Is energy a stimulus for economic growth? A focused study on Malaysia using the auto regressive distributed lag technique

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20 January 2016

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Abstract

It is without doubt that a country's economic growth is important to ensure the well-being of its population as well as the country's accreditation of its own economic standing to the world. With time, economic growth is often associated with the consumption of energy. Being the aim of any country to characterise itself with sustainable development, energy becomes prevalently abused to the extent of the considerable consequences we are experiencing today. However, it is uncertain whether it is the abusive energy consumption that results the economy to grow favourably, or is it the economy that leads to consuming energy in the first place. The conservation hypothesis, growth hypothesis, feedback hypothesis and neutrality hypothesis each explains this causal relationship differently. Previous studies have been done on finding the causality between the two, many using co-integration and vector error correction modelling techniques but the results are still mixed. In this study, we intend to apply the Auto Regressive Distributed Lag (ARDL) technique to investigate the issue at hand in the case of Malaysia for the period of 1971-2012. Malaysia is a good reference for a country which has grown and developed progressively in the Asian region, with its abundance of natural oil and gas as the main drivers of energy sources for the country. Our study brings us to the finding of a unidirectional causality running from economic growth to energy consumption. We also take note on the weak causality from economic growth and energy consumption to energy price. Thus, with the unidirectional finding from economic growth to energy consumption, policy makers are able to formulate effective measures for energy conservations without affecting the economic growth of the country.

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Introduction

To investigate the relationship between economic growth and energy consumption is vital for every country, especially one with a developing market. It is crucial to address the matter in order to be clear whether a trade-off exists if the country's main aim is towards future growth, most importantly a sustainable one. Clearly, a country which is energy dependent is most likely concerned on this matter as most of the energy consumed for industrial sectors come from non-renewable energy sources. Even though measures are taken to bring about non-dependency of non-renewable resources by shifting to those which are renewable, progress are still slow. Not to mention the problems of climate and environmental changes associated with energy consumption through the emission of carbon dioxide gases into the atmosphere, which is the main headline in the recent Environmental Summit in France to which carbon pricing will be set effectively anytime soon. This results government and policy makers to formulate more energy conservation policies but how far these policies work will need to be tested in the long run. Therefore, this study is done for the case of Malaysia, one of the emerging economy also dependent on its non-renewable energy sources. Before drawing any conclusions, it is important to investigate whether it is the growth of the economy that leads to more energy consumption or whether the consumption of energy that leads the economy's growth.

The causal relationship between economic growth and energy consumption has been a continuous ongoing debate for decades. The core of this debate postulates the question of which causes which; on whether it is economic growth that leads to consumption of energy or whether it is energy consumption that will drive the economy towards growth. Many research studies have been done circulating this debate both theoretically and empirically, as well as for different countries, different time periods and for different time periods within the same country. Review of these studies show that there is a relationship that exists between economic growth and energy consumption but the results remain unclear on which snowballed the other. Some found that economic development has an impact on the usage of energy (Toman & Jemelkova, 2003) while others like Stern and Cleveland (2004) found that it is energy that is essential for economic growth, as energy is an essential factor of production. Others even found the bidirectional causality between the two (Loganathan & Subramaniam). Aziz (2011) who also investigated the relationship by focusing on Malaysia also found that economic growth exerts a causal influence on energy consumption. Lee and Chien (2010), on the other hand, surprisingly found no causality exist between them. Due to the mix results on the relationship between economic growth and energy consumption, further research is needed to clarify the matter.

Some of the previous studies mentioned have some limitations. Firstly, majority of the studies mostly concentrated on the use of a bivariate causality test for example by just using two variables, one representing growth and the other representing energy consumption, except in the case of Aziz (2011) and Adjaye (2000). Results for those studies, may suffer from omission of variable bias. Therefore, by introducing a third variable that affects both the economic growth and energy consumption the bias may be alleviated, as it may not only alter the causality direction between economic growth and energy consumption but also the magnitude of the estimates. Although this study bears a close similarity with that done by Aziz (2011), where the consumer price index is also used as the proxy, this study further extends the research by lengthening the time for the data samples from 1971-2012.

Secondly, some of the previous studies focusing on this debate used cross-sectional data to examine the causal relationship. Most of the previous studies have mainly used the residual-based co-integration test which is associated with Engle and Granger (1987) and the maximum likelihood test based on Johansen (1988) and Juselius (1990). However, it is now well known that these co-integration techniques may not be appropriate when the sample size is too small (Narayan &Smyth, 2005). As Aziz (2011), is also focusing on the energy-economic growth nexus on Malaysia, our study differs in the approach being used as well as the addition of several years not covered by the study of Aziz (2011) as mentioned previously.

This study will therefore try to make a humble attempt to fill the gap by investigating the link between economic growth and energy consumption using the ARDL approach. This study incorporates economic growth measured by GDP and energy consumption measured by energy use in thousand tonnes of oil equivalent (ktoe), with energy price measured by consumer price index as the proxy.

The remainder of the paper is organised as follows: Section 2 comprises of the background of the study and the theoretical underpinnings of economic growth and energy consumption. Section 3 will be on the objective of the study. Section 4 presents the literature review, while the description of data and methodology, as well as the empirical findings and discussion of results are presented in Section 5. Section 6 concludes the study with policy implications.

Background of the study and theoretical underpinnings

Over the last three decades, the relationship between energy consumption and economic growth has been a widely discussed agenda in empirical literature. Many studies have been done focusing on different countries and different time periods. Different proxies have also been used to investigate the causal relationship between the two, but the results found on the direction of causality have always been mixed.

