Environmental Kuznets Curve and the Relationship between Energy Consumption, Economic Growth and CO_2 Emissions in Malaysia

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Abstract

The paper examines the impact of energy consumption and economic growth on CO_2 emissions in Malaysia, covering 1965-2015 period. Simple ordinary least squares technique was employed to achieve the objective. The result indicated that CO_2 emission decreases with an increase in income and increases with an increase in trade openness. While environmental Kuznets curve is nonexistent. We therefore recommended that CO_2 mitigation policies should be prioritized.

Keywords: CO_2 emissions, energy consumption, economic growth, OLS

1. Introduction

One of the most topical issues and a subject of investigation by researchers in the recent times is global warming and its resulting effects. IPCC (2007) projected that global temperature may rise from 1.1 to 6.4^0C if the current greenhouse gas (GHG) emissions level is maintained. This projection signals future danger of rise in sea level from 16.5 to 53.8 cm by the year 2100 if the trend current remains. World Bank report suggests that the main component of the GHG that contribute to global warming and climate change is CO_2 emissions (Mendelsohn, 2010). Thus, CO_2 emissions largely contribute to global warming. Many existing literature have investigated the relationship between energy consumption, CO_2 emissions and economic growth in different countries and regions, using different methodologies and varying sample sizes. These investigations mostly relied on econometric methodologies and a framework of environmental Kuznets curve (EKC) hypothesis. However, the results of the studies still remain controversial and ambiguous. The ambiguity or mixture of the findings can be attributed to the sample periods used, variables employed, methodologies used or country/region focused on. Due to the non-consensus and identified weaknesses of methodologies used by some previous studies, the topic is still opened to further research.

This study focuses on Malaysia as a country of study. The choice of Malaysia as a case study is motivated based on the fact that it is one of the fastest growing developing economies (Saboori et al., 2012), with an average economic growth rate of 7.7% in 1970s to 1980s, 5.8% in 1990s and average of 6.5% after 2000. At 2014, the growth rate was 6.0 %, which is far above the global average of 2.5%. This growth can be connected with shift from agriculture to industrial production. The rapid industrialization witnessed by country has led to an increase in productive activities, which in turn facilitate greenhouse gas emission, particularly CO_2 emissions. To show the enormity of the problem, Saboori et al., (2012) disclose that in 2007, while the global average of CO_2 emission was 4.63 metric tons, Malaysian emission rate was 7.32 tons, which is quite above the global average. The Malaysian CO_2 emission in 2011 stood at 7.9 metric tons, which was above the World average of 4.9 metric tons. The continuous increase in CO_2 emission in Malaysia can be linked to continuous increase in energy consumption to facilitate productive activities in recent times. This can be further observed from how energy consumption in the country rose from 908 kg of oil equivalent per capita in 1981 to 2, 799 kg of oil equivalent per capita in 2012. From the forgoing, it can be seen that CO_2 emissions and energy consumption have continued to increase over time. At the same time, the economic growth remains high and above World's average.

The relationship among these three interest variables is empirically investigated in this study. The study also checks the existence of EKC in Malaysia. This topic has been of great interest by many researchers after the pioneer study of Kraft and Kraft (1978) who revealed a one-way causality running from output to energy consumption for USA. These researchers found different results (see Saidi and Hammani, 2015; Ajmi et al., 2015; Inglesi-Lotz et al., 2015; Sulaiman, 2014; Omri, 2013; Mugableh, 2013; Jalil and Mahmud, 2009; Omri et al., 2014; Chindo et al., 2015; Nasir and Rehman, 2011; Pao and Tsai, 2011; Lotfalipour et al., 2010; Ang, 2008; Wolde-Rufael, 2010). The mix nature of the outcome of these studies therefore calls for further empirical investigation.

The remainder of the paper is structured as follows. Section two explains the theoretical framework and methodology employed in the study. The results and discussions are presented in section three of this paper. While section four concludes and discusses policy recommendation.

2. Theoretical framework and Methodology

2.1 Theoretical framework

The theoretical framework for this study is based on environmental Kuznets curve (EKC) hypothesis. The theory states that at the early stage of the economic development, pollution/environmental degradation increases, until it reaches particular level after which the trend will start reversing (see Figure 1). This asserts that, at very high-income level, economic growth could result in the improvement of the environment. Mathematically represented as:

$$ED = \alpha_1 + \alpha_2 Y + \alpha_3 Y^2 \qquad (1)$$

where *ED* represents environmental degradation (pollution), Y is per capita income and Y^2 is the turning point level of income after which environmental degradation will start falling with rise in income.

