The relationship between energy consumption, financial development and economic growth: an evidence from Malaysia based on ARDL

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The relationship between energy consumption, financial development and economic growth: an evidence from Malaysia based on ARDL

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Abstract

This study aims to examine the short-run and long-run relationship between economic growth, energy consumption, financial development, capital formation and population by using data set of Malaysia for the period 1971–2014. An emerging economy like Malaysia has high energy consumption which is intensified by its growing population. Economic growth and energy consumption in Malaysia have been rising over the past several years. The motivation to this study is related to four policy objectives of Malaysia; economic growth, financial development, energy conservation and reduction on pollution. The auto regressive distributed lag (ARDL) bounds testing approach to test the long run relationship among the variables, while short run dynamics were investigated using the Vector Error Correction Model (VECM). Variance decomposition (VDC) technique was used to provide Granger causal relationship between the variables.The findings suggest that energy consumption is influenced by economic growth and financial development, both in the short and the long run. The population–energy relationship however only holds in the long run. The results have important policy implications for balancing economic growth vis-à-vis energy consumption for Malaysia, and other emerging nations to explore new and alternative sources of energy to meet the rising demand of energy to sustain economic growth.

Key words: GDP, Energy consumption, Financial Development, Capital, Population Growth, Malaysia

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1.0 Introduction

The relationship between economic growth and energy consumption has been one of the most pursued areas of research over the past decades. Numerous studies have investigated the causal relationship between energy consumption and economic growth but the evidences have been inconclusive. As the pursuit for economic prosperity in the emerging nations intensifies, the significance of the subject is expected to gain its momentum. Energy is an essential basis for social and economic development. The increase in vehicles and domestic equipments contributed by the growth in population has led to a significant increase in energy demand. Furthermore, the energy used in the production of goods and services has also been increasing in tandem with the economic growth.

Numerous researchers have focused on examining the relationship between electricity consumption and economic growth including Squalli (2007), Apergis and Payne (2011), Shahbaz et al. (2013), Wolde-Rufael (2014), Rafindadi and Ozturk (2016) and Sarwar et al. (2017). Energy is a relevant factor of domestic production and, hence, economic growth (Costantini and Martini, 2010) and any shortages may cause disruption to the output (GDP) and economic growth of a nation (Shahbaz and Ali, 2016). The significance of the causal relationship between the energy consumption and economic growth has brought about energy policy implications for the policymakers especially energy conservation policies. Policies should be developed to avoid energy wastage and reduce consumption where possible (Shahbaz and Ali, 2016).

Frankel and Romer (1999) pointed out that financial development in a country may attract foreign direct investment (FDI) and in turn can, increase the level of economic growth. However, Jensen (1996) found that financial development may lead to increased industrial activities which may lead to industrial pollution as observed in China from 1953 to 2006. Ang (2008a) pointed out that financial deepening in Malaysia leads to higher FDI inflows and Tamazian and Rao (2010) found that increase in FDI inflows and R&D activities can reduce environmental pollution. Moreover, the limited supply of world oil and natural gas (source of energy) potentially pose a threat to the economic growth. This has brought about discussion on the need for alternate energy sources and the incentive for research and development in this area of concern supported by government grants and government policy.

This area of study on the relationship between energy consumption, financial development and economic growth is essential in supporting the policy makers in policy making. The Granger

(1981) and, Engle and Granger (1987), Autoregressive Distributed Lag (ARDL) cointegration technique or bound test of cointegration (Pesaran et al. 2001) and, Johansen and Juselius (1990) cointegration techniques have become the solution to determining the long run relationship between series that are non-stationary, as well as reparameterizing them to the Error Correction Model (ECM).The objective of this paper is to examine the long run relationship between energy consumption, financial development, economic growth, capital formation and population for Malaysia by implementing the autoregressive distributed lag (ARDL) approach to cointegration; and test the direction of causality using the Vector Error Correction Models (VECM).

Industrialization of Malaysia in the 1970s and 1980s has contributed to its rapid economic growth, accompanied by significant improvement in its financial system. As illustrated n Figure 1, the ratio of domestic credit to GDP increased from 24% in 1970 to 69% in 1980 and peaked at 163% of GDP in 1997. Malaysia's financial sector and its economy were severely affected by the Asian financial crisis explaining the negative GDP growth of 7.4% in 1998 but rebound quickly in 1999. The ratio of domestic credit to GDP has been declining since the Asian financial crisis and reached 109% of GDP in 2007. Market capitalization as a % of GDP also increased from 61% in 1981 to 321% in 1993 but went down to 82% of GDP during the Asian financial crisis in 1998.

Today, Malaysia is the third largest economy in Southeast Asia and the 35th largest economy in the world. The government's development plans under the Tenth Malaysia Plan is largely centered on accelerating economic growth through the three selected sectors (agriculture, manufacturing and services) of the economy and building infrastructure to support these sectors. Malaysia prides of being the highest growth economy amongst the emerging nations.

Studies conducted have validated the correlation between energy consumption and economic growth but the causality direction between them is still outstanding. Does energy consumption lead to economic growth or does economic growth promote energy consumption?

Given that the three major public policy goals of Malaysia are economic growth, financial development and population growth, policymakers is interested to understand the long and short run causality among the series and their direction which will aid in their policy making decision.

