistics. The results show evidence of one cointegrating relationship for Malaysia and Indonesia at 5% significance level, implying that there is clear evidence of a long run relationship between these variables.

Given that there is an evidence of cointegration, the long run coefficients of energy resource use and economic development can be derived in the CO_2 emission equation. Table 5 summarizes the long run coefficients and the t-statistics. The results show that the EKC hypothesis is not valid among these two countries. Since Malaysia and Indonesia are developing countries, the EKC hypothesis is not valid because they may not have achieved a level of income to apprehend the inverted U-shaped. This finding is consistent with results from previous study conducted by Lean and Smyth (2010), Narayan and Narayan (2010), Chandran and Tang (2013) and Azlina *et al.* (2014). Conversely, EKC hypothesis is significant in case of developed countries because the developed countries have higher turning point of inverted U-shaped than developing countries. Furthermore, higher economic growth may lead to different impacts on environmental quality (Al-Sayed & Sek 2013).

Table 4: Johansen-Juselius cointegration tests results

Country / Hypothesized no. of CE(s)	Trace statistics	Maximum eigenvalue statistics
Malaysia		
$r = 0$	79.98896*	34.85670*
$r \leq 1$	45.13226	21.41627
$r \leq 2$	23.71600	11.32994
$r \leq 3$	12.38606	7.692097
$r \leq 4$	4.693965	4.693965
Indonesia		
$r = 0$	86.05905*	41.23018*
$r \leq 1$	44.82887	22.09054

Note: An asterisk ***,** and * represent 1% significance level, 5% significance level and 10% significance level, respectively.

Table 5: Long-run estimation

Dependent variable: CO_2 Explanatory variables	Coefficients	Standard error	t-statistics
Malaysia			
Constant	-9.6753**	4.9010	-1.9741
GDP	0.1208	0.0885	1.3657
GDP2	-0.0004	0.0003	-1.2093
EC	0.5403	0.3238	1.6690
RE	0.0377	0.0484	0.7800
Indonesia			
Constant	4.3890*	2.4680	1.7784
GDP	-5.3690***	1.7198	-3.1219
GDP2	0.9786***	0.2749	3.5604
EC	0.5940***	0.1436	4.1376
RE	-0.0756	0.0576	-1.3126

Note: An asterisk ***,** and * represent 1% significance level, 5% significance level and 10% significance level, respectively.

Granger Causality Based on VECM

Since all variables are found to be integrated of order one and there is evidence of cointegration, this implies the existence of causal relations between variables. Nevertheless, the direction of causality is not detected at this stage. In order to identify the direction and causal relationship among variables, the Granger causality test was performed in the VECM. The VECM allows a distinction to be made between short-run causality and long-run causality.

Table 6: Granger causality estimated under VECM approach in Malaysia and Indonesia

Dependent variable	Sources of causation (independent variables)					
	Short-run				Long-run	
	ΔCO2	ΔGDP	Δ GDP2	Δ EC	Δ RE	Δ ECT
Malaysia						
ΔCO2	-	1.7097	1.5350	5.0030**	0.1134	0.0437
ΔGDP	4.0061**	-	4.4772	0.7305	0.1045	2.2237
Δ GDP2	3.9531	4.1280	-	0.7705	0.1045	535.8371
Δ EC	0.3949	2.0282	2.0284	-	0.0280	0.1552
Δ RE	1.6029	6.3394***	7.2813	21.1103***	-	-1.1436***
Indonesia						
ΔCO2	-	0.2308	0.2222	1.8370	3.4040**	0.2840
ΔGDP	1.1042	-	1.1889	0.5151	3.4004**	0.0432
Δ GDP2	1.1089	1.1531	-	0.5400	3.5526	0.3740
Δ EC	0.2272	1.3588	1.3217	-	1.3525	0.1397
Δ RE	0.3430	0.2030	0.1886	0.5290	-	-0.7066

Note: An asterisk ***,** and * represent 1% significance level, 5% significance level and 10% significance level, respectively.

The results for joint Wald F-statistics of the lagged explanatory variables of the VECM which indicates the significance of short run causality is shown in Table 6. Meanwhile, the long run causality is shown by the t-statistics for coefficients of the ECT. The findings of short run causality in Malaysia indicates that F-statistics i) for energy consumption (equation 4) is significant at 5% level respectively, ii) for CO_2 emission (equation 5) is also significant at 5% level, respectively and iii) for energy consumption and economic growth (equation 8) is significant at 1% level. The result of the short run causality suggests that causality running from energy consumption to CO_2 and renewable energy, CO_2 to GDP and GDP to renewable energy in Malaysia. Besides, the results of t-statistics found that the coefficient of ECT is significant in the renewable energy at 1% significance level. This result revealed that there are long run equilibrium relationship exists in renewable energy in Malaysia.