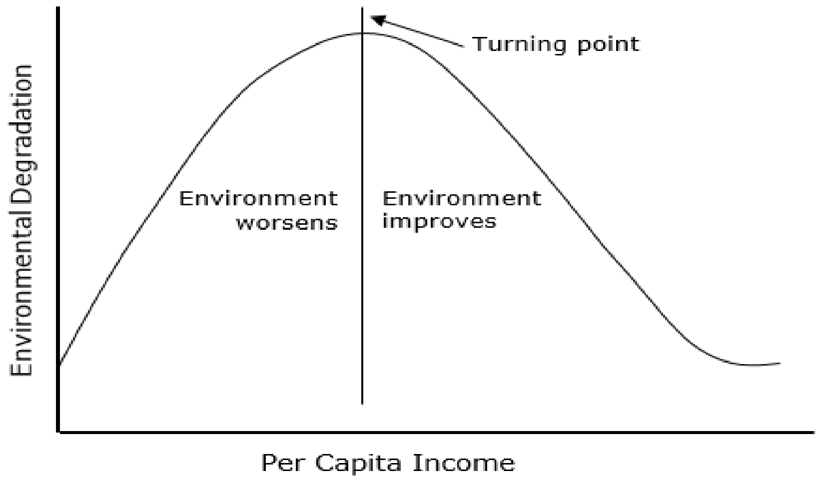

Figure 1. Environmental Kuznets curve

2.2 Model Specification

To achieve our objective of investigating the relationship between energy consumption, CO_2 emission and economic growth in Malaysia, we follow Omri (2013) based on environmental Kuznets curve (EKC) theory and specified our model as thus:

$$\ln C_t = \eta_0 + \eta_1 \ln Y_t + \eta_2 \ln Y_t^2 + \eta_3 \ln EN_t + \eta_4 \ln TO_t + \varepsilon_t \quad (2)$$

where C_t is CO_2 emissions measured in kg of oil equivalent per capita, Y_t is economic growth measured by real GDP per capita, EN_t is energy consumption, TO_t is trade openness, ε_t is the error term, $\ln$ is the natural logarithm, η_0 is the intercept and η_1-η_4 are coefficients of the variables in the model. All the data collected on the variables for the period 1965-2015 (51 observations) are sourced from World Bank database.

The impact of economic growth and energy consumption on CO_2 emissions are analyzed through Equation 2. Wang et al. (2011) disclose that energy consumption could increase CO_2 emissions. Energy use per capita is used as a measure of energy consumption. Economic growth as hypothesized by environmental Kuznets curve is directly associated with CO_2 emissions. A control variable of trade openness is included in the model.

2.3 Method of Estimation

This study employs ordinary least squares (OLS) method of time series to achieve our objective. It is one of the most common techniques of multivariate analysis. OLS has some important statistical properties that make it one of the most powerful methods of regression analysis. These properties comprise the Gauss-Markov theorem. An estimator such as β_2 (in Equation 3 for example) is referred to as the best linear unbiased estimator (BLUE) of β_2 if:

First property: it is linear. The estimator must linear function of a random variable.

Second property: it is unbiased. The mean (expected) value $E(\beta_2)$, is equal to the true value, β_2 .

Third property: it has a minimum variance in the class of all such linear unbiased estimators. An unbiased estimator with the least variance is called an efficient estimator.

$$Y_t = \beta_1 + \beta_2 X_t + \varepsilon_t \quad (3)$$

However Gauss-Markov Theorem states that, given the assumptions of the classical linear unbiased regression model, the least-squares estimators, have minimum variance of the class of unbiased estimators, that is, they are blue. Therefore, these assumptions will be captured in the diagnostic tests in this study.

3. Results and Discussion

Prior to estimating Equation 2, unit root and cointegration tests were conducted to assess the order of integration of the variables and long-run relationship among them, respectively. For unit root test, augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test statistics were employed. While, for cointegration test, Johansen cointegration test was employed. The results for unit root and cointegration tests are presented in Table 1 and 2, respectively. The unit root test results in Table 1 shows both ADF and PP test statistics indicate that all the variables are stationary at level. Thus, given the stationarity nature of the variables OLS can be most suitable method for estimating Equation 2. The Johansen cointegration test result reported in Table 2, suggests that there exist three cointegrating equations. This means that the variables have long-run relationship. Confirming the long-run relationship among the variables, we can proceed to the estimation of our main model using OLS.