2.0 Literature review

2.1 Theoretical Perspectives on Energy Consumption and Economic Growth

Studies conducted have validated the correlation between energy consumption and economic growth but the causality direction between them is still outstanding. Does energy consumption lead to economic growth or does economic growth promote energy consumption? The study of interaction between economic activities and energy consumption was first published in the 1950s by Mason (1955) and Frank (1959). The studies of Kraft and Kraft (1978) found unidirectional causality between energy consumption and economic growth in the US market for the period 1947 to 1974. The interest in this topic has lead to many more studies done including Grossman and Krueger (1995) and Selden and Song (1994), Akarca and Long (1980), Erol and Yu (1988), Masih and Masih (1996), Aqeel and Butt (2001), Soytas and Sari (2003), Lee (2006), Huang et al. (2008), Narayan and Smyth (2008), Bowden and Payne (2009), Lee and Chien (2010), Shahbaz and Lean (2012a) and Shahbaz and Feridun (2012).

Although economic theories do not explicitly state a relationship between these variables, theoretically the possible directions of causality can be explained by supply-leading and demand-following hypothesis (Patrick, 1966). The supply-leading hypothesis infers a causal relationship from energy consumption to economic growth i.e. energy consumption will lead to economic growth. The demand-following hypothesis infers the opposite i.e. economic growth leads to energy consumption. Studies found there is a relationship between energy consumption and economic growth.

McKinnon (1973), King and Levine (1993a, b), Neusser and Kugler (1998), Darrat (1999), Levine, Loayza and Beck (2000), Fase and Abma (2003), Christtopoulos and Tsionas (2004), Chang and Caudill (2005), Rousseau and Vuthipadadorn (2005), Apergis and Payne (2009), Ozturk et al. (2010), Ouedraogo (2013) and Aslan et al. (2014b) validated the growth hypothesis i.e. energy consumption leads to economic growth while Gurley and Shaw (1967), Jung (1986), Lucas (1988), Chandavarkar (1992), Liang and Teng (2006), Huang et al. (2008), Narayan et al. (2010), and Kasman and Duman (2015) validated the conservative hypothesis i.e. that economic growth influences energy consumption.

2.2 Empirical Review

The early empirical studies examined the energy-growth relationship using traditional stationary econometric approach such as Granger and Sims causality test based on the VAR methodology

(Akara and Long 1980, Yu and Wang 1984, Yu and Choi 1985). The long-term and short-term relationship between energy consumption and economic growth has also been extensively investigated using non-stationary approaches such as Vector Error Correction Model (VECM) to test for Granger causality (Cheng and Lai 1997, Stern 2000, Narayan and Singh 2007, Ghosh 2009, Iyke 2015 and Shabhaz et al. 2016). Narayan and Singh (2007), Ghosh (2009), Shahbaz and Lean (2012) and Polemis and Dagoumas (2013) have sought to explain the electricity-growth nexus by using symmetric causality tests.

Researcher such as Al-Iriani (2006), Narayan and Smith (2009), Costantini and Martini (2010), Acaravci and Ozturk (2010), Wolde-Rufael (2014) and Karanfil and Li (2015) applied panel methods to test for cointegration and Granger causality. Costantini and Martin (2010) and Acaravci and Ozturk (2010) suggest use of panel techniques related to unit root, cointegration and causality tests to eliminate the problems associated traditional unit root and cointegration tests.

Investigating electricity consumption - economic growth nexus in Pakistan, Shahbaz and Lean (2012) found that electricity consumption has a positive effect on economic growth. The empirical evidence provides a bi-directional Granger causality between electricity consumption and economic growth in the short run suggesting that an electricity conservation policy may hinder economic growth. In the case of Greece for the period 1970 to 2011, Polemis and Dagoumas (2013) empirical findings revealed that Greece is an energy dependent country and energy conservation policies by the policymakers can boost economic activity.

Narayan and Smyth (2009) found that incorporating other relevant factor in the production function changes the causality direction. Shabhaz et al. (2013) argue that the exclusion of some relevant variables in the empirical model clearly causes inconsistency in the econometric specification and introduces biased estimates. This study considers the vital role of financial development in production. Financial development has a positive effect on energy consumption which is positively related to economic growth (Sadorski 2011b, Aslan et al. 2014, Rashid and Yousaf 2015 for among others). Financial development may contribute to economic growth directly and indirectly via capitalization (Shahbaz et al. 2017). Financial development affects electricity consumption via consumer, wealth and business effects (Sardosky 2010, Shahbaz and Lean 2012). According to Sadorski (2011b), this positive causality can be explained by three effects: the direct effect (households consuming), business effect (industrial production) and confidence effect (known as the wealth effect). Financial development is measured by banking variables such as bank deposits, financial system deposits and liquid liabilities.

3.0. Data

We have taken annual data from the World Development Indicator (WDI) published by the World Bank for the period 1971–2014. The study comprises of time series data on GDP growth (annual percentage), energy use (kg of oil equivalent), domestic credit to private sector (percentage of GDP), gross fixed capital formation (annual percentage growth) and population growth (annual percentage) of Malaysia. These variable has been used in numerous studies including Soytas and Sari (2009), Menyah and Rufael (2010), Shahbaz and Lean (2012), Dogan (2015b), and Streimikienne and Kasperowicz (2016). There are bank-based and market-based financial indicators to measure financial development. We have applied the commonly used domestic credit as a % of GDP as a proxy for financial development (Clarke et al, 2006; Ang, 2010; Shahbaz and Islam, 2011; Baligh and Piraee, 2013; Naceur and Zhang, 2016; and others).

As explained in the earlier section, economic growth also relies on other important inputs such as financial development. Financial development is crucial in its role in sustaining energy efficient technology (Shahbaz et al. 2011 and Tang et al. 2013) in enhancing domestic production and investments in reducing greenhouse gases emissions. We included capital formation variable as empirical evidence suggest that capital facilitates the transition from fossil fuels to alternative renewable energy sources (Best, 2017).