With respect to the emissions-growth nexus, the findings of this study show evidence of causality from emissions to income. Our results are consistent with Ang (2008) and Azlina and Nik Mustapha (2012) for Malaysia and Yoo (2006) for Indonesia. As for energy-emission nexus, there is causality from energy to CO_2 emissions. Furthermore, we also found the evidence of Granger causality from economic growth and energy use to renewable energy. Therefore, it can be concluded that Malaysia relies on energy consumption to boost its economic development. Furthermore, industrialization and services plays a vital role for the emerging growth in energy consumption that contributed to environmental problem indirectly. In fact, the increase of energy consumption that contributed to increase the emissions of CO_2 gives an adverse impact to environmental. Therefore, most of ASEAN countries realized the importance of renewable energy use in order to minimize the level of CO_2 emission. Hence, Malaysia is working towards the use of green technologies to reduce the environmental problems.

On the other hand, in Indonesia, there is evidence of causality runs from renewable energy to carbon dioxide emissions. This can be referred from the short run causality which indicates that F-statistics for renewable energy in the carbon dioxide emissions and economic growth equation is significant at 5% level. Moreover, there is evidence of causality from renewable energy to GDP. The finding of this study suggests that renewable energy use is a crucial component to encourage the economic growth while implementation of renewable energy contributes to CO_2 emissions. Following this, we can conclude that Indonesia is a developing country that is dependent on energy consumption in pursuit to expand the economic growth towards developed country. Thus, the increased of carbon dioxide emissions is the factor that contributes to environmental problem is noteworthy. Renewable energy seems to be promising alternative for the current energy sources to reduce the carbon dioxide emissions in the future.

Conclusion

This study examines the link between CO_2 emissions, consumption of energy resources and economic development and for Malaysia and Indonesia over the period 1980 to 2011. The unit root test shows all the variables were stationary at first difference. The results of Johansen's test indicate that the existence of long run equilibrium relationships between variables. The causality test revealed the causality was running from energy use to CO_2 and renewable energy, CO_2 to GDP and GDP to renewable energy in Malaysia. Besides, the result provides an evidence of long run equilibrium relationship between variables. Conversely, we found short run causality from renewable energy to GDP and CO_2 emission in Indonesia. In addition, the EKC hypothesis is not valid among these two countries.

There is an urgent need for strengthening a policy recommendation on both energy and economic sector in Malaysia and Indonesia. With respect to Malaysia, the government should develop local energy policies to reduce environmental degradation. Any policy to combat CO_2 emissions should ensure that it will not affect economic growth in the future. Since Malaysia is gifted with abundance supply of renewable resources, there is large potential for renewable energy utilization to become an alternative to current energy sources. Renewable energy should be used for major sectors not only to conserve non-renewable energy but also to combat emission. In the case of Indonesia, the government may consider to put a limitation for exporting gas and coal in order to conserve its fossil energy reserves. In other words, renewable energy should be used as alternatives to oil and must be utilized as well to stop the exports of gas and coal. In the light of these findings, developing countries seem to have an imperative need to promote and explore the use of renewable energy as an alternative to the current energy sources and for sustainable growth.

To conclude, this study on the effect of energy consumption, renewable energy consumption and economic growth on CO_2 emission in Malaysia and Indonesia revealed that both countries should focus more on optimizing the energy use through renewable energy and energy efficiency that particularly contribute to achieve high income or GDP. These countries should realize the important of energy efficiency in order to combat pollution emissions and to achieve the sustainable development. Moreover, these countries should realize that renewable energy use is the one of alternative that should be promoted to major sectors. In fact, the use of renewable energy is not only to conserve energy but also to reduce emission. Meanwhile, the government incentives in investment of high technologies in major sectors also can help to improve the environmental problems in order to achieve sustainable development.

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References

Al-Mulali, U., Fereidouni, H. G., Lee, J. Y., & Sab, C. N. C., (2013). Examining the bi-directional long run relationship between renewable energy consumption and GDP growth. *Renewable Sustainable Energy Review,* 22: 209-222.

Al-Sayed, A. R. M., & Sek, S. K. (2013). Environmental Kuznets Curve: Evidences from developed and developing economies. *Applied Mathematical Sciences,* 7(22): 1081-1092.

Ang, J. B. (2008). Economic development, pollutant emissions and energy consumption in Malaysia. *Journal of Policy Modelling,* 30(2): 271-278.

Azam, M., & Khan, A. Q. (2016). Testing the Environmental Kuznets Curve hypothesis: A comparative empirical study for low, lower middle, upper middle and high income countries. *Renewable and Sustainable Energy Reviews,* 63: 556–567.

Azlina, A. A. (2011). On the causal links between energy consumption and economic growth in Malaysia. *International Review of Business Research Papers,* 7(6): 180-189.

Azlina, A. A., & Nik Mustapha, N. M. (2012). Energy consumption, economic growth and pollutant emissions nexus: The case of Malaysia. *Procedia – Social and Behavioral Sciences,* 65: 1-7.

Azlina, A. A., Law, S. H., & Nik Mustapha, N. H. (2014). Dynamic linkages among transport energy consumption, income and CO_2 emission in Malaysia. *Energy Policy,* 73: 598-606.

Begum, R. A., Sohag, K., Abdullah S. M. S., & Jaafar, M. (2015), CO_2 emissions, energy consumption, economic and population growth in Malaysia. *Renewable and Sustainable Energy Reviews,* 41: 594-601.

