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Procedia - Social and Behavioral Sciences 65 (2012) 1 – 7

Procedia
Social and Behavioral Sciences

International Congress on Interdisciplinary Business and Social Science 2012

(ICIBSoS 2012)

Energy, Economic Growth and Pollutant Emissions Nexus: The case of Malaysia

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Abstract

The objective of this study is to investigate the causal relationships between energy consumption, economic growth and pollutant emissions for Malaysia over the period 1970-2010. By applying techniques of cointegration and vector error correction modelling, the result shows the existence of the long-run relationship between energy consumption, economic growth and emission. The results also point to a unidirectional causality running from economic growth to energy consumption, from pollutant emissions to energy consumption and from pollutant emissions to economic growth.

Selection and peer-review under responsibility of JIBES University, Jakarta

Keywords : Energy consumption; economic growth; emission; causality

1. Introduction

In recent years, there has been a vast increase in awareness in the environment and its interaction with the economy. In general, there is interdependence between the economy and the environment and this interdependence operates in both directions. For instance, economic development can have major impact on the environment and in the long run, environmental change may have feedback effects to the economy. As Malaysia's economic activities globalize, there is a strong interactive connections between economic and energy supply and demand. Malaysia energy sector is still heavily dependent on fuel such as crude oil, natural gas and coal as a source of energy. Today, around 95% of the Malaysia's energy demands are met by fossil fuels, which will continue to be the predominant source of energy. However, at the same time, the consumption of these non-renewable fuels is gradually depleting and can contribute to huge

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Selection and peer-review under responsibility of JIBES University, Jakarta
doi:10.1016/j.sbspro.2012.11.082

amount of greenhouse gas emission (GHG). Therefore, considering to this scenario, there is an interesting question needs to be considered. Will Malaysia be able to sustain economic growth without running into resource constraints or despoiling the environment?In order to overcome the phenomena, the government of Malaysia is aware of its role in formulating its national energy development policies, which is sensitive towards the environment and the sustainability of energy resources. However, to curb the greenhouse gas emissions and to ensure the sustainability of the economic development, it is important to better understand the link between greenhouse gas emission, energy consumption and economic growth.

In the energy economics literature, the linkages between energy and the economy have been addressed in several ways, which largely reflect the theoretical background of each approach. Within the neoclassical theory of economic growth, the focus has been on the interaction between energy, technical progress, productivity as well as examining the substitutability or complementarity between energy and other factors of production (Berndt and Wood, 1975). This framework is also supported by Ghali El-Sakka (2004) and Soytas and Sari (2007) where they viewed energy as an important input in the production process. In the same context, but from a different perspective, Toman and Jemelkova (2003) examine the relationship of energy development with economic development, that is, how energy usage is driven by economic development. They claimed that the linkages among energy and economic growth vary with the stages of the development process and conclude that energy development is an important component of economic development. For instance, at the lowest level of development, energy mainly comes from biological sources (wood, dung, sunshine for drying) and human effort. In the intermediate stages, more processed biofuels (charcoal/fuel wood), animal power and some commercial fossil energy become more important. In the most advanced stages of development, commercial fuels like electricity become prevalent. In contrast to the above study, Stern and Cleveland (2004) adopt a different point of view on the relationship between energy and economic development. Building on a strand of ecological economics, they emphasize that there are limits to both technical progress and substitution possibilities between inputs (i.e. energy, capital, labour, etc.) in the production process (Stern, 1997). Therefore, they suggest that all economic processes require energy as an essential factor of production and conclude that energy is necessary for growth.

Based on the above discussions, there are four views exist regarding the causal relationship between energy consumption and economic growth. The first view considers economic development as the main driver for energy demand. The second view stressed the importance of considering energy as an essential factor of production and thus suggested that energy is necessary for economic growth. The third view contends that both energy consumption and economic growth cause each other, i.e. that there is a bi-directional causality between energy consumption and economic growth. The fourth view argues that there is no causal relationship between energy consumption and economic growth.