The description of each variable is summarized below:

- Gross domestic product (GDP) in annual percentage growth rate of GDP at market prices based on constant local currency
- Energy consumption (ENE) measured in kg of oil equivalent per capita
- Domestic credit to the private sector per capita is a measure of financial development
- Gross fixed capital formation per capita is a proxy for capital
- Population growth (annual %)

Figure 1 displays the time trend of the variables. The plot for GDP and CAP shows a close relationship between the two variables and a steep in 1998 i.e. during the Asian Financial Crisis. We transform the variables to logarithmic form to make the series stationary in its variance as displayed in figure 1. Detailed data descriptions, sources and transformations are provided in the appendix 1.

We aim to explore whether changes in the economic growth – energy consumption relationship are dependent to changes in the domestic credit to the private sector (DCP) and capital (CAP) which was used as a proxy for financial development. We perform standard time series econometrics methodologies: unit root tests and cointegration analysis. If a long-run relationship does exist, we can apply error correction modeling technique to ascertain the causal direction.

Figure 2. LGDP, LENE, LDCP, LCAP and LPOP

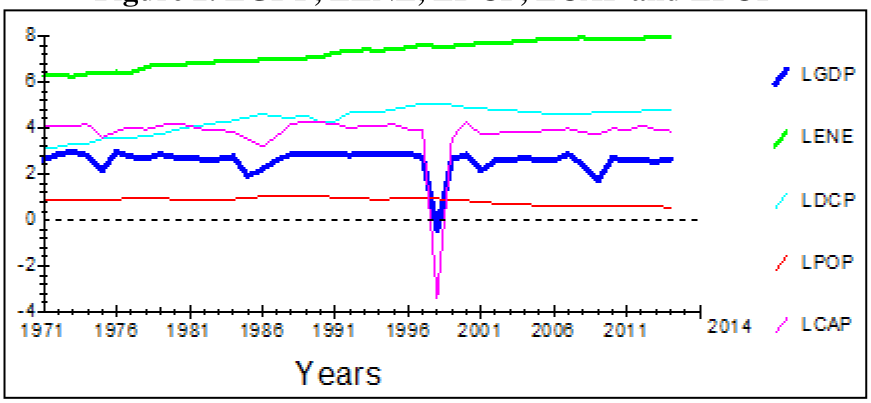
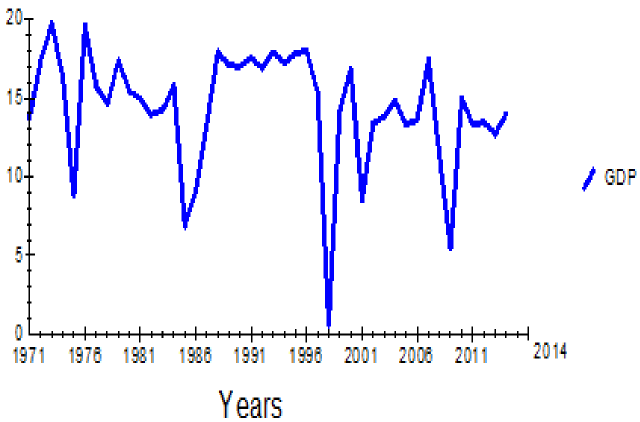
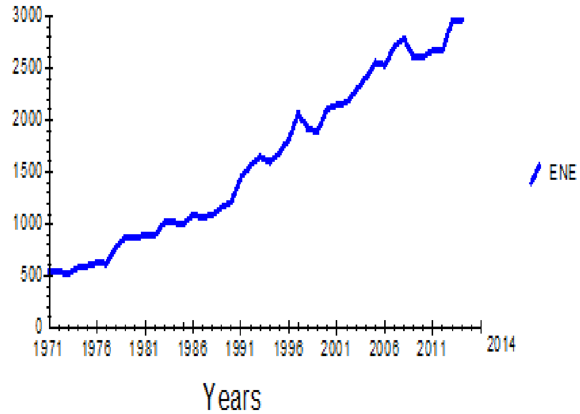


Figure 1: Trends in GDP, ENE, CAP, DCP AND POP for Malaysia from 1971 to 2014

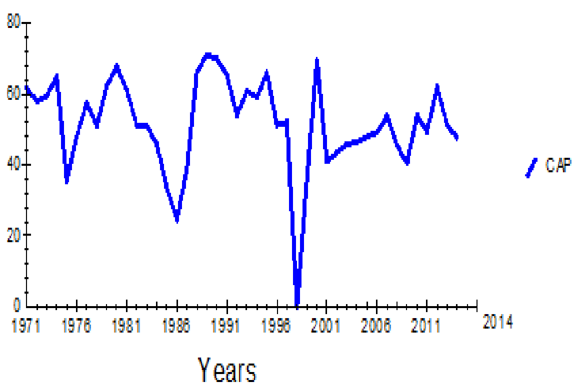
a) GDP per capita



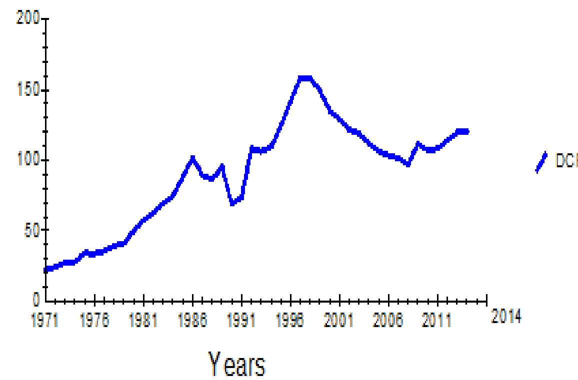
***b) Energy use per capita** (kg of oil equivalent)*