Table 1. Unit root test results

Variables	Level				First Difference			
	ADF		PP		ADF		PP	
	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend
$\ln CO_{2t}$	-8.523*** (0.000)	-8.433*** (0.000)	-8.463*** (0.000)	-8.377*** (0.000)	-	-	-	-
$\ln Y_t$	-6.203*** (0.000)	-6.214*** (0.000)	-6.209*** (0.000)	-6.214*** (0.000)	-	-	-	-
$\ln EN_t$	-7.221*** (0.000)	-7.153*** (0.000)	-7.240*** (0.000)	-7.183*** (0.000)	-	-	-	-
$\ln TO_t$	-5.236*** (0.000)	-5.476*** (0.000)	-5.198*** (0.000)	-5.423*** (0.000)	-	-	-	-

Note: ***indicates significance at 1% level. Parentheses are *p*-values.

Table 2. Johansen cointegration test results

Hypothesized No of CE (s)	Eigenvalue	Trace Statistic	*p*-value
None*	0.550	97.966	0.000
At most 1*	0.443	59.598	0.002
At most 2*	0.347	31.479	0.031
At most 3	0.199	10.974	0.213
At most 4	0.006	0.304	0.581

Note: *denotes rejection of the hypothesis (no cointegration) at the 0.05 significant level.

Next, we present the estimated result for our main model specified in Equation 2, in Table 3. The result indicates that economic growth has significant negative relationship with CO_2 emissions. This suggests that CO_2 emissions decreases with an increase in economic growth. Income-squared, which represents a turning point for growth, yields a significant positive impact of CO_2 emissions. This indicates that at certain point of economic growth in Malaysia, CO2 emissions will begin to increase with further increase in economic growth. Based on the obtained coefficients of income and income-squared, we can safely conclude that EKC does not exist in the case of Malaysia. Because, for EKC to exist, the coefficient of income and income-squared must be significantly positive and negative, respectively. However, what is revealed in Table 3 is the opposite. The coefficient of energy consumption is found to be positive but insignificant. This implies that energy consumption does not increase CO_2 emissions significantly. The control variable, trade openness yields correct sign and is significant. It entails that CO_2 emissions increase with a rise in trade openness, which is in accordance with the theory.

Table 3. OLS estimated result of the impact of energy consumption and economic growth on CO_2 emissions

Dependent variable, $\ln CO_{2t}$		
Regressor	Coefficient	t-statistics (*p*-value)
$\ln Y_t$	-3.489***	-4.840 (0.000)
$\ln Y_t^2$	0.248***	5.463 (0.000)
$\ln EN_t$	0.237	1.618 (0.112)
$\ln TO_t$	0.356***	4.420 (0.000)
Constant	9.442***	3.119 (0.003)
Adjusted R-squared	0.987	
F-statistic	1013.956 (0.000)***	
Durbin-Watson stat (DW)	1.529	
Akaike info criterion (AIC)	-2.370	
Schwarz criterion (SC)	-2.297	
n = 51 observations		

Note: ***indicates significance at 1% level. Parentheses are *p*-values.

The adjusted R-squared (0.987), which is the coefficient of determinstion, indicates that the model is good fit. The F-statistic shows that all explanatory variables included in the model have joint explanatory power on CO_2 emissions. The DW, AIC and SC show that the estimated model is reliable.

To further assess the reliability and efficiency of the model, the estimated model has been subjected to different diagnostic tests, whose results are presented in Table 4. The diagnostic tests conducted included Breusch-Godfrey serial correlation LM test for autocorrelation, Ramsey RESET test for mis-specification, Jarque-Bera for normality, heteroskedasticity test: Breusch-Pagan-Godfrey for normality, and CUSUM and CUSUM of squares for stability. Their estimated results revealed that the model passed all the tests as we failed to reject their null hypotheses at 5% significant level. While CUSUM and CUSUM of squares illustrated in Figs. 2 and 3, indicate that the model is fairly stable. Thus, the model is acceptable for inference.

Table 4. Diagnostic test results

Diagnostic test	*F*-statistic	*p*-value
Breusch-Godfrey Serial Correlation LM Test	13.504	0.196
Ramsey RESET Test	1.387	0.245
Jarque-Bera	3.295	0.192
Heteroskedasticity Test: Breusch-Pagan-Godfrey	9.479	0.050
CUSUM	Stable	
CUSUM of Squares	Stable	

