The Effect of Public Debt on Energy-Growth Nexus: Threshold Regression Analysis

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Abstract

ASEAN countries are dealing with challenging external environment recently with the deterioration of the global commodity price and the volatility of oil price. Most of the developing countries rely heavily on the energy consumption for the economic development purpose especially ASEAN countries which are the major energy exporter like Malaysia and Indonesia. This study aims to examine the relationship between energy consumption and economic growth from the perspective of public debt for Indonesia and Malaysia between periods of 2000 - 2013 via the threshold regression analysis. Our empirical results indicate that there are significant relationship between energy consumption and economic growth from the public debt threshold perspective for both countries. The analysis of Indonesia shows that higher level of public debt will lead to greater impact on energy consumption and economic nexus. In contrast, the impact of the energy consumption on economic growth for the case of Malaysia indicates a diminishing trend in the energy and economic growth nexus when the public debt is above the threshold level. Important policy implication from this study suggests that Indonesia and Malaysia should be more careful in formulating the energy consumption related policy by considering different perspectives such as public debt level of the nation. Moreover, both countries should consider reducing their dependence on the non-renewable energy resources and shifting to renewable energy resources such as solar, hydro, landfill gas for their economic development in the future.

Keywords: Energy consumption; economic growth; public debt; threshold regression analysis.

JEL classification: Q43; O40; H63; C32

1. Introduction

Energy is key resources that contribute to the industrial and economic development in any nation. The contribution of energy in economy of production can be viewed from demand and supply perspectives. On the demand side, electricity consumption is one of the form of energy that used by customer to satisfy their utility. Meanwhile, energy is viewed as vital factor of production from the supply side to increase the national output and stimulate the economic growth of a nation (Mathur et. al, 2016). High demand on energy which engaged in the process of economic development is rising from year to year especially in developing countries over the last 50 years (Omay et.al, 2015). Developing countries like Association of Southeast East Asian Nations (ASEAN) member countries are playing essential roles to influence the trends of world energy consumption. However, most of the ASEAN countries are dealing with challenging external environment recently with the deterioration of the global commodity price and the volatility of oil price. These countries rely heavily on the energy consumption where the energy serves as one of the driver for growth in this region

especially those major fossil-fuel producer and exporter like Indonesia and Malaysia. According to World Energy Outlook Special Report (2015), energy demand of ASEAN member countries escalated over 50% between 2000-2013. Besides, this report revealed that Indonesia is the largest energy consumer among the ASEAN member countries as well as the world largest coal exporter and major liquefied natural gas (LNG). Meanwhile, Malaysia ranks third largest energy consumer among the ASEAN countries and the world's second largest liquefied natural gas (LNG) in 2014 other than the oil exporter.

There are numerous studies on the energy consumption and economic growth nexus. Most of them suggested that economic growth have significant relationship with energy consumption. (Ang, 2008; Sharma, 2010; Loganathan et.al, 2010; Mathur, 2016). Nevertheless, there are some researchers disagreed with this finding. In fact, they indicated that the impact of energy consumption on economic growth is minimal. (Okonkwo and Gbadebo, 2009 and Noor et.al, 2010).The mixed findings of previous literatures failed to show consensus among the researchers either on the relationship of energy consumption and economic growth in general or the direction of causality for these two variables in specific. Most of the previous literatures study on the short run and long run relation or the direction of causality between energy consumption and economic growth nexus. There were very few studies examined the energy consumption and economic growth nexus from other perspectives.

One of the elements that might influence energy consumption and economic growth nexus is public debt. The swelling of public debt has become an emergence issues after the European debt crisis. Public debt crises raise the awareness of policy makers on the public debt issue such as dealing with the risk of credit slowdown and or bust that might affect the economic growth. Public debt is an important instrument that used to measure the sustainability of the country's finances. It reflects the repayment ability of a country to their debtors. High level of public debt will lead to the financial risk in term of outright default or capital flight. Moreover, it will also crowd out domestic spending via the escalating of interest risk premium and limit economic growth (Makin, 2005). Reinhart and Rogoff (2010) stated that growth performance of country will be deteriorated when public debt surpasses 90% of GDP threshold level. However, reasonable levels of public debt are likely to enhance its economic growth by financing productive investment. Therefore, this study aims to investigate the influence of threshold level of public debt on energy consumption and economic growth nexus. This paper is differs from other literatures from two aspects. Firstly, this study focuses on Indonesia and Malaysia through threshold regression model for the period of 2000-2013. The sample period reflects up-to-date development for Indonesia and Malaysia in 2000s. Secondly, this study is examining the energy consumption and economic growth nexus from threshold level of public debt. As per our knowledge, there are hardly to find literatures that review on the relationship between energy consumption and economic growth from public debt perspectives. The findings of this paper will provide new insight to the current literatures as well as to fulfill the existing gaps. The rest of this paper is organized as follows. Section 2 discusses on literature reviews. Section 3explain the data and methods. Section 4 presents the empirical results and the last section provides conclusion and policy implication.