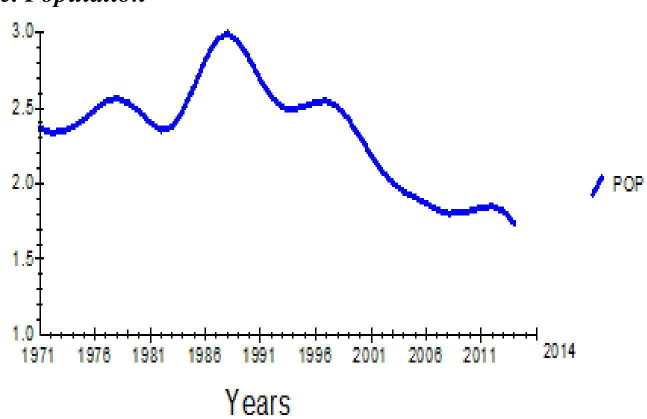
c) Capital Formation



d) Financial development



e. Population



4.0 Methodology

This paper employs the ARDL bounds testing cointegration approach to inspect whether a long run dynamic relationship exists between GDP, energy consumption, financial growth, capital formation and population growth. Various approaches have been applied to test the presence of cointegration between variables in numerous studies and are explained in this section.

4.1 Unit Root / Stationarity Tests

A non-stationary time series is a stochastic process with unit roots or structural breaks. The presence of a unit root indicates that a time series under consideration is non-stationary and the absence a unit root indicates time series is stationary. The unit roots test is required to ascertain the number of times a variable has to be differenced to achieve stationarity. A variable Y, is said to be integrated of order d, I(d)] if it attained stationarity after differencing d times (Engle and Granger, 1987). There are various methods of testing unit roots including Durbin-Watson (DW) test, Dickey-Fuller test(1979)(DF), Augmented Dickey-Fuller(1981) (ADF) test, Philip-Perron (1988) (PP) test and Kwiatkowski-Phillips-Schmidt-Shin (1992) (KPSS).

Standard unit root tests were used to assess if the variables were stationary: the Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test. Dickey and Fuller (1981) recommended the ADF test to handle the AR(p) process in the variables. Perron (1989) noted that the unit root problem in the series may cause biased empirical results. The ADF and PP tests the null hypothesis of a unit root, against the alternative that it is stationarity. The ADF test adjusts the DF test to take care of possible autocorrelation in the error terms by adding the lagged difference term of the dependent variable. The PP test also takes cares of the autocorrelation in the error term and heteroscedasticity.

$\mathbf{H_0}$: p_1 =0 ($p_1 \sim$ I(1)), i.e. not stationary

$\mathbf{H_A}$: $p_1 < 0$($p_1 \sim$ I(0)). i.e. it is stationary

When a series has a unit root *(p1 =0),* any shock to the data series is long lasting and hence suggest stability in any policy formulation and implementation.

4.2 Tests for Lag Order Selection

The ARDL econometric specification relies on the assumption that the error term is serially uncorrelated. Therefore, it is important to choose an appropriate lag order *p* that is high enough to remove problems of serial correlation. However, given the relatively small sample size we should avoid over-parameterization and be careful not to include too many lags. The Schwartz-Bayesian Criterion (SBC), Akaike Information Criterion (AIC) or Hannan-Quinn Criterion (HQC). is used to determine the optimal number of lags included in the test. AIC focuses on a large value of log-likelihood and hence chooses a higher order of lags, whereas SBC is concerned with over-parameterization and selects a lower order of lags.

4.3 ARDL Model to Test Cointegration

The ARDL bounds testing cointegration approach by Pesaran, Shin, and Smith (2001) to examine the existence of a long run dynamic relationship between GDP, energy consumption, financial development, capital formation and population growth. Researchers have applied various approaches to test the presence of cointegration between variables in their studies. Two most common approaches used is the Engle and Granger test (Engle and Granger, 1987) for bivariate data and Johansen test (Johansen and Juselius, 1990) when multivariate. Both tests require that all the series should be integrated at the order of integration I(1). Engle-Granger test for one cointegrating relationship and Johansen test allows for multiple cointegrating relationships.

The ARDL bounds testing procedure involves two stages; first to test for the existence of a long-run relationship between the variables and second to estimate the coefficients of the long-run relations and make inferences about their values. The calculated F-statistic is compared against the upper critical bound (UCB) and lower critical bound (LCB) provided by Pesaran et al. (2001) which correspond to the assumptions that the variables are I(0) and I(1) respectively. If the computed F-statistic is greater than the UCB value, then the H0 is rejected (the variables are cointegrated). If the F-statistic is below the LCB value, then the H0 cannot be rejected (there is no cointegration among the variables). If it falls between the LCB and UCB value, the result of the inference is inconclusive.

cointegration is inconclusive if it is between the UCB and the LCB. While these asymptotic critical values are reliable for large samples. For smaller samples ranging from 30 to 80 observations, Narayan (2005) provides F-test the critical values bounds. The computed F-tests in this subsection will be compared against both sets of critical values.

The ARDL bound testing is more suitable than other traditional cointegration tests as it corrects for endogeneity problem. Furthermore, traditional Engel-Granger test is unable to test long run relationships of variables. The ARDL method can be used for data series integrated at the order I(0) or I(1) and calculates short run and long run parameters simultaneously. The ARDL approach is superior in small samples to other single and multivariate cointegration methods (Narayan, 2005).