Carbon Dioxide Information Analysis Centre (2012). CDIAC Data. Retrieved from http://cdiac.ess-dive.lbl.gov/2012, 2 March 2017.

Chandran, V. G. R., & Tang, C. F. (2013). The impacts of transport energy consumption, foreign direct investment and income on CO_2 emissions in ASEAN-5 economies. *Renewable Sustainable Energy Revision,* 24: 445-453.

Chang, C. C. (2010). A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. *Applied Energy,* 87(11): 3533-3537.

Chen, S.T., Kuo, H.I., & Chen, C.C. (2007). The relationship between GDP and electricity consumption in 10 Asian countries. *Energy Policy,* 35(4): 2611-2621.

Copenhagen Accord (2009). Fifteenth session of the Conference of the Parties (COP 15). Retrieved from http://unfccc.int/meetings/copenhagen_dec_2009/meeting/6295.php, 2 March 2017.

Energy Information Administration (2017)

Ghosh, S. (2010). Examining carbon emissions – Economic growth nexus for India: A multivariate cointegration approach. *Energy Policy,* 38: 2613-3130.

Granger, C. W. J. (1987). Some recent development in the concept of causality. *Journal of Economics,* 39: 199-211.

Halicioglu, F. (2009). An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. *Energy Policy,* 37: 1156-1164.

International Energy Agency (2015). Data and statistics manual. Retrieved from https://www.iea.org/countries/non-membercountries/indonesia/, 13 January 2018.

Energy Information Administration (2017). International Energy Outlook 2017. Retrieved from https://www.eia.gov/outlooks/ieo/exec_summ.php, 13 January 2018.

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. *Energy Policy.* 37: 5167-5172.

Jamaluddin, S., Azlinda, A., & Behnaz, S. (2013). The potential of renewable energy: Using the Environment Kuznets Curve model. *American Journal of Environmental Science,* 9(2): 103-112.

Jebli, M. B., Youssef, S. B., & Ozturk, I. (2016). Testing Environmental Kuznets Curve hypothesis: The role of renewable and non-renewable energy consumption and trade in OECD countries. *Ecological Indicators,* 60: 824–831.

Jobert, T., & Karanfil, F. (2007). Sectoral energy consumption by source and economic growth in Turkey. *Energy Policy,* 35: 5447-5456.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration-with applications to the demand for money. *Oxford Bulletin of Economics and Statistics,* 52(2): 169-210.

Lean, H. H., & Smyth, R. (2010). CO2 emissions, electricity consumption and output in ASEAN. *Applied Energy,* 87(6): 1858-1864.

Lidula, N. W. A., Mithulananthan, N., Ongsakul, W., Widjaya, C., & Henson, R. (2006). ASEAN towards clean and sustainable energy: Potentials, utilization and barriers. *Renewable Energy,* 32: 1441-1452.

Narayan, P. K., & Narayan, S. (2010). Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. *Energy Policy,* 38: 661-666.

Ozturk, I., Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data from low and middle income countries. *Energy Policy,* 38(8): 4422-4428.

Payne, J. E. (2009). On the dynamics of energy consumption and output in the US. *Applied Energy,* 86(4): 575-577.

Sebri, M., & Ben-Salha, O. (2014). On the causal dynamics between economic growth, renewable energy consumption, CO_2 emissions and trade openness: Fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews,* 39: 14-23.

Soytas, U., & Sari, R. (2003). Energy consumption and GDP: Causality relationship in G-7 countries and emerging markets. *Energy Economics,* 25: 33-37.

Soytas, U., & Sari, R. (2009). Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. *Ecological Economics,* 68(6): 1667-1675.

Stern, D. I. (2004). The rise and fall of the Environmental Kuznets Curve. *World Development,* 32: 1419-1438.

Stern, D. I. (2010). *The role of energy in economic growth. Centre for Climate Economics & Policy working paper 3.10.* Canberra, Australia: Crawford School of Economics and Government, The Australian National University.

Tang, C. F., & Tan, E. U. (2013). Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia. *Applied Energy,* 104: 297-305.

Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy,* 79: 447-454.

Tiwari, A. K. (2011). A structural VAR analysis of renewable energy consumption, real GDP and CO_2 emissions: Evidence from India.

Economics Bulletin, 31(2): 1793-1806.

Tsani, S. (2010). Energy consumption and economic growth: A causality analysis for Greece. *Energy Economics,* 32: 582-590.

World Bank (2014). The World Development Indicators 2014 Database. Retrieved from https://data.worldbank.org/products/wdi, 18 January 2017.

World Bank (2015). The World Development Indicators 2015 Database. Retrieved from https://data.worldbank.org products/wdi, 18 January 2017.

Yoo, S. (2006). The causal relationship between electricity consumption and economic growth in ASEAN countries. *Energy Policy,* 34: 3573-3582.

Zhang, X. P., & Cheng, X. M. (2009). Energy consumption, carbon emissions, and economic growth in China. *Ecological Economics,* 68(10): 2706-2712.