Empirical findings, on the other hand, are not unanimous in their results and this leads to a commonly accepted conclusion that the discussion on the interactions of energy with the economy remains open to different interpretations. For instance, the first view has been widely supported by Azlina (2011) and Ang (2008) for the case of Malaysia, Zhang and Cheng (2009) for the case of China and Mozumder and Marathe (2007) for the case of Bangladesh. The empirical work, which is consistent with the second view, includes studies such as Menyah and Rufael (2010) for the case of South Africa and Narayan and Smyth (2008) for the case of G7 countries. The third view, which maintains that both energy consumption and economic growth Granger cause each other has been widely supported by studies such as Chang (2010) for China and Paul and Bhattacharya (2004) for India. Finally, the fourth view has been supported by the studies of Jobert and Karanfil (2007) and Altinay and Karagol (2004), both for the case of Turkey.

Recently, there is an emerging line of literature to analyze the linkages between energy consumption and economic growth due to the increasing attention of environmental issues and policies needed to reduce greenhouse gas emissions. Studies show that economic growth is major driving forces behind increased energy use and a cause of CO_2 emissions. See for example, Hamit-Haggar (2012), Zhang and Cheng (2009) and Ang (2008), amongst others.

Therefore, the purpose of this paper is to fill the gap by studying the causality between energy consumption and economic growth using multivariate models, which are closer to economic theory. The framework for the analysis is the economic interaction between energy demand, economic growth and pollutant emissions. The Vector Error Correction Model (VECM) approach used in this paper allows all these variables to be endogenous, thereby allowing for additional channels of causality. For example, it allows for both energy and GDP to have a causal relationship with a third endogenous variable, without restricting the direction of this relationship. This would explain the correlation between GDP and energy without implying that there is a causal relationship between the two. The results of this study is expected to be an important reference for the government of Malaysia to formulate the long-term energy policies in order to ensure the long-term reliability and security of energy resource and environmental sustainability without having to jeopardize its economic growth.

The rest of the paper is structured as follows. Section 2 deals with the empirical model specification, a description of the data used in the empirical analysis and the econometric methodology. Section 3 reports the empirical results and Section 4 discusses policy implications of the findings and concludes the paper.

2. Methodology

The model specification to examine the link between energy consumption, economic growth and pollutant emissions is based on a simple trivariate framework where the relationship can be specified as follows:

$$LE_t = \alpha + \beta_1 LY_t + \beta_2 LC_t + \mu_t \tag{1}$$

where LE, LY and LC represent the natural logarithms of energy consumption, real income and CO_2 emissions (as the proxy for the level of pollution), respectively.

There are three steps involved in estimating the interdependencies. The first step is to test the stationarity of the series or their order of integration in all variables. Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test were used to determine the stationary state of the series. The choice of the PP test to complement the ADF test is motivated by the argument the ADF test has low power to reject a unit root whereas the PP tests correct for serial correlation in unit root testing. Therefore, by combining these two tests, the order of integration for all series are robust.The second step is to examine the presence of a long run relationship among all variables in the equation. In this case, the co-integration tests will be conducted to investigate the existence of long-run relationships between the variables. Once the co-integration is confirmed in the model, the residuals from the equilibrium regression can be used to estimate the Vector Error Correction Model (VECM) in the third step. The VECM representation is as follows:

$$\Delta LE_t = \alpha_1 + \sum_{i=1}^{p} \beta_{11i}\, \Delta LE_{t-i} + \sum_{i=12i}^{p} \beta_1\, \Delta LY_{t-i} + \sum_{i=1}^{p} \beta_{13i}\, \Delta LC_{t-i} + \gamma ECT_{t-1} + \varepsilon_{1t} \tag{2}$$

$$\Delta LY_t = \alpha_2 + \sum_{i=21i}^{p} \beta_2\, \Delta LE_{t-i} + \sum_{i=1}^{p} \beta_{22i}\, \Delta LY_{t-i} + \sum_{i=1}^{p} \beta_{23i}\, \Delta LC_{t-i} + \gamma ECT_{t-1} + \varepsilon_{2t} \tag{3}$$

$$\Delta LC_t = \alpha_3 + \sum_{i=31i}^{p} \beta_3\, \Delta LE_{t-i} + \sum_{i=1}^{p} \beta_{32i}\, \Delta LY_{t-i} + \sum_{i=1}^{p} \beta_{33i}\, \Delta LC_{t-i} + \gamma ECT_{t-1} + \varepsilon_{3t} \tag{4}$$

where LE, LY, and LC represents energy consumption, aggregate output or GDP, and CO_2 emissions, respectively. The symbol Δ indicates first differences. The terms ECT refer to the error correction terms, whose coefficients measure speeds of adjustment and are derived from the long-run cointegrating relationships (i.e. $LE_t = \lambda_1 LY_t + \lambda_2 LC_t + \mu$) where μ is the stationary residuals). α_i are intercepts, and p is the lag lengths.