The ARDL model specifications of the functional relationship between Gross Domestic Product (GDP), Energy Consumption (ENE), Financial Growth (DCP), Capital Formation (CAP) and Population Growth (POP) is shown below:

$$\Delta GDP_t = a_0 + \sum_{t=1}^{p} b_1 \Delta GDP_{t-1} + \sum_{t=1}^{p} c_1 \Delta ENE_{t-1} + \sum_{t=1}^{p} d_1 \Delta DCP_{t-1} + \sum_{t=1}^{p} e_1 \Delta CAP_{t-1} + $$
$$+ \sum_{t=1}^{p} f_1 \Delta POP_{t-1} + \delta_1 GDP_{t-1} + \delta_2 ENE_{t-1} + \delta_3 DCP_{t-1} + \delta_4 CAP_{t-1} + \delta_5 POP_{t-1} + \varepsilon_t$$

$$\Delta ENE_t = a_0 + \sum_{t=1}^{p} b_1 \Delta GDP_{t-1} + \sum_{t=1}^{p} c_1 \Delta ENE_{t-1} + \sum_{t=1}^{p} d_1 \Delta DCP_{t-1} + \sum_{t=1}^{p} e_1 \Delta CAP_{t-1} + $$
$$+ \sum_{t=1}^{p} f_1 \Delta POP_{t-1} + \delta_1 GDP_{t-1} + \delta_2 ENE_{t-1} + \delta_3 DCP_{t-1} + \delta_4 CAP_{t-1} + \delta_5 POP_{t-1} + \varepsilon_t$$

$$\Delta DCP_t = a_0 + \sum_{t=1}^{p} b_1 \Delta GDP_{t-1} + \sum_{t=1}^{p} c_1 \Delta ENE_{t-1} + \sum_{t=1}^{p} d_1 \Delta DCP_{t-1} + \sum_{t=1}^{p} e_1 \Delta CAP_{t-1} + $$
$$+ \sum_{t=1}^{p} f_1 \Delta POP_{t-1} + \delta_1 GDP_{t-1} + \delta_2 ENE_{t-1} + \delta_3 DCP_{t-1} + \delta_4 CAP_{t-1} + \delta_5 POP_{t-1} + \varepsilon_t$$

$$\Delta CAP_t = a_0 + \sum_{t=1}^{p} b_1 \Delta GDP_{t-1} + \sum_{t=1}^{p} c_1 \Delta ENE_{t-1} + \sum_{t=1}^{p} d_1 \Delta DCP_{t-1} + \sum_{t=1}^{p} e_1 \Delta CAP_{t-1} + $$
$$+ \sum_{t=1}^{p} f_1 \Delta POP_{t-1} + \delta_1 GDP_{t-1} + \delta_2 ENE_{t-1} + \delta_3 DCP_{t-1} + \delta_4 CAP_{t-1} + \delta_5 POP_{t-1} + \varepsilon_t$$

$$\Delta POP_t = a_0 + \sum_{t=1}^{p} b_1 \Delta GDP_{t-1} + \sum_{t=1}^{p} c_1 \Delta ENE_{t-1} + \sum_{t=1}^{p} d_1 \Delta DCP_{t-1} + \sum_{t=1}^{p} e_1 \Delta CAP_{t-1} + $$
$$+ \sum_{t=1}^{p} f_1 \Delta POP_{t-1} + \delta_1 GDP_{t-1} + \delta_2 ENE_{t-1} + \delta_3 DCP_{t-1} + \delta_4 CAP_{t-1} + \delta_5 POP_{t-1} + \varepsilon_t$$

The ARDL cointegration test is testing the following hypotheses:

$\mathbf{H_0} = \delta_1 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$; (there is no cointegration i.e. no long run relationship between the variables)

$\mathbf{H_A} = \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$ (i.e. there is cointegration or long run relationship between the variables)

This is tested in each of the models as specified by the number of variables and denoted as follows:

$F_X (X_1 \mid Y_1 \ldots . Y_k)$

$F_Y (Y_1 \mid X_1 \ldots . X_k)$

The hypothesis is tested by means of the F- statistic (Wald test).

4.4 Error Correction Model (ECM)

The ARDL model establishes the existence of a long-run relationship between economic growth and energy consumption but it does not explain the short-run dynamics that brings about the long-run equilibrium. We use the t-statistic of the error correction model (ECM) to test the causality of the variables while the coefficient of the ECT from the ECM indicates the speed of adjustment of the dependent variable towards its long run equilibrium. ECM identifies which variable is exogenous (strong) and which is endogenous (weak) If the value is zero, then there exists no long-run relationship. If the speed of adjustment value is between -1 and 0, then there exists partial adjustment.

The ECM tests the following hypothesis:

$\mathbf{H_0}$: The variable is exogeneous

$\mathbf{H_A}$: The variable is endogenous

4.5 Variance Decomposition (VDC)

ECM model only provides information about the absolute endogeneity or exogeneity. The relative degree of endogeneity or exogeneity of the variables can be determined using the variance decomposition (VDC) test. The VDCs provides a decomposition of the variance of the forecast errors of each of the variables in the VAR (vector auto regression) at different horizons into proportions attributable to shocks from each variable in the system including its own. The variable that depends most on its own past is the most exogenous. To affect the endogenous variable, policymakers will set the exogenous variable as an intermediate target.