There are four major hypotheses in the energy economic literature regarding the causal relationship between energy consumption and economic growth. The first hypothesis is known as the “conservation hypothesis”. According to this hypothesis, it is economic growth that causes energy consumption. This indicates that a country is not dependent on energy for growth and development and energy consumption policies will have only slight or no effect on the economic growth. The second hypothesis is called the “growth hypothesis”. Opposite to the first view, this hypothesis states that it is energy consumption that causes economic growth. This suggests that energy consumption plays a very important role for the economy to grow. The third hypothesis is the “feedback hypothesis”. According to this hypothesis, both energy consumption and economic growth cause each other (a bidirectional causality). This means that energy consumption and economic growth complement each other. The fourth is the “neutrality hypothesis” which implies that there is no causality between energy consumption and economic growth. Thus for this hypothesis, neither conservative nor expansive policies which are in relation to energy consumption have any effect on economic growth.

Energy consumption plays a crucial role in the process of a country’s economic growth. Energy consumption patterns, which differ from one country to another, are also very much affected by energy prices. When energy prices are high, energy consumption is expected to fall while if energy prices are low, energy consumption is high. The GDP per energy unit actually differs between economies as they use energy less or more efficiently and because of the differences in industrial structures. For example, countries whose main sectors are agriculture and service sectors will generate a higher GDP per unit energy than manufacturing sectors. Therefore, in the case the two economies/countries that have identical industrial sectors, the differences in the GDP per unit energy will actually reflect the level of efficiency of energy use between the economies. It is also ascertained that if a country produces more GDP per unit over time, with the condition that the industrial structure has not changed, implies better energy efficiency of the country (Loganathan et.al, 2010; Mohamed and Lee, 2006; World bank 2009; Asian Development Bank, 2009)

Our initial country of interest for this study was Brunei Darussalam. This is due to the fact that the energy consumption of the country is assumed to have brought a bigger impact in determining whether it is the consumption of energy (which basically is from their abundance of oil wealth) that leads to the country's economic growth or is it the economic growth of the country that drives them to use more energy. The investigation would have been vital in highlighting the country's 2035 vision[3] of economic growth. However, due to insufficient data available, we have directed our focus to a more reliant country to test this causal relationship. The graph in the table below further shows Malaysia as a better focus for this study than Brunei Darussalam. In table 1, the energy consumption of Brunei Darussalam is more than Malaysia. However, it could be seen that in table 2, that the economic growth of Malaysia is progressing more towards the years of our study compared to Brunei Darussalam. This further supports our selection on making Malaysia as the country of study.

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[3] Wawasan Brunei 2035 or Brunei Vision 2035 aims to turn Brunei Darussalam into a nation widely recognized for: 1)the accomplishments of its well-educated and highly-skilled people as measured by the highest international standard; 2)quality of life that is among the top 10 nations in the world; and 3)dynamic and sustainable economy with income per capita within the top countries in the world (Brunei Economic Development Board, n.d.).

Table 1. Energy Use per capita between Malaysia and Brunei Darussalam.

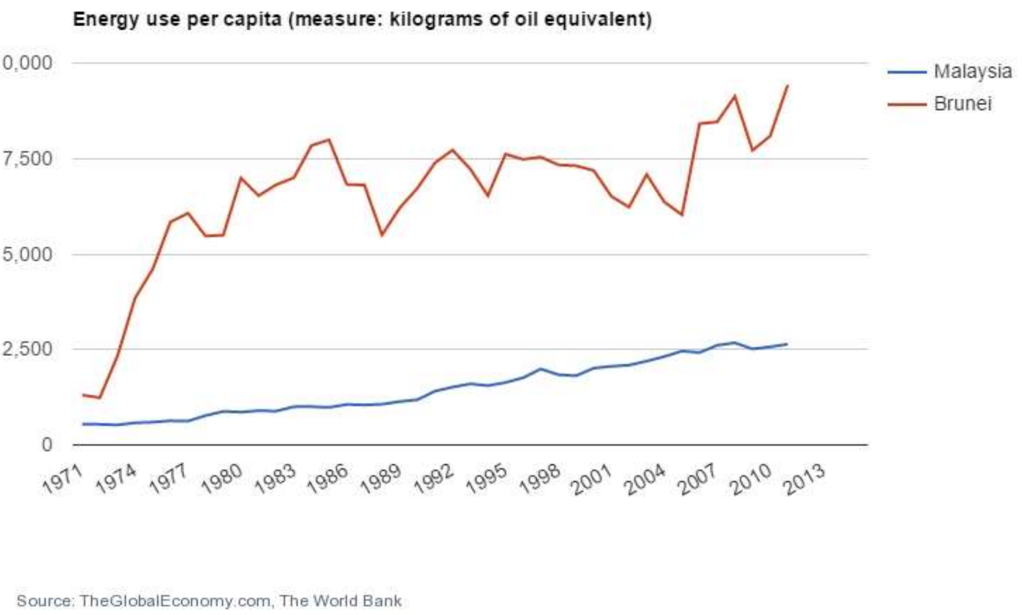
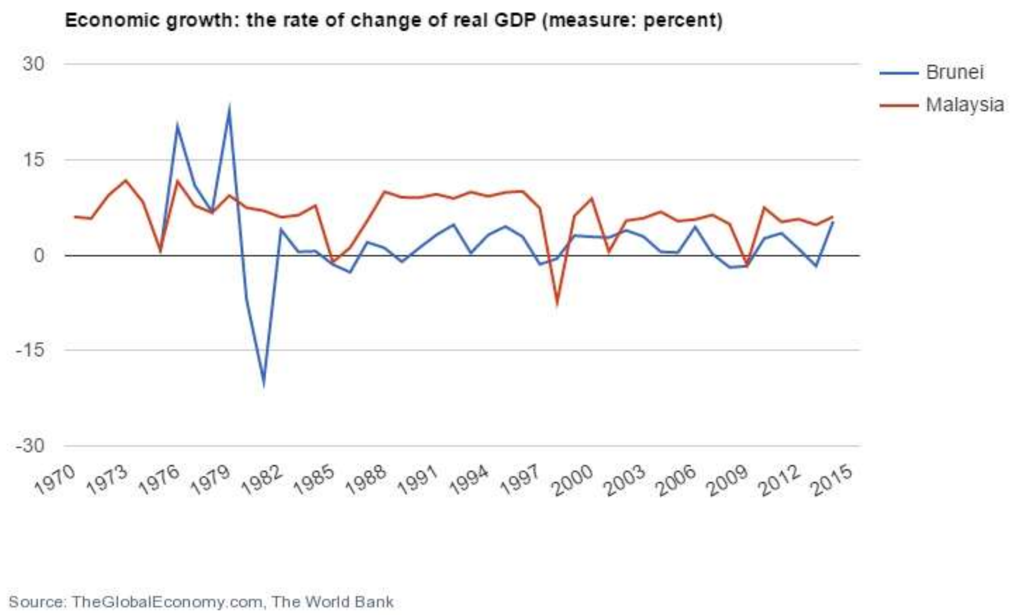