2. Literature Review

Energy consumption is an eminent issue that has been thoroughly discussed by scholars, academician, researcher as well as government policy maker over the past decade. There were numerous empirical literatures on the relationship between energy consumption and economic growth. Most of the literatures on energy consumption and economic growth nexus focus on developing countries especially ASEAN region. Ang (2008) examined the relationship of energy and output of Malaysia for the period of 1971 to 1999 revealed that

energy consumption have positive relationship with economic growth in the long run. Besides, the causality result indicates that economic growth has causal effect on energy consumption for long run and short run in Malaysia. The case of Malaysia was further investigated by Loganathan et.al (2010) who discovered the existence of bidirectional co-integration effects between the total energy consumption and the economic growth of Malaysia over the period of 1971 to 2008. They applied different methods such as Ordinary Least Square Engel-Granger (OLS-EG), Dynamic Ordinary Least Square (DOLS), Autoregressive Distributed Lag (ARDL) Bounds testing approach and Error Correction Model (ECM) to examine the sustainability of energy consumption and economic performance of Malaysia. Furthermore, their findings revealed that energy consumption was on supportable perimeter with 57% speed of adjustment to achieve the long run equilibrium due to the short run shock in economic growth of Malaysia. Besides the case of Malaysia, Gross (2012) who study the non-causality between energy and economic growth in the US for the period of 1970 to 2007 through Granger causality test for three sectors consists of industry, commercial sector and transport sector. The empirical result shows that there is unidirectional long run Granger causality in the commercial sector from growth to energy and bi-directional long-run Granger causality in the transport sector.

On the other hand, some researchers investigated the relationship of energy consumption and economic growth based on many countries at the same region or different regions such as Sharma (2010), Apergis and Payne (2010), Razzaqi et. al (2011) and Omay et.al (2015). Study of Sharma (2010) focus on the linkage between energy consumption and economic growth for 66 countries across few regions such as Asia Pacific region, Europe and Central Asian region, Latin America and Caribbean region and sub-Saharan, North Africa and Middle Eastern region. Dynamic panel data models have been applied in the study and the result stated that energy consumption (both electricity and non-electricity type energy variables) has significant relationship with economic growth in Europe and Central Asian region. Meanwhile, Apergis and Payne (2010) who study on the renewable energy consumption and economic growth for 20 OECD countries over the period of 1985-2005 provide evidence to show that there are long run significant relationship between energy consumption and economic growth through panel cointegration test. The Granger causality test shows that there is bi-directional causality between energy consumption and economic growth in short run as well as long run. Apparently, their funding was supported by Razzaqi et. al (2011) who examined on the relationship between energy consumption and economic growth for developing-8 (D8) countries (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey) via Johansen's cointergation test proved that the existence of dynamic relationship between energy consumption and GDP occur in all D-8 countries. Moreover, their research also provides the evidence of bi-directional long run causality between energy consumption and economic growth exist through VECM and VAR causality test for the case of Indonesia and Malaysia. Another study of Omay et.al (2015) on the relationship of energy consumption and economic growth for eight developing countries from Europe and Central Asia (Azerbaijan, Bulgaria, Kzakhstan, Latvia, Lithuania, Romania, Russia Federation and Turkey) via the non-linear causality test suggested that the existence of two way relationship running from economic growth to energy consumption. The causality test revealed that one way causality running from economic growth to energy consumption was found.

There is another strand of researchers who show their disagreement on the findings of causal relationship exist between energy consumption and economic growth such as Chiou-Wei et. al (2011) and Mathur (2016). Chiou Wei et.al (2011) conduct their research based on meta-

analysis on the energy consumption and economic growth nexus stated that not all the developing countries shows the unidirectional causality from energy consumption to economic growth as compare with developed countries. Their finding was supported by Mathur (2016) who studied on the energy-growth nexus for 52 countries that consist of 18 developing countries, 16 transition ad 18 developed countries via various panel data estimation methods such as panel data cointegration, panel causality, panel VECM, panel VAR and panel data ARDL and SURE. Their result revealed that energy consumption has a negative impact on the economic growth for developing countries and transitional economies. In contrast, there are positive effect of energy consumption towards economic growth exists for the case of developed countries.

3. Data and Medothology

Sample period used in this study covers from 2000:Q1-2013:Q4. Gross domestic product is the dependent variable whereas energy consumption as independent variable. In addition, the public debt expressed as percentage of GDP is the threshold variable. All the variables are obtained from World Development Indicator (WDI).

Initially, the stationarity test of the time series variables will be performed prior estimation. This is crucial as to avoid spurious regression due to regressing non-stationary variables. Augmented Dickey-Fuller (ADF) unit root test proposed by Dickey and Fuller (1979) is adopted in this study as shown in Equation (1).

$$\Delta Y_t = \alpha + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_2 Y_{t-i} + \varepsilon_t \qquad (1)$$

where ΔY_t refers to the first difference of Y_t, α refers to the intercept while βs refers to the coefficients. p refers to the number of lagged terms chosen, t is time and ε_t is the white noise. The selection of optimal lag length is based on Schwartz Information Criterion (SIC). In addition, Kwiatkowski-Philips Schmidt-