From the two types of VDCs, generalized VDC is preferred as it is invariant to the ordering of the variables and is self-dependence in response to shocks. The orthogonalized VDCs however are not unique and are dependent on the particular ordering of the variables in the VAR. It also assumes that when a particular variable is shocked, all other variables in the model are switched off. generalized forecast error VDC permits one to make robust correlation of the
strength, size and persistence of shocks from one equation to another (Payne, 2002)

4.6 Impulse Response Functions (IRFs)

Impulse response function (IRF) displays the impact of a shock on one variable to others and validates the degree of response and the time horizon taken to normalize. IRF provides similar information to VDC in graphical form. When there is a shock to endogenous variable, the exogenous variables are highly affected as it takes shorter period to normalize.

5.0 Findings and Discussion

5.1 Unit Root Tests

The result for the five variables from both ADF and PP tests is summarized in Table 1a and Table 1b below. The differenced form of variables is integrated of order two, I(2) indicating the existence of a unit root. The ADF and PP test found the series to be non-stationary at level form and stationary at different form

Table 1a: Empirical results of a Unit Root Tests (ADF)

Level Form				*Difference Form*			
VARIABLE	**T-STAT.**	**C.V.**	**RESULT**	**VARIABLE**	**T-STAT.**	**C.V.**	**RESULT**
LGDP	-3.1038	-3.5313	Non-stationary	DGDP	-3.6321	-3.5348	Stationary
LCAP	-2.5497	-3.5313	Non-stationary	DCAP	-3.7553	-3.5348	Stationary
LDCP	-2.2450	-3.5313	Non-stationary	DENE	-6.0034	-3.5348	Stationary
LPOP	-.86131	-3.5313	Non-stationary	DDCP	-2.8664	-3.5348	Non-stationary
LENE	-2.1356	-3.5313	Non-stationary	DPOP	-3.2236	-3.5348	Non-stationary

Difference Form (Second)

VARIABLE	**T-STAT.**	**C.V.**	**RESULT**
DGDP	-6.620035	-3.615588***	Stationary
DCAP	-4.961703	-3.626784***	Stationary
DENE	-6.452480	-3.615588***	Stationary
DDCP	-10.30228	-3.605593***	Stationary
DPOP	-3.562778	-2.948404**	Stationary

**** Show significance at the 1% level*
*** Show significance at the 5% level*
** Show significance at the 10% level*

Table 1b: Empirical results of a Unit Root Tests (PP)

Level Form *First Difference Form*

VARIABLE	T-STAT.	C.V.	RESULT	VARIABLE	T-STAT.	C.V.	RESULT
DGDP	-6.307457	-3.592462***	Stationary	DGDP	-30.20152	-3.596616***	Stationary
DCAP	-6.166937	-3.592463***	Stationary	DCAP	-37.38675	-3.596616***	Stationary
DENE	-1.643071	-2.603944*	Non-stationary	DENE	-7.145207	-3.596616***	Stationary
DDCP	-2.659923	-2.603944*	Stationary	DDCP	-5.782205	-3.596616***	Stationary
DPOP	-0.230937	-2.603944*	Non-stationary	DPOP	-2.416331	-2.604867*	Non-stationary

**** Show significance at the 1% level*
*** Show significance at the 5% level*
** Show significance at the 10% level*

5.2 Tests for Lag Order Selection

The corresponding value to the highest AIC in Table 2 suggest lag order of 3.

Table 2: Optimal Lag Selection

Order	LL	AIC	SBC	LR test	Adjusted LR test
4	228.3958	123.3958	36.0588	------	------
3	210.7277	**130.7277**	**64.1852**	CHSQ(25)= 35.3363[.082]	16.3090[.905]
2	180.7371	125.7371	79.9891	CHSQ(50)= 95.3174[.000]	43.9927[.712]
1	133.6659	103.6659	78.7125	CHSQ(75)= 189.4598[.000]	87.4430[.154]
0	86.9307	81.9307	77.7718	CHSQ(100)= 282.9303[.000]	130.5832[.022]

AIC=Akaike Information Criterion SBC=Schwarz Bayesian Criterion

5.3 ARDL Approach to Cointegration

The results for F-test for cointegration are presented in Table 3. Overall, we find sufficient evidence of a long-run relationship when LGDP and LCAP are the dependent variables.

Table 3: Empirical results of ARDL Tests – F-test

Models	F-statistics
FLGDP (LGDP | LENE, LDCP, LCAP, LPOP)	3.5744***
FLENE (LENE | LGDP, LDCP, LCAP, LPOP)	2.5867
FLDCP (LDCP | LGDP, LENE, LCAP, LPOP)	1.2391
FLCAP (LCAP | LGDP, LENE, LDCP, LPOP)	3.0260*
FLPOP (LPOP | LGDP, LENE, LDCP, LCAP)	0.81684

***** Show significance at the 1% level*
*** Show significance at the 5% level*
** Show significance at the 10% level*

F-stat			
Significance	10%	5%	1%
LCB	1.825	2.157	2.903
UCB	2.943	3.340	4.261

The ARDL bound test result above reveals that the calculated F-statistics exceeded the upper critical value in two out of six equations tested at standard acceptable significance levels. We conclude that the variables are cointegrated and there is long-run theoretical relationship \among economic growth, energy consumption, financial growth, capital formation and population growth of Malaysia for the period of 1976-2014.