Table 2. The Economic growth of Malaysia and Brunei Darussalam.



The interest of studying the relationship between energy consumption and economic growth arises from the need to understand the complex links between the two. Such an understanding is important and relevant to regulators as well as policy makers. Thus, a similar study would be beneficial in the case of Malaysia, inorder to design an economic policy framework which is suitable for the country.

Malaysia has always been a good example in this region for adopting researches done on western countries due to the ongoing development and progress of the country. Without doubt, the debate on whether energy consumption leads to economic growth or the other way round shall and should be applied and questioned for Malaysia as well.

The former Prime Minister of Malaysia, Tun Mahathir Mohamad, outlined his ideal Vision of 2020, in which Malaysia would become a self-sufficient industrialised nation by 2020. In 2010, the current minister Najib Tun Razak announced the broad outline of the New Economic Model (NEM). The main objective of this model is for Malaysia to join the ranks of the high-income economies (Schellekens, 2010). HSBC reported that Malaysia will become the world's 21st largest economy by 2050, with a GDP of $1.2 trillion (Year 2000 dollars) and a GDP per capita of $29,247 (Year 2000 dollars). The report also states that, "the electronic equipment, petroleum and liquefied natural gas producer will see a substantial increase in income per capita. Malaysian life expectancy, relatively high level of schooling, and above average fertility rate will help in its rapid expansion," (Wikipedia, 2015). The managing director in Credit Suisse, has also commented that "Malaysia has all the right ingredients to become a developed nation," (Shen, 2012).

This main objective of Malaysia towards economic growth will have a causal impact to the energy consumption of the country as Malaysia's industrial sector accounts for 36.8%, over a third of the country's GDP in 2014, and employs 36% of the labour force in 2012. The industrial sector is mostly contributed by the electronics industry, automotive industry and construction industry (Wikipedia, 2015).

The energy production in Malaysia is largely based on oil and natural gas, owing to Malaysia's oil reserves and natural gas reserves, which is the fourth largest in Asia-Pacific after China, India and Vietnam(Selamat & Abidin, 2010). Malaysia's energy infrastructure sector is largely dominated by Tenaga Nasional Berhad, the largest electric utility company in Southeast Asia. Malaysia's total power generation capacity was over 29,728 megawatts, in the year 2013. The total electricity generation was 140,985.01 GWh and total electricity consumption was 116,087.51 GWh (Energy Commission, 2013).

Throughout the years, the Malaysian government has formulated some policies and programs on energy in order to ensure the long term reliability and security of energy supply for sustainable social-economic development in the country. These policies include the National Energy Policy (1979), National Depletion Policy (1980) and Fuel diversification policy (1981 & 1999). The Malaysia Energy centre (PTM) administered by the Ministry of Energy, Communications and Multimedia is responsible for the coordination and implementation of these policies (Mohamed & Lee, 2006).

Although the main focus of this article is on the lead-lag relationship between energy consumption and economic growth, we bring in another variable as proxy for energy prices which is CPI (consumer price index). Following strong basis of other literature in finding the relationship between economic growth and energy consumption, economic growth will be represented by real GDP per capita , and energy consumption by energy use in thousand tonnes of oil equivalent (ktoe) . Thus, the lead-lag relationship between energy consumption and economic growth has been tested for the following variables: an economic growth variable (GDP), an energy consumption variable (ENG) and energy price (CPI). We expect the economic growth variable and the energy consumption variable to be positively related. The causality will be tested mainly through the error correction model. All the data has been sourced from the worldbank website (www.worldbank.org).

Objective of the study

Given the crucial importance of the direction of causality between economic growth and energy consumption, we humbly attempt this issue through the application of the Autoregressive Distributed Lag Model (ARDL), in order to examine both the potential short run dynamics and long level term effects. Our main focus for this study is Malaysia, using data from 1971 to 2012. This study of ours will depart slightly from previous works done in the area and represent our attempts at advancing the research study in the following ways; i) as far as our knowledge goes, this study will investigate the issue of causal direction between economic growth and energy consumption in the case of Malaysia by utilising the ARDL techniques with more recent years, from 1971 up to 2012. A study by Aziz (2011) also used Malaysia as a case study but the data was only up to 2009 and the researcher did not use the ARDL technique, thus this study of ours will be the first attempt to the best of our knowledge, ii) with the findings of this study on the directional causality, the findings will have distinct policy implications for Malaysia, for the country's continued growth and development.

