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On the Causal Links between Energy Consumption and Economic Growth in Malaysia

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This paper examines the causal relationship between energy consumption, energy prices and economic growth in Malaysia by using co-integration and vector error-correction modeling techniques. Empirical results for Malaysia over the period 1970 to 2009 provide evidence for the existence of a long-run relationship between energy consumption, energy prices and economic growth in Malaysia. Results for the existence and direction of causality show that economic growth exerts a causal influence on energy consumption. Hence, an important policy implication of the analysis is that energy conservation measures may be implemented without putting economic development at risk.

JEL Codes: C32, O13 and Q43

1. Introduction

The need to determine the causal relationship between energy and economic growth has been the subject of intense research over the past three decades. A great number of empirical studies have dealt with different aspects of energy and growth issues using both theoretical and empirical evidence. The review of literature states that a relationship exists between energy consumption and economic growth. However, when it comes to whether energy use is a result of, or a prerequisite for, economic growth, there are no clear conclusions in the literature. Toman and Jemelkova (2003) claimed that economic development has an impact on energy use. In contrast to the above view, Stern and Cleveland (2004) view energy as an essential factor of production and thus suggested that energy is necessary for growth. Empirically, Loganathan and Subramaniam (2010) who examined the relationship in Malaysia found evidence of bidirectional causality between energy consumption and economic growth. On the other hand, Ang (2008), who also examined the relationship between energy consumption and economic growth in Malaysia, found that economic growth has an impact on energy consumption. Therefore, further research on the link between energy consumption and economic growth is needed to address this issue due to the mixed theoretical views and empirical findings in the literature.

From a policy point of view, the direction of causality between energy consumption and economic growth has significant implications. Ozturk and Acaravci (2010) classified this direction based on four important hypotheses. The first is called 'conservation hypothesis'. This hypothesis argues that economic growth causes energy consumption. A finding in favour of this causality direction may imply that a country is not dependent on energy for its economic growth. Thus, energy conservation policies may be implemented with no adverse effect on growth. The second hypothesis is known as 'growth hypothesis' and it argues that energy consumption causes economic growth.

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This implies that economic growth is dependent on energy consumption and hence energy is a stimulus to growth. This means that a shortage of energy may negatively affect economic growth or may cause poor economic performance, leading to a fall in income. The third hypothesis is referred as ‘feedback hypothesis’ where it implies that both energy consumption and economic growth cause each other. Finally, the ‘neutrality hypothesis’ implies that there is no causality between energy consumption and economic growth.

The central issue concerns the question of which variable takes precedence over the other. Is energy consumption a stimulus for economic growth or does economic growth lead to energy consumption. This study is relevant for Malaysia, as the energy consumption in Malaysia is becoming of an interest nowadays given the fact that Malaysia has a very interesting energy profile and its economy has been growing steadily in the last several decades. Malaysia is endowed with both conventional and non-conventional energy sources and has a good mix of energy resources such as oil, natural gas, coal and renewable energies (biomass, solar and hydro). In 2008, the final energy demand and primary energy supply was 44,901 and 75,490 ktoe (kilo tonnes of oil equivalents), respectively. As energy consumption grows rapidly, one may deduce that this may be one of the important factors that lead to a growth of a nation.

Although many studies have been done to look at this issue, most of them are concentrated mainly in developed countries. Study on energy consumption in Malaysia, yet is relatively few and limited to Ang (2008) with recent contribution by Loganathan and Subramaniam (2010). However, these studies suffer from two major limitations. Firstly, both studies ignored the role of energy price in the framework analysis. Secondly, the latter study only limited to analyzing the relationship between two variables and may suffer from the omission of variables bias. Therefore, the purpose of this study is to fill the gap by studying the causality between energy consumption and economic growth in Malaysia from 1970 to 2009 using multivariate framework. In this study prices are included in the model because it has been argued that price responses may play a crucial role in affecting income and energy consumption (Asafu-Adjaye, 2000). For example, when price increases, demand will decrease and this leads to reduction in aggregate output. Similarly, with respect to the effect for energy consumption, when prices increase, this will lead to a reduction in energy demand, thereby leading to a reduction in energy consumption.