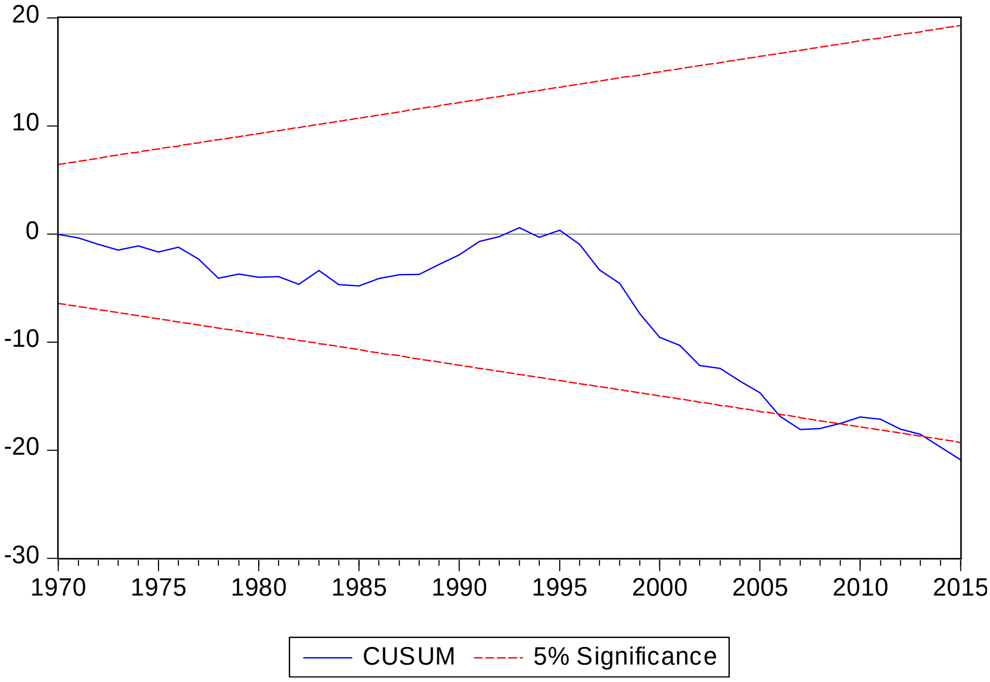

Fig. 2. CUSUM test

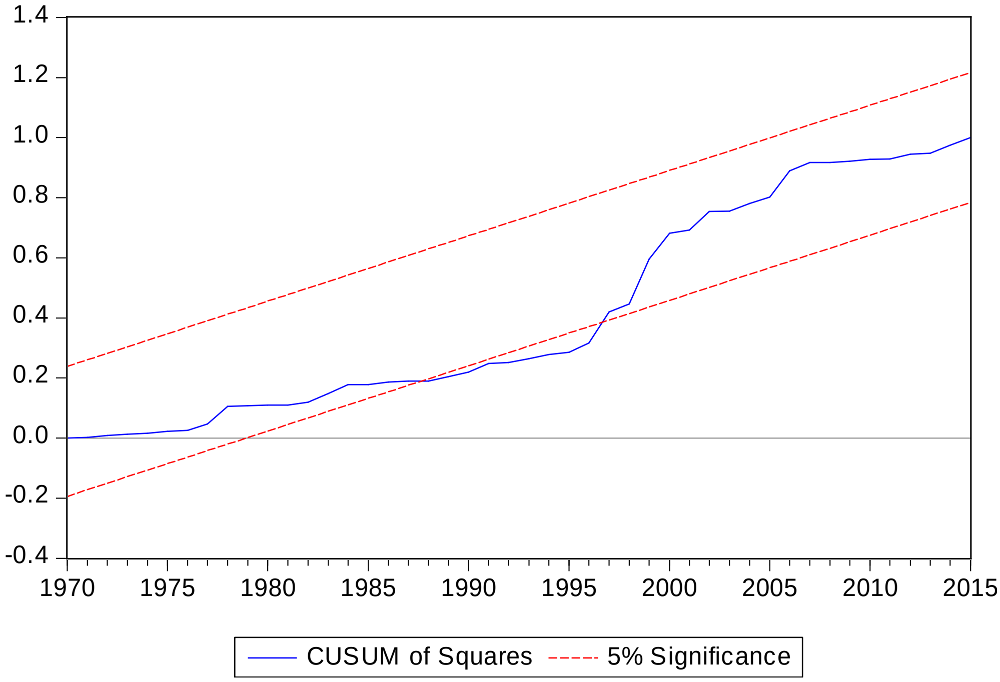

Fig. 3. CUSUM of Squares test

4. Conclusion and Recommendation

This study investigated the impact of energy consumption and economic growth on CO_2 emissions in Malaysia from 1965 to 2015. Simple OLS method was employed after unit root and cointegration tests were conducted.

The results show that CO_2 emissions decrease with an increase in economic growth and that EKC is nonexistence. Energy consumption is found to have insignificant impact on CO_2 emissions. Whereas trade openness is shown to be influential in increasing CO_2 emission in the country.

Thus, policy makers must embark on economic policies that will mitigate CO_2 emissions. Similarly, since trade openness is found to be a driver of CO_2 emissions in the country, trade related policies that will reduce emissions are needed.

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