Literature review

A review of past literature on the relationship between energy consumption and economic growth indicates Kraft and Kraft (1978) as the pioneer in this research study. According to their study, there is a unidirectional relationship that runs from GDP to energy consumption. They used the standard Granger causality test and their data stretched for the period of 1947 to 1974 for United States of America. Further researches on this causality have spurred afterwards, following different sample periods and time frames. However, the result of these studies remained to vary from one another with some having unidirectional causality, some bidirectional and some even found no link between the two. The studies are also still fickle on whether more energy consumption is because of the growing economy or whether it is the growing economy which is responsible for the increase energy consumption.

Unidirectional causality from energy consumption to economic growth

There are some studies that found the unidirectional causality from energy consumption to economic growth. For example, Tsani (2010) studied the causal relationship between energy consumption and growth for the period of 1960-2006 for Greece and found a unidirectional causality that runs from energy consumption to economic growth. Menyah and Wolde-Rufael(2010) examined the case in South Africa for the period 1965 to 2006. They also found evidence of unidirectional causality running from energy consumption to economic growth. Lee and Chien (2010) studied the period from 1960-2001 by examining the relationship between energy consumption, capital stock and real income in G-7 countries. Unidirectional causality was also found in the study running from energy consumption to economic growth in Canada, Italy and the United Kingdom. A study was also done by Lee and Chang (2008) taking 16 Asian economies for the period of 1971-2002. They also found the causality running from energy consumption to economic growth. Masih and Masih (2007) studied the causality between energy consumption and GDP in Asian countries using vector error correction model (VECM) and VAR analysis. They used the annual data from 1955 to 1999 and found unidirectional causality from energy consumption to GDP only for the case of India. For these studies, as the causality only runs from energy consumption to economic growth, thus steps for energy consumption will hinder the economic growth of the countries.

Unidirectional causality from economic growth to energy consumption (conservation hypothesis)

There are also studies that actually found evidence of unidirectional causalities running from economic growth to energy consumption, the reversal of previous findings of the literature reviewed. In a recent study by Aziz (2011), she focuses her study on Malaysia using the sample period from 1970 to 2009. Using cointegration and vector-error correction modelling techniques, she found that economic growth exerts a causal influence on energy consumption.

Among the studies that found the same finding is that by Odhiambo (2010) where he takes three sub-saharan African countries; South Africa, Kenya and Congo as his focus study. As the unidirectional causality runs from economic growth to energy consumption, the implementation of energy conservation policy will thus be feasible here. Another study is done by Wolde Rufael(2009), as the researcher found causality running from economic growth to energy consumption in Egypt, Ivory Coast, Morocco, Nigeria, Senegal, Sudan, Tunisia as well as Zambia. A study by Akinloo (2008) studied the causality for 11 Sub-Sahara African countries. They used the autoregressive distributed lag (ARDL) bounds test and found evidence of unidirectional causality running from economic growth to energy consumption for the case of Zimbabwe and Sudan. Masih and Masih (2007) also found unidirectional causality from GDP to energy consumption in Indonesia.

Bi-directional causality between energy consumption and economic growth

Some studies have also found evidence on the bi-directional causality, meaning the causality runs in both directions. Among the studies done are those of Asafu-Adjaye(2000) for the case of Thailand and the Phillippines, Yang (2000) and Chang et.al (2001) for the case study in Taiwan, Glassure (2000) for Korea, Paul and Bhattacharya (2004) for India, Ghali and El-Sakka (2004) in the case of Canada, Masih and Masih (2007) found bidirectional causality in Pakistan while Erdal et.al(2008) in the case of Turkey. As the causality runs in both direction, this means that energy consumption policy will hamper the economic growth of the countries, and at the same time the growth of the countries' economy will affect the energy level of the countries.

No causality between energy consumption and economic growth

There are also some studies that found no causality between energy consumption and economic growth. Erol and Yu (1987) tested data for six industrialized countries and found no significant causal relationship between energy consumption and GDP growth. This result was also found in the case of Cheng (1997) for Mexico and Venezuela, Fatai et.al (2002) for New Zealand, Jobert and Karanfil (2007) in Turkey, Masih and Masih (2007) for the case of Malaysia, Singapore and the Philippines, Akinlo(2008) in his study for Cameroon and Cote D'Ivoire, Payne (2009) in USA as well as Lee and Chien (2010) in the case of Germany and the United States of America.

Data description and methodology

Model Specification and Data

As in empirical literature, the standard log-linear form functional specification of long-run relationship between energy and consumption and real GDP, with energy price as proxy may be expressed as:

$ENGt = \alpha + \beta_2 \, GDP_t + \beta_3 \, CPI + \varepsilon_t$

Where ENGt is the energy use (kg of oil equivalent per capita), GDP, is the real GDP per Capita (constant 2000 US$), CPI is the consumer price index (proxy).

Our model for this study is then estimated as the following:

$LENG \tilde{} \; \alpha + \beta_1 \, LGDP + B_2 \, LCPI + \varepsilon_t$

Where,

LENG= energy consumption in Malaysia

LGDP= Gross Domestic Product in Malaysia

LCPI= Consumer Price Index in Malaysia (Proxy for energy prices).