This study investigated the relationship between energy and income from the perspective of the demand side (or energy demand function) with three variables, namely energy, GDP and prices. In order to examine a long run relationship among energy consumption, economic growth and prices, this study utilized the Johansen co-integration test. Then, the Granger procedure is used to test the direction of causality within the Vector Error Correction Model (VECM). The VECM approach used in this paper allows all the variables in the model to be endogenous, thereby allowing for additional channels of causality to be investigated. 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. Another advantage of the VECM approach is that it can distinguish between a long run and short run relationship among the variables, and can identify sources of causation that cannot be detected by the usual Granger causality test.

The remainder of this paper is structured as follows. Section 2 presents the literature review. Section 3 deals with the empirical model specification, a description of the data used in the empirical analysis and the econometric methodology. Section 4 reports the empirical results and Section 5 concludes with some policy implications.

2. Literature Review

Studies on the relationships between energy consumption and economic growth can be traced back to Kraft and Kraft (1978) with the application of a standard Granger causality test. They used the USA data for the period 1947-1974 and found that a unidirectional long run relationship running from GDP to energy consumption. Since then, there has been a vast body of literature testing for the existence and direction of causality between the two variables in either a bivariate or a multivariate context. However, the empirical evidence is ambiguous and the direction of causation of this relationship remains controversial, that is whether energy consumption causes economic growth or whether energy use is determined by the level of output. Previous empirical studies found different results for different countries as well as for different time periods within the same country.

In a recent study, Tsani (2010) examined the causal relationship between energy consumption and economic growth for Greece for the period 1960-2006, and found that a unidirectional causality runs from energy consumption to economic growth. Similarly, Menyah and Wolde-Rufael (2010) examined the relationship between energy consumption, pollutant emissions and economic growth in South Africa for the period 1965-2006. They also found evidence of unidirectional causality running from energy consumption to economic growth, thus suggesting that an energy conservation policy is feasible. Lee and Chien (2010) examined the relationship between energy consumption, capital stock and real income in G-7 countries for the period 1960-2001. They found evidence of unidirectional causality running from energy consumption to economic growth in Canada, Italy and the UK. Lee and Chang (2008) examined the relationship between energy consumption and economic growth in 16 Asian economies for the period 1971-2002. They also found evidence of causality running from energy consumption to economic growth.

On the other hand, Odhiambo (2010) examined the relationship between energy consumption and economic growth in three sub-Saharan African countries, namely South Africa, Kenya and Congo (DRC). He found evidence of unidirectional causality running from economic growth to energy consumption in Congo (DRC). He therefore suggested that the energy conservation policy is feasible to be implemented in this country because the economy in this country is not energy dependent. Wolde-Rufael (2009) examined the relationship between energy consumption and economic growth in African countries. He also found evidence of causality running from economic growth to energy consumption in Egypt, Ivory Coast, Morocco, Nigeria, Senegal, Sudan, Tunisia and Zambia. Similarly, Akinlo (2008) examined the relationship between energy consumption and economic growth for 11 Sub-Sahara African countries. Using the autoregressive distributed lag (ARDL) bounds test, he found evidence of unidirectional causality running from economic growth to energy consumption in Sudan and Zimbabwe.

In some other cases, causality was found to be running in both directions between energy consumption and economic growth. These include Turkey (Erdal et al., 2008), Canada (Ghali and El-Sakka, 2004), India (Paul and Bhattacharya, 2004), Greece (Hondroyianais et al., 2002), Korea (Glassure, 2000), Taiwan (Yang, 2000 and Chang et al., 2001), and Thailand and the Phillipines (Asafu-Adjaye, 2000). Finally, there are cases where no causality was found in Germany and in the U.S (Lee and Chien, 2010), Cameroon and Cote D'Ivoire (Akinlo, 2008) and Mexico and Venezuela (Cheng, 1997).

3. Methodology and Research Design

Model Specification

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

$$E = f(Y, P, I) \quad [1]$$

where E represents energy consumption, and Y, and P represent aggregate output or real income and energy price (which is proxy by the consumer price index), respectively.

Data

Annual data covering the period 1970 to 2009 were used in this study. All the series are obtained from the World Development Indicators (WDI) online database (www.worldbank.org). Yearly data on energy consumption is represented by energy use in thousand tonnes of oil equivalent (ktoe). Data on real gross domestic product (GDP) are based on purchasing power parity and denominated in constant 2000 US$. The consumer price index is used to proxy energy price (2005 as base year). Logarithm transformations of energy consumption, economic growth and energy price were all taken before the analysis.