Table 4: Empirical results of ARDL Tests – F-test

K	LGDP
LENE	.47154**
LDCP	-.42195**
LCAP	.47089***
LPOP	1.3287***
INPT	-1.9619

***** Show significance at the 1% level*
*** Show significance at the 5% level*

The results in above table reveals that there is a positive long run relationship between energy consumption and GDP and highly significant at 5%. This implies that a 1% increase in energy consumption would increase GDP by 4.72% and supports the numerous studies that found positive relationship between energy consumption and GDP (Khan and Qayyum, 2006). Hence, energy consumption is crucial in generating economic growth.

Similarly, there is positive long run relation between fixed capital formation and GDP and population growth and GDP. Both relationships are highly significant at 1%. This implies that a 1% increase in fixed capital formation or population growth would increase GDP by 4.71% and 13.79% respectively. The positive long run relationship does not hold for Domestic credit to the private sector (proxy for financial growth) as our findings reveal that an increase in financial growth leads to negative economic growth.

5.4 Error Correction Model (ECM)

The result of T-stat and the causality coefficient of ECM test are shown in table 5. We found that only CAP and POP is significant and thus is endogenous. Meanwhile GDP, DCP and ENE are found to be exogenous (not statistically significant in ECM model).

Table 5: Error Correction Model

Dependent Variable = Economic Growth

	Coefficient	Standard error	T-Stat	Probability	Result
dLCAP	0.43350	0.030139	14.3833***	0.000	Exogenous
dLDCP	-0.31310	0.24063	-1.3012	0.202	Endogenous
dLPOP	1.0957	0.50510	2.1693	0.037	Endogenous
dLENE	0.43468	0.28846	1.5069	0.141	Endogenous
ecm (-1)	-1.000	0.000	-7.1735	0.000	

**** Show significance at the 1% level*
*** Show significance at the 5% level*
** Show significance at the 10% level*

The results imply that when we shock capital formation the exogenous variables (GDP, ENE, DCP and POP) will affected. Hence, should the policymakers wish to control the exogenous variables e.g. energy consumption, they should control the fixed capital formation in the country.

The exogenous variables would receive market shocks and transmit the effects of those shocks to other variables. The coefficient of ecm(-1) tells us how long it will take to get back to long term equilibrium if that variable is shocked. The coefficient of the error correction term i.e. ecm(-1) is negative and statistically significant suggesting that it would take a long time for the equation to return to equilibrium once it has been shocked.

ECM model only distinguishes the absolute endogeneity and exogeniety of a variable but does indicate the relative degree of endogeneity or exogeneity. This can be identified using the variance decomposition technique (VDC).

4.5 Variance Decomposition (VDC)

The results from the VDC test is shown in table 6. The variable ranked higher is the leading variable, and should targeted by policymakers. We include three time horizons, 5, 10 and 15, to depict the short-term, the medium-term and the long-term impact of shocks, respectively. As seen in table 6, capital formation is the most exogenous while energy consumption is most endogenous for time horizon 5 years. The standing of capital formation and energy growth remained throughout the 15 years. However the standing of most endogenous variable changed to population growth in 10 years horizon and financial growth in 15 years horizon.

5.6 Impulse Response Functions (IRFs)

Figure 2 are the graph for IRFs for the period of 30 years. The graph explains that when the capital is shock, we can see the fast response from the other four variables but normalizes after a certain time horizon. Judging by the graph, GDP and CAP normalizes after 4 year horizon, ENE after 10 years horizon and DCP and POP takes more than 10 years to normalize after a ‘shock’. The endogenous variables are more affected and the exogenous variables are least affected.

Hence policymakers will make decision on GDP will influence the CAP as changes in CAP will give impact on GDP.

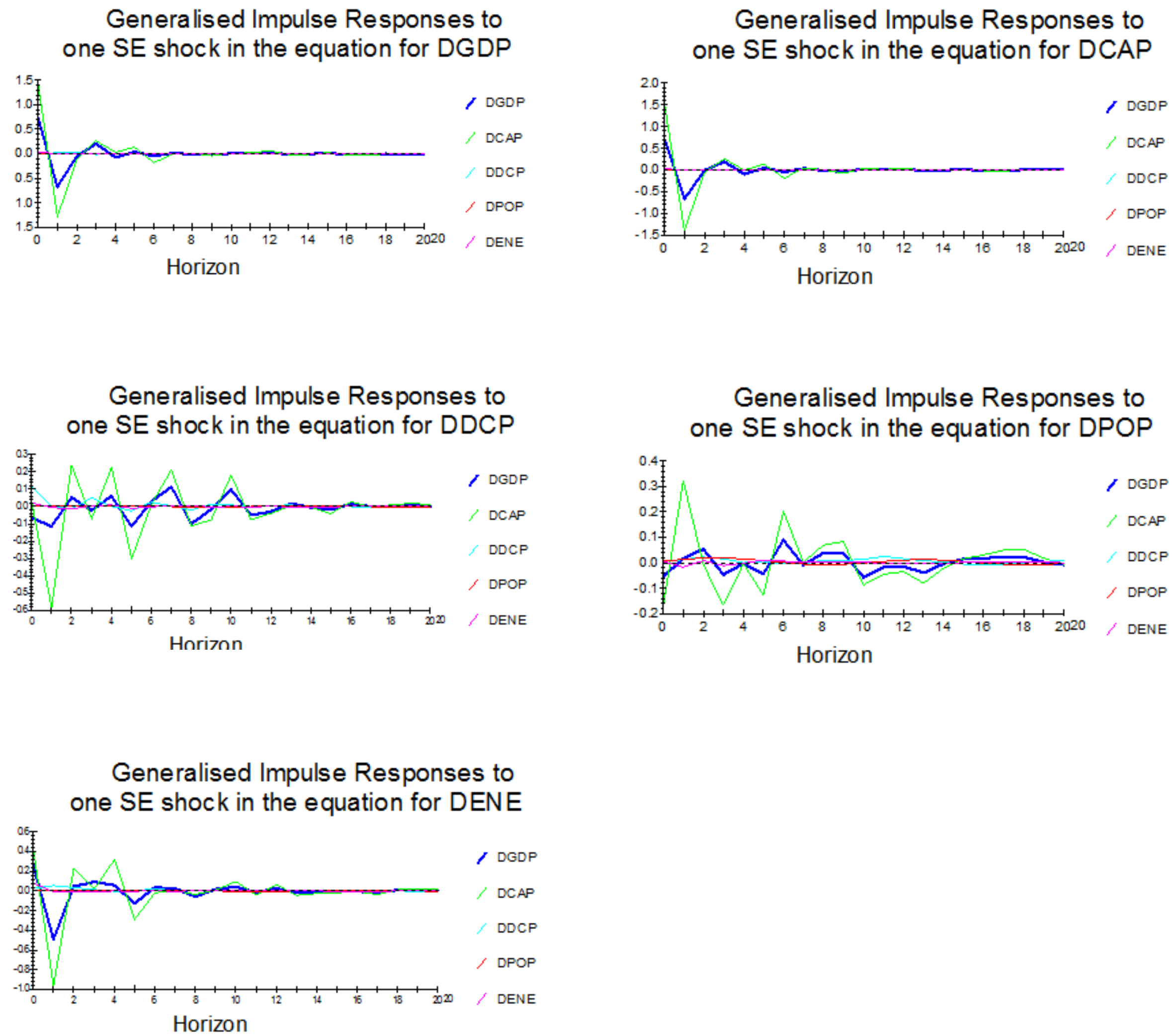
Table 6. Variance Decomposition (VDCs) for Horizon 5, 10 and 15