ε_t= error term

We have intentionally written the model in the Vector error correction model form even though this time series study is not following the traditional time-series analytical method. We have refrained from putting the equality sign at this initial stage.

For this study, the data used is annual data for Malaysia which covers the period of 1971 to 2012. The data of the series is obtained from the World development Indicators (WDI) online database. The annual data for energy consumption is represented by energy use in thousand tonnes of oil equivalent (ktoe), the data on the real GDP (Gross Domestic product) is based on the purchasing power parity and denominated in constant 2000 US$, whereas the data for consumer price index is used to proxy energy price. The selection of variables are based on variables used from previous robust empirical studies. A total of 42 observations were obtained from the sample study. All the data are transformed to logarithms before any analysis is done to make the series constant in their variance.

Methodology

The recently developed ARDL approach is used in empirical literature to determine the relationship among the variables. This study also employs this ARDL bounds testing approach in investigating the economic-energy growth nexus. The ARDL cointegration approach has numerous advantages in comparison with other cointegration methods such as Engle Granger, Johansen and Johansen and Jesulius procedures. Firstly, the ARDL approach can be applied whether the regressors are I(1) and/ or I(0). There is still however a prerequisite that none of the variables is of I(2) or a of a higher order, as the ARDL procedure will be inefficient in the existence of I(2) variables or of a higher order. Secondly, while the Johansen techniques require large data samples, the ARDL is the more statistically significant approach to determine the cointegration relation in small or finite samples consisting of 30 to 80 observations (Pattichis, 1999; Mah, 2000).in mubin. Thirdly, The ARDL approach enables the variables to have different optimal lags as this is something which is impossible with conventional cointegration techniques. Lastly, the ARDL approach also employs a single reduced form equation. The ARDL model takes sufficient numbers of lags and direct the data generating process in a general to specific modelling framework (Harvey, 1981).In conventional cointegration procedures, the long-run relationships are estimated within a context of system equations (Ozturk, 2010).

Unlike multivariate cointegration techniques like Johansen (1988), the ARDL model permits the cointegration relationship to be estimated by the OLS once the model's lag order has been identified. The Error correction model (ECM) can also be drawn from the ARDL approach (Sezgin and Yildrim, 2003). The error correction model enables us to draw outcomes from the long run estimates while the traditional cointegration techniques do not provide such privilege. According to Pesaran and Shin (1999), "the error correction model joins together the short run adjustments with the long run equilibrium without losing the long run information."

Thus, with the advantages of the ARDL approach listed above, the use of the ARDL bound testing approach for this study to analyse the relationship among GDP, ENG and CPI is justified.

The next step in this study is by using the F-statistic to test the null hypothesis of no cointegration against the alternative hypothesis that there is cointegration between the variables. The error correction model is then used to examine the short-run and long-run linkage. The error correction equation is utilised to find out the adjustment speed of the variable to equilibrium.

The initial equation[4] for this study can thus be presented in the following ARDL form:

$$\Delta ENG_t = \alpha + \sum_{i=1}^{k} \emptyset_i \, \Delta ENG_{t_{-i}} + \sum_{j=0}^{l} \beta_j \Delta GDP_{t_{-j}} + \sum_{k=0}^{m} \beta_k \Delta CPI_{t_{-k}} + \delta_1 \, ENG_{t_{-1}} + \delta_2 \, GDP_{t_{-1}} + \delta_3 \, CPI_{t_{-1}} + \nu_t$$

Where ν_t and Δ are the white noise term and the first difference operator. The appropriate lag selection is based on Akaike Information criterion (AIC) and Schwarz Bayesian Criterion (SBC). The ARDL bounds testing procedure is based on the joint F-statistic or the Wald statistic that tests the null of no contegrations, $H_o: \delta_r = 0$, against the alternative hypothesis $H1: \delta_r \neq 0, where \ r = 1, 2$. Then there are two sets of critical bounds, where the upper bound of the critical values refers to the I(1) series and the lower bound critical values to the I(0) series. If the results of the F-statistics is above the upper bound, we reject the null meaning there is cointegration. If the result is below the upper critical values, we cannot reject the null hypothesis, meaning there is no cointegration. However, if it lies between the bounds, then the result is inconclusive as we cannot make any inferences (Ozturk, 2010).

If there is cointegration between the variables, thus the long run model and short run will be presented in the following equations:

$$ENG_t = \alpha + \sum_{i=1}^{k} \emptyset_i \, \Delta ENG_{t-i} + \sum_{j=0}^{l} \boldsymbol{\beta}_j \Delta GDP_{t-j} + \sum_{k=0}^{m} \beta_k \Delta CPI_{t_{-k}} + \mu_t$$

[4] Due to our shortcomings in deriving equations, the following equations are done based on references stated.

$$\Delta ENG_t = \alpha + \sum_{i=1}^{k} \emptyset_i \, \Delta ENG_{t-_i} + \sum_{j=0}^{l} \beta_j \Delta GDP_{t-_j} + \sum_{k=0}^{m} \beta_k \Delta CPI_{t-_k} + \psi \, ECT_{t-_1} + \xi_t$$

Where ψ is the coefficient of error term (hereafter ECT). It shows how quickly variables converge to equilibrium and it should have a statistically significant coefficient with a negative sign (Ozturk, 2010).

Causality analysis

For the ARDL cointegration, it tests whether there is existence or non-existence of long-run relationship between energy consumption per capita and the real GDP per capita. This test does not tell the direction of causality. The next step is to estimate the VECM model (after estimating the long-run model to obtain the estimated residuals). This is done by making the variables in their first differenced and including the long-run relationships as error correction terms in the system (Ozturk, 2010).