Econometric Methodology

The time series econometric procedures were used in order to examine the relationship between energy consumption and economic growth i.e. whether energy consumption will affect economic growth or is it economic growth drives the demand for more energy consumption in the economy. There are three steps involved in estimating the relationship between energy consumption and economic growth. The first step is to test the stationarity of the series or their order of integration in all variables i.e. energy consumption, energy prices and economic growth. In this study, the Augmented Dickey

Fuller (ADF) and Phillips and Perron (PP) test will be utilized. Both tests were used to check the robustness of the results.

The second step is to examine the existence of a long run relationship between energy consumption, energy prices and economic growth, i.e. whether a linear combination of the series is stationary. This stationary linear combination of the variables converges to a long-run equilibrium over time and is known as the co-integrating equation. In this study, the Johansen test (Johansen, 1988; Johansen and Juselius, 1990) will be used to investigate the existence of long-run relationships between the variables. Although there exists a number of co-integration tests, such as the Engle and Granger (1987) method and the Stock and Watson (1988) test, Johansen's test has a number of desirable properties, including the fact that all test variables are treated as endogenous 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 will be estimated to assess the direction of causality between energy consumption and economic growth. The VECM equations take the form:

$$\Delta E_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} \Delta Y_{t\ 1} + \sum_{i=1}^{p} \gamma_{1i} \Delta E_{t\ 1} + \sum_{i=1}^{p} \delta_{1i} \Delta P_{t\ 1} + \theta_{1,1} ECT_{1,t\ 1} + \varepsilon_{1t} \quad [2]$$

$$\Delta Y_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} \Delta Y_{t\ 1} + \sum_{i=1}^{p} \gamma_{2i} \Delta E_{t\ 1} + \sum_{i=1}^{p} \delta_{2i} \Delta P_{t\ 1} + \theta_{2,1} ECT_{1,t\ 1} + \varepsilon_{2t} \quad [3]$$

$$\Delta P_t = \alpha_3 + \sum_{i=1}^{p} \beta_{3i} \Delta Y_{t\ 1} + \sum_{i=1}^{p} \gamma_{3i} \Delta E_{t\ 1} + \sum_{i=1}^{p} \delta_{3i} \Delta P_{t\ 1} + \theta_{3,1} ECT_{1,t\ 1} + \varepsilon_{3t} \quad [4]$$

where E represents energy consumption, Y and P represent aggregate output or real income, and energy price, respectively. The symbol Δ indicates first differences. The terms ECT_i refer to the error correction terms, whose coefficients measure speeds of adjustment and are derived from the long-run cointegrating relationships (i.e. $E_t = \lambda_1 Y_t + \lambda_2 P_t +_t + \mu$) where μ is the stationary residuals). α_i are intercepts, and p is the lag lengths. In each equation, the right hand side variable is regressed against past values of itself and past values of other variables. In this paper, equation [2] will be used to test causation from income and prices to energy consumption. Equation [3] will be used to test causality from energy consumption and prices to income, whereas equation [4] will test causality from income and energy consumption to prices.

The VECM captures both short-run dynamics and long-run equilibrium. For instance, the coefficients β_j's of lagged variables $\Delta Y_{t\ 1}$ reflect the immediate response of Y to changes in X (the left hand-side variable). Thus, they refer to the short-run elasticity of Y with respect to X. In the ECT, the cointegrating vector (the long-run cointegrating relationships), represents the long-run equilibrium between variables. Therefore, the coefficient λ_1 for instance, represents the long-run elasticity of Y with respect to E. In addition, the coefficient θ_i of the ECT measures the speed of adjustment towards the long-run equilibrium, or the proportion of the long-term imbalance of the dependent variable that is corrected in each short-run period. Thus, the size and the statistical significance of this coefficient measure the extent to which each dependent variable has a tendency to return to its long-run equilibrium.

The ECTs in the VECM provide an additional channel for Granger causality to emerge that is completely ignored by the standard (VAR based) Granger causality tests. The Granger causality test in the VECM can be divided into short-and long-run tests. Masih and Masih (1996, 1997 and 1998) indicate that the tests of lagged parameters give the indications of short-term causal effect and significance of ECT indicates the long-term causal effect. Thus, the short-run test considers restrictions on the lagged first differenced terms (since the coefficients of lagged variables capture the short-run dynamic). In this case, a joint F test or Wald χ^2 test is used to detect the Granger causal relation. On the other hand, the test for the long-run considers restrictions on the coefficient of ECT (since the ECT captures the long-run equilibrium between variables). This test is based on the null hypothesis that there is no Granger causality (i.e. the coefficients are zero, $\theta_i = 0$). The t-test is used to detect the Granger causal relation in the long-run.