	Horizon	LGDP	LCAP	LDCP	LPOP	LENE	TOTAL	RANK
LGDP	**5**	21%	72%	5%	0%	1%	100%	**2**
LCAP	**5**	24%	70%	3%	0%	3%	100%	**1**
LDCP	**5**	33%	62%	4%	0%	0%	100%	**4**
LPOP	**5**	22%	65%	3%	5%	5%	100%	**3**
LENE	**5**	29%	67%	2%	2%	0%	100%	**5**

	Horizon	LGDP	LCAP	LDCP	LPOP	LENE	TOTAL	RANK
LGDP	**10**	27%	42%	18%	4%	9%	100%	**2**
LCAP	**10**	36%	59%	1%	1%	3%	100%	**1**
LDCP	**10**	25%	66%	5%	1%	2%	100%	**3**
LPOP	**10**	35%	54%	9%	0%	1%	100%	**5**
LENE	**10**	28%	67%	2%	1%	1%	100%	**4**

	Horizon	LGDP	LCAP	LDCP	LPOP	LENE	TOTAL	RANK
LGDP	**15**	32%	50%	15%	1%	2%	100%	**2**
LCAP	**15**	33%	44%	19%	0%	3%	100%	**1**
LDCP	**15**	27%	63%	2%	5%	2%	100%	**5**
LPOP	**15**	36%	37%	11%	14%	2%	100%	**3**
LENE	**15**	2%	50%	30%	13%	7%	100%	**4**

Figure 2: Impulse Response Functions (IRFs) results – 30 year



6.0 CONCLUSION AND POLICY IMPLICATIONS

This study investigated the relationship between economic growth, and energy consumption in Malaysia using annual time series data for the period of 1976 – 2014. ARDL cointegration method developed by Shin et al. (2014) was applied and we tested the causal relationship between the variables using VECM, VDCs and IRF tests. The empirical results provide evidence that the variables are asymmetrically cointegrated. The finding of this study is crucial as it suggests that a change in the energy consumption will affect the economic growth in Malaysia and the impact of a reduction in energy consumption will have a larger effect compared to an increase in energy consumption. Policymakers in Malaysia can influence the economic growth in Malaysia by controlling the energy consumption of the nation. Government incentives in encouraging energy saving behavior and development of alternate source of energy can lead to sustained economic growth without impacting the production level of the nation.

The findings also revealed positive relationship between financial development and economic growth, population growth and economic growth and capital formation and economic growth. The coefficient and raking of capital formation suggest that this variable is most significant among the variables in the study. Positive shock to capital formation will lead to higher long-term fiscal investments in infrastructure development and hence increases economic growth in the long term. We recommend that the policymakers in Malaysia to focus on improving fixed capital formation and encourage larger sum of investment in infrastructure development for sustainable economic growth.

Last not but least, the causality result recommends that to influence the GDP i.e. economic growth, policymakers should impact capital formation to influence the economic growth in the short term, medium and in the long run (5 to 15 years horizon). This can be done via not only infrastructure upgrade but also policies to encourage capital investment. Perhaps including foreign direct investment as a control variable may enhance the findings and strengthen the findings on the influence of CAP on GDP.

Appendix 1: Data Transformations

Economic Growth	LGDP=LOG(GDP) DLGDP=LGDP – LGDP(-1)
Energy Consumption	LENE = LOG(ENE) DLENE = LENE – LENE(-1)
Financial Development	LDCP = LOG(DCP) DDCP = LDCP – LDCP(-1)
Capital Formation	LCAP = LOG(CAP) DCAP = LCAP – LCAP(-1)
Population	LPOP = LOG(POP) DPOP = LPOP – LPOP(-1)

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