Empirical findings and discussion of results

We begin the empirical research by determining the stationarity of the variables used in the time series. In order to be able to proceed to cointegration testing, our variables should be I(1) in their original level form, indicating they are non-stationary and in their differenced form they are stationary. The differenced form for each of the variable used is done by taking the difference of the log forms of the variables. An example of the changing of the level form into their differenced form is,

$DENG=LENG-LENG_{t-1}$

We later conducted the stationary testing of the variables using the Augmented Dickey Fuller (ADF), Philip-Perron (PP) and KPSS test. The tables below summarize the results for all the tests in both the level and differenced form of the variables.

ADF test for level and differenced form

Variable		Test Statistic	Critical Value	Implication
	Variables in Level Form			
LENG		-2.3933	-3.5386	Non-stationary
LGDP		-3.1933	-3.5386	Non-stationary
LCPI		AIC(5) -3.5882	-3.5386	Stationary

		SBC(1) -2.8812		Non-stationary

Table 3a ADF test for level form

Variable		Test Statistic	Critical Value	Implication
	Variables in Differenced Form			
DENG		-6.1740	-2.9472	Stationary
DGDP		-4.9609	-2.9472	Stationary
DCPI		-3.2114	-2.9472	Stationary

Table 3b ADF test for Differenced form

pp test for level and differenced form

Variable		Test Statistic	Critical Value	Implication
	Variables in Level Form			
LENG		-1.4997	-3.5217	Non-stationary
LGDP		-3.9613	-3.5217	Stationary
LCPI		-4.6080	-3.5217	Stationary

Table 4a PP test for Level form

Variable		Test Statistic	Critical Value	Implication
	Variables in Differenced Form			
DENG		-7.2520	-2.9358	Stationary
DGDP		-4.9567	-2.9358	Stationary
DCPI		-3.7158	-2.9358	Stationary

Table 4b PP test for Differenced Form

kpss test for level and differenced form

(The null hypothesis for KPSS is stationary)

Variable		Test Statistic	Critical Value	Implication
	Variables in Level Form			

LENG		0.15625	0.17228	Stationary
LGDP		0.14281	0.17228	Stationary
LCPI		0.15139	0.17228	Stationary

Table 5a KPSS test for level form

Variable		Test Statistic	Critical Value	Implication
	Variables in Differenced Form			
DENG		0.31323	0.38761	Stationary
DGDP		0.27644	0.38761	Stationary
DCPI		0.38819	0.38761	Non-Stationary

Table 5b KPSS test for differenced form

Referring to the table of results above, the unit root tests show that the results are inconsistent from one test to another test. Some of the variables that was supposed to be non-stationary in its level form resulted to be stationary in the other. Furthermore, when we test with KPSS, the mixed results increase. This means that not all the three variables used in this time series are I(1), but they consist of I(0) and I(1). Due to the mix results, we are not able to use the normal cointegration test. Thus, we have decided to use the ARDL technique to test the long run relationship among the variables.

We have discussed earlier that due to the problems encountered in the unit root tests, we applied the recent technique of ARDL. We first check the long run relation between economic growth, energy consumption and energy price.

LENG	2.1255[.127]
LGDP	1.1117[.367]
LCPI	3.6741[.029]*

Table 6: Variable Addition tests.

*significant at 5% level based on bound 2.476-3.646

The above F-statistics relates to the 'variable addition test', a test to know whether the 'lagged level form' of the variables added to the equation is significant or not. The 'F' statistics will test the joint null hypothesis that the coefficients of the 'level' variables are zero. If the 'F' statistic is significant this means that the null hypothesis of the test, which is there is no long run relationship between the variables, is rejected. From the result, it is seen that when energy consumption (ENG) is taken as the dependent variable, there is no evidence of long run relationship as the calculated F-statistic (2.1255), falls below the critical bound. The same result is found when we make GDP as the dependent variable, as the F statistic (1.1117) falls below the critical bound. Since one of the model's F is significant, in this case CPI (3.6741), it implies that there is a long run relationship that exists between economic growth (GDP), energy consumption (ENG) and energy price (CPI).

Static long run results

The estimation of the ARDL model is based on the Akaike Information Criterion (AIC). The reason we chose the AIC over the SBC for this test is because we have found an issue with our model using SBC in the diagnostics test of normality. The standard error found in AIC is also found to be smaller compared to the one in SBC, thus lesser probability of making Type 1 and Type II error. The static long-run results and the diagnostic test statistics of our estimated model is reported in the following table.

Variable	Coefficient	Standard Error	T-Ratio
LENG	.38890	.11381	3.4170[.002]*
LGDP	.14137	.059009	2.3957[.023]**

Diagnostics Tests

Test Statistic	M-Version	F-Version
A:Serial Correlation	CHSQ(1)= 2.6657[.103]	F(1,28)=2.1124[.157]
B:Functional Form	CHSQ(1) =1.4502[.228]	F(1,28)=1.1109[.301]
C:Normality	CHSQ(2) = 1.8576[.395]	Not applicable
D:Heteroscedasticity	CHSQ(1) = .45771[.499]	F(1,36)=.43891[.512]

Table 7: Long-run estimates based on AIC-ARDL (1,4,1).
Dependent Variable is LCPI
Note: *, ** imply significance at the 1% and 5% levels respectively.
There is no problem detected in the AIC diagnostics test.