4. Discussion of Findings

The results of the unit root tests are summarized in Table 1. Columns 1 and 2 report the Augmented Dickey Fuller test and Phillips-Perron 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 mostly 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) over the sample under consideration.

As integration of order one is established for the variables under investigation, the next step is to determine whether a long-run relationship exists. Given the small sample size, the lag length was chosen to be equal to 2. 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 cointegrating relationship between the variables.

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 presents the results of causality test based on the VECM framework. The test, which is referred as the short-run causality test, is conducted using a joint F-statistic. With regards to the long-run causality test, it is supported by the coefficient of the lagged error-correction term.

Table 1: Results of Unit Root Tests

	Augmented Dickey Fuller Test		Philips-Perron Test	
	Level			
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
LEC	-1.1818 (0.6723)	-1.9110 (0.6297)	-1.1750 (0.6755)	-1.9110 (0.6297)
LEG	-1.8445 (0.3542)	-1.1350 (0.9097)	-1.7654 (0.3915)	-1.2800 (0.8782)
LEP	-1.7284 (0.4073)	-3.8480 (0.0249)	-3.9308 (0.0043)	-1.9632 (0.6026)
	First Difference			
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
DLEC	-7.4328*** (0.0000)	-7.5100*** (0.0000)	-7.5256*** (0.0000)	-8.4846*** (0.0000)
DLEG	-4.6988*** (0.0005)	-5.0451*** (0.0011)	-4.6445*** (0.0006)	-5.0622*** (0.0011)
DLEP	-3.7403*** (0.0084)	-3.7093** (0.0372)	-3.5470** (0.0119)	-4.3438*** (0.0073)

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

Table 2: Results of Johansen Co-integration Tests

Hypothesized no. of CE(s)	$r = 0$	$r \leq 1$	$r \leq 2$
Trace statistics	56.21204***	14.5805	1.7590
Hypothesized no. of CE(s)	$r = 0$	$r \leq 1$	$r \leq 2$
Maximum eigenvalue statistics	41.6314***	12.8215	1.7590

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

Consistent with the findings of Odhiambo (2010) for South Africa, Kenya and Congo (DRC), Wolde-Rufael (2009) for African countries, Akinlo (2008) for 11 Sub-Sahara African countries, Ang (2008) for Malaysia, Yoo (2006) for Indonesia, Oh and Lee (2004) for Korea and Masih and Masih (1996) for Indonesia the results reported in Table 3 show causality running from economic growth to energy consumption, not only in the short-run, but also in the long-run. Therefore, there is evidence that unidirectional causality runs from income to energy consumption, which implies that economic growth stimulates energy consumption in Malaysia. Economic growth and energy consumption also have an impact on energy prices. This result is consistent with the result of Odhiambo (2010) for Congo (DRC).

Table 3: Granger Causality Results based on VECM

Dependent variable	Sources of causation (independent variables)						
	Short-run			Long-run	Strong causality		
	ΔLE	ΔLY	ΔLP	ECT	ΔLE, ECT	ΔLY, ECT	ΔLY, ECT
ΔLE	-	3.1904* (0.0559)	0.3984 (0.6750)	-0.4178** [-2.0650]	-	2.6652* (0.066)	1.6892 (0.1911)
ΔLY	0.5003 (0.6114)	-	1.6444 (0.2106)	0.2542 [2.3795]	2.1510 (0.1154)	-	2.2357 (0.1053)
ΔLP	3.5331** (0.0423)	1.3994 (0.2629)	-	0.2891 [5.5784]	10.8243*** (0.0001)	14.0376*** (0.0000)	-

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

5. Conclusion

This study examines the link between energy consumption and economic growth for Malaysia over the period 1970 to 2009. In order to avoid biases associated from the bivariate causality analysis, the study incorporates prices as additional variables to be considered in the energy-growth nexus. In addition, by allowing more variables to be endogenous, this model accounts for more channel of adjustment.

The empirical results of co-integration test show that energy consumption and economic growth are cointegrated. In addition, causality test results reveal that there is a short-run and long-run Granger causality running from economic growth to energy consumption for Malaysia. 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 have important policy implications and it shows that this issue still deserves further attention in future research. As a policy implication for future research on energy-growth relationship and causality, the authors may use multivariate models including new variables (such as real gross fixed capital formation, labor force, carbon dioxide emission, etc.).

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