Using the model in equations (2-4), Granger causality tests between the variables can be investigated through the following three channels: (i) Statistical significance of the lagged error correction terms (ECTs) by applying separate t-tests on the adjustment coefficients. The significance of ECT indicates the long-term causal effect. (ii) A joint F-test or a Wald χ^2 test applied to the coefficients of each explanatory variable in one equation. For example, in the short run economic growth does not Granger-cause energy consumption if $\beta_{12i} = 0$ in equation (2). Alternatively, energy consumption does not Granger-cause economic growth if $\beta_{23i} = 0$ in equation (3). Short run causality tests between the other variables can also be undertaken in a similar way. (iii) A joint F-test or a Wald χ^2 test applied jointly to the terms in (i) and (ii) to check for strong causality.

3. Discussion on Findings

The results of the unit root tests are summarized in Table 1. Columns 1 and 2 report the ADF test and PP test, whose null hypothesis is the existence of a unit root test. The results show that the null of a unit root in both tests cannot be rejected in any of the relevant variables in their level. However, upon taking first differences, the null of unit roots is rejected at the 1% significance level. Therefore, it is concluded that all the series are non-stationary and integrated of order one, i.e I(1).

Table 1: Results of Unit Root Tests

	Augmented Dickey Fuller Test (ADF)		Philips-Perron Test (PP)	
		Level		
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
LE	-0.9188	-1.6968	-1.0145	-1.6611
	(0.7719)	(0.7342)	(0.7389)	(0.7498)
LY	-1.7246	-1.3677	-1.6715	-1.4809
	(0.4115)	(0.8553)	(0.4376)	(0.8196)
LC	-0.8621	-1.8940	-0.8621	-1.9362
	(0.7899)	(0.6390)	(0.7899)	(0.6172)
		First Difference		
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
DLE	-7.1444***	-7.2645***	-7.1895***	-7.4935***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
DLY	-5.2575***	-5.5466***	-5.2293***	-5.5531***
	(0.0001)	(0.0003)	(0.0001)	(0.0003)
DLC	-7.3568***	-7.2985**	-7.3099**	-7.2897***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: Figures in the parentheses are p- value. (***),(**) and (*) indicate 1%, 5% and 10% level of significance, respectively.

The results of the co-integration tests for the relevant variables are shown in Table 2. The empirical results of Johansen trace statistics and Johansen maximum eigenvalue statistics suggest evidence in favor of a long-run relationship between energy consumption, economic growth and energy prices, at the 1% level of significance. Therefore, there appears to be clear evidence that there is one co-integrating relationship between the variables.

Table 2: Results of Johansen Cointegration Tests

Hypothesized no. of CE(s)	$r = 0$	$r \leq 1$	$r \leq 2$
Trace statistics	40.7781***	13.8631	2.7175
Hypothesized no. of CE(s)	$r = 0$	$r \leq 1$	$r \leq 2$
Maximum eigenvalue statistics	26.9150***	11.1456	2.7175

Notes: (***),(**) and (*) indicate 1%, 5% and 10% level of significance, respectively.

Since all the variables are I(1) and there is evidence of co-integration, this implies the existence of causality, at least in one direction. However, it does not indicate the direction of causality. Therefore, to identify the direction of the causal relationship, the Granger causality test is performed in the vector error correction model (VECM).