The table above shows that LENG and LGDP have the expected positive signs and exert statistically significant effects on CPI. The figures show that a 1% increase in energy consumption will increase the energy price by 0.38% while a 1% increase in GDP will only increase the energy price by 0.14%. The results imply that, in the long run, a long level relationship exists between the variables. This means that when the country uses more energy, the energy price hike of 0.38% will happen. This is congruent with the theory of demand and supply. On the other hand, a 1% increase in GDP increasing the energy price by 0.14% can be explained by the main objective of the country such as Wawasan 2020 as well as the New Economic Model to foster an economic-centred Malaysia. The increase in GDP of the Malaysian economy will drive towards more industrial activities and productivities, increasing the demand for energy supply of the country, thus resulting the increase in energy price. Our findings is rather an interesting turn, as the main focus was to see whether it is the economic growth that results energy consumption or otherwise. Finding the case that, the added variable acting as a proxy for energy prices which is CPI (consumer price index) to have a significant long level relationship with the other two variables ENG and GDP when it is the dependent variable in this test, needs further explanation before we can actually conclude our findings. We therefore proceed with the next test.

Short run dynamics

The short run dynamics of our model using the ARDL is reported in the following table:

Variable	Coefficient	Standard Error	T-Ratio
dLENG	.025572	.038531	.66368[.512]
dLGDP	.0061176	.020764	.29462[.770]
ecm (-1)	-.29981	.089465	-3.3511[.002]*
ecm = LCPI -.38890 (LENG) -.14137(LGDP) + 2.1083(INPT)			
R-Squared .65363	R-Bar-Squared .55808		
S.E. of Regression .012235	F-Stat. F(6,31) 9.1210[.000]		
Mean of Dependent Variable .031446	S.D. of Dependent Variable .018405		
Residual Sum of Squares .0043413	Equation Log-likelihood 118.5464		
Akaike Info. Criterion 109.5464	Schwarz Bayesian Criterion 102.1772		
DW-statistic 1.5320			

Table 8: Short Run Dynamic Results
Dependent Variable is dLCPI.
Note: * implies significance at 1% level.

The results of the short-run dynamics of the coefficients indicate that the variables have the same expected signs as in the static long run test. The ecm value of - .29981, which is between 0 and -1 and its significance means that there exists a partial adjustment. The speed of adjustment here is slow as the ecm coefficient is close to zero (in absolute terms).The magnitude of the coefficient implies that 29% of disequilibrium caused by previous year's shocks converges back to the long run equilibrium in the current year. However, unlike in the static long run, both energy consumption (dLENG) and economic growth (dLDP) was not found to be statistically significant. This is because the long run energy consumption and GDP effects are weak on energy price. This maybe due to the fact that there is much intervention by the government of Malaysia on the consumer price index in the country, in this case the price of energy.

The table below shows the short run-dynamics in the case that the dependent variable is LENG (energy consumption).

Variable	Coefficient	Standard Error	T-Ratio
dLGDP	.22484	.083075	2.7065[.011]**
dLCPI	.38809	.26197	1.4815[.148]
ecm(-1)	-.33946	.15711	-2.1606[.038]**
ecm = LENG -.074385*LGDP -1.1433*LCPI -.74596*INPT R-Squared .30723 R-Bar-Squared .22326 S.E. of Regression .055275 F-Stat. F(3,34) 4.8783[.006] Mean of Dependent Variable .041622 S.D. of Dependent Variable .062718 Residual Sum of Squares .10083 Equation Log-likelihood 58.7874 Akaike Info. Criterion 53.7874 Schwarz Bayesian Criterion 49.6934 DW-statistic 2.0227			

Table 9. Short run dynamics result
Dependent Variable dLENG
Note: ** Significant at 5% level.
LENG here is endogenous

According to the table above, the ecm coefficient -.33946, which is between 0 and -1, as well as its significance at the 5 % level implies that there is partial adjustment. The adjustment speed is also slow in this case as the ecm coefficient is close to zero (in absolute terms). The coefficient implies that 33% of the disequilibrium caused by previous year's shocks converges back to the long-run equilibrium in the current year. The significance of the t ratio of the ecm value indicates that ENG (energy consumption) here is endogenous, as it is significant at 5% level, rejecting the null of that it is exogenous. From the table, it is seen that dLGDP is significant at 5 % level when the dependent variable is dLENG. These results imply that, through the short run dynamics test, there is unidirectional Granger causality running from

GDP to energy consumption. While dCPI has a neutral effect on both energy consumption and GDP(economic growth), due to the government interference mentioned earlier.

The table below shows the short run-dynamics in the case that the dependent variable is dLGDP (economic growth).

Variable	Coefficient	Standard Error	T-Ratio
dLENG	.80791	.29851	2.7065[.011]**
dLCPI	-.090276	.51259	-.17612[.861]
ecm(-1)	-.11458	.12631	-.90710[.371]
ecm = LGDP -2.4459*LENG + .78791*LCPI -10.7237*INPT			
R-Squared .20464		R-Bar-Squared .10823	
S.E. of Regression .10478		F-Stat. F(3,34) 2.8301[.053]	
Mean of Dependent Variable .089672		S.D. of Dependent Variable .11095	
Residual Sum of Squares .36229		Equation Log-likelihood 34.4856	
Akaike Info. Criterion 29.4856		Schwarz Bayesian Criterion 25.3916	
DW-statistic 1.7390			

Table 10. Short-run dynamics result

Dependent Variable dLGDP

GDP here is exogenous

Note: ** Significant at 5% level.

From the table above, it can be seen that the t-ratio of the ecm coefficient is not statistically significant although the ecm coefficient is having the right negative sign and is close to zero (in absolute terms). This result implies that GDP is an exogenous variable as we fail to reject the null hypothesis of exogeneity. This indicates that there is no adjustment done by GDP as it is an exogenous variable. Thus, there is no granger causality of energy consumption to GDP, even though energy consumption is statistically significant here at the 5% level.

Therefore, it is concluded from the short-run dynamic results that there is a unidirectional causality from GDP to energy consumption only, and not vice versa. It is also noted on the granger causality from both economic growth and energy consumption to energy price (CPI) in the short run dynamic as well as in the static long run.

Our results tally, with the findings of Aziz (2011), in the case of Malaysia, Odhiambo (2010) in the case of the three Sub Saharan African countries, Wolde Rufael(2009) and Akinloo (2008) where they found evidence of unidirectional causality from economic growth to energy consumption. These studies together with our findings support the conservation hypothesis on the theory behind the causality of economic growth to energy consumption.

Although the main objective of this study is to find the lead-lag relationship between energy consumption and economic growth only, we wanted to add further small contributions by conducting further tests into this empirical study. These post ARDL tests will not be possible if we only had two variables in this study which is GDP and ENG, but due to the fact that we have included a proxy of energy price which is CPI, we conclude that we are able to do so. However, it is to our disappointment that we are not able to get a proper lag order. We have tried using various lag orders such as 4, 6 and even 12, but a proper lag order could not be found. We assume that the reason may be contributed to the fact that CPI which is a proxy for energy price in this study is controlled by the Malaysian government. Even though we have found a level relationship between the three variables, economic growth (GDP), energy consumption (ENG) and CPI when CPI is made the dependent variable, however in the short run dynamics, both the two variables (GDP & ENG) although they have the correct signs, are not significant. This is because the strength of GDP and ENG on price is weak. Both economic growth and energy consumption would not have been able to affect the CPI so much because of the control index nature the CPI has by the Malaysian government.

This may support our argument that CPI may not be a suitable measure for analytical price movement when there are subsidies involved. According to the International Labour organization (2004:54),

> For some analytical purposes and policy purposes, it may be useful to estimate a CPI that measures price movements excluding the effects of changes in taxes and subsidies. For monetary policy makers, the price increases resulting from changes in indirect taxes leads or subsidies are not part of an underlying inflationary process but are attributable to their own manipulation of these economic levers… An increase in subsidies might be intended to stimulate consumption, but the resulting lower prices could be offset by smaller increase in indexed wages and benefits.

A recent headline in the Kosmo newspaper further states on the continuance of the Malaysian government to subsidize their electrical tariff from 1st January until June 2016, which is 1.54 cents per kilowatt-j for west Malaysia, and 1.20 cents per kilo-watt-j for Sabah and Labuan (Kosmo, 2015). The Malaysian government has also been gradually reforming the subsidy system, via a series of reductions in subsidies for fuel and sugar since 2010 (Nadaraj, 2014).

Both of the excerpts may explain why we are not able to get a proper lag order to proceed with our subsequent tests to further add value to this study. This indicates that including CPI in this empirical relationship to further proceed with the post ARDL steps may not be suitable, when subsidies are at play. Perhaps more relevant variables can be further included in future studies to counter our shortcomings such as carbon dioxide emissions, imports, exports and foreign direct investments. The time period of the study could also be lengthen to include the aftermath of 2014, which is not included in the years we covered in this study. The year 2014 was when the Malaysian government ended all the fuel subsidies ,taking advantage of low prices at the time which potentially saves the government almost RM20 billion ringgit (US $5.97 billion) annually (Nadaraj, 2014), which is not included in the years we covered in this study. The reduction of the subsidies are deemed to strengthen the government finances as well as to improve economic efficiency.

However, the results of the post ARDL tests are still done by the researcher and are attached in the appendices for knowledge reference even though the results are not interpreted and are not able to give more weightage to this study.

Conclusion & policy implications

The purpose of this study was to test the Granger causality between energy consumption and economic growth for Malaysia, including an added variable CPI as the proxy for energy price. Based on our empirical analysis of our annual data derived from 1971 until 2012, we found that there is a unidirectional causality from economic growth to energy consumption which supports the “conservation theory”. Therefore, we are able to negate the notion that energy is not a stimulus for economic growth in this case. Throughout the study, we also captured the existence of a long run level relationship among the three variables; economic growth represented by GDP, energy consumption represented by ENG and energy price (CPI). We also take note on the weak causality found from both economic growth and energy consumption to energy price. However, both energy consumption and economic growth were found to be not significant. We predict that this is because of the intervention of the Malaysian government in controlling the consumer price index, which we used as a proxy for energy price in this study. Hence, we were not able to run further tests post ARDL techniques to make additional contributions to the study.

With the finding of a unidirectional causality from economic growth to energy consumption, this means that measures of energy conservations can be done effectively in the case of Malaysia. The goals of the country to becoming a more developed country towards 2020 may be realised without hindrance as Malaysia is not energy dependent in order to grow after all. Although without restraints, policy makers and forecasters must be wary on the detrimental effects a growing economy can do to its non-renewable energy sources. The empirical results of this study will provide policy makers a better understanding of the energy-consumption nexus to formulate relevant and suitable policies in Malaysia for sustainable development of the country. This issue however deserves further attention in the future. It is suggested that future research will include other variables not included in this study such as carbon dioxide emission, foreign direct investment and others which may be deemed suitable to add more robustness into the study. This is because in conducting this study, we bear in mind the shortcomings of our data as well as our limitations in including other variables which are necessary. However, it is with great hope that this study will be a cursor in light of finding the causality between economic growth and energy consumption using the ARDL techniques in the future.

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