Table 3: Granger Causality Results based on VECM

Dependent variable	Sources of causation (independent variables)						
	Short-run			Long-run	Strong causality		
	Δ LE	Δ LY	Δ LC	ECT	Δ LE, ECT	Δ LY, ECT	Δ LC, ECT
Δ LE	-	3.7294**	3.3214**	-0.4156***	1.9415	3.1806**	3.0724**
		(0.0358)	(0.049)	[-2.2568]	(0.1442)	(0.0381)	(0.0427)
Δ LY	0.0576	-	2.6000*	0.1737	1.4042	1.3489	2.3531*
	(0.9441)		(0.0909)	[1.6347]	(0.2608)	(0.2772)	(0.0920)
Δ LC	0.4433	2.0737	-	-0.2879	0.7130	1.4293	1.2607
	(0.6460)	(0.1434)		[-1.4825]	(0.5074)	(0.2537)	(0.3055)

Notes: Figures in the parentheses ( ) and brackets [ ] are p-value and t-statistic, respectively. (***),(**) and (*) indicate 1%, 5% and 10% level of significance, respectively.

Table 3 presents the results of causality test based on the VECM framework. The result of the short-run causality shows the *F*-statistics is statistically significant in the energy equation. The long-run causality, on the other hand, is supported by the coefficient of the lagged error correction term, which is negative and statistically significant, also in the energy equation. The evidence is further supported by the results of the strong causality tests which show the overall causality for both the short-run and long-run. Hence, our results show strong evidence that there is unidirectional causal flow from economic growth to energy consumption. This finding is consistent with Azlina (2011) and Ang (2008) for Malaysia and Yoo (2006) for Indonesia. This result suggests that Malaysia is less energy-dependent economies and implies that economic growth stimulates energy consumption in Malaysia. Therefore, energy consumption measures may be taken without jeopardizing economic growth.

On the relationship between pollutant emissions and energy consumption, there is evidence of unidirectional causal flow from pollutant emissions to energy consumption implying that emissions lead to energy consumption. The implication of this finding indicates that it is not possible to reduce emissions without reducing energy consumption.

Some weak support for unidirectional causality running from pollutant emissions to economic growth is also found at the 10% level of significance, both in the short-run and long-run. This relationship is in line with the empirical evidence found by Menyah and Wolde-Rufael (2010) for South Africa and Ang (2008) for Malaysia. The inference to be drawn here is that any policies that emerge the reduction of pollutant emissions will bring an impact to economic growth. This is not to suggest however, Malaysia needs to sacrifice its economic growth. The option therefore, Malaysia needs to enhance the level of efficiency in not only in the energy sector, but also other sector such as industrial, transportation and services which have a close link with the environmental degradation level.

4. Conclusion

This study examines the link between energy consumption and economic growth for Malaysia over the period 1970 to 2010. The empirical results of co-integration test show that energy consumption and economic growth are co-integrated. In addition, causality test results reveal that there is a short-run and long-run Granger causality running from economic growth to energy consumption, from pollutant emissions to energy consumption and from pollutant emissions to economic growth. The empirical results of this study provide policy makers a better understanding of energy consumption-economic growth nexus to formulate energy policies in Malaysia. In this study, since economic growth cause energy consumption, it suggests that the implementation of energy conservation policies may be implemented with little or no adverse effect on economic growth. Therefore, there is relatively more scope for energy conservation measures as a feasible policy in Malaysia.

The findings of this study show that this issue still deserves further attention in future research. Malaysian economy will continue to grow particularly with the concern for environmental degradation among the new generation is fast escalating. The depletion of energy resource due to its non-renewable nature is surely happening but the extinction is an uncertainty. The plausible argument is that exploration activities for new oil wells will continue to be intensified because of commercialization and economic importance of this sector to the country. Alternatively the economy might resort to rely on the import of energy resource from outside rather than totally dependent on domestic oil which Malaysia is doing currently. One should also realize that sources of economic growth come with advancement of technology as the result of research and development. Malaysia will be influenced partly by the global achievement in technology and innovation besides her own development in this field. Cheaper and abundant resource friendly to the environmental may be developed in long run which is happening with the introduction of hybrid cars. High production cost and exhaustible energy resources will be replaced by the abundant resources of close substitutes that are friendly to the environment. The economic growth scenario for the country is surely believed to be sustained into the future.

Acknowledgements

We would like to thank tow anonymous referees of this journal for their suggestions and helpful comments which have significantly improved the quality of this paper. We also thank the Editor of the journal for his support. The usual disclaimer applies and views are the sole responsibility of the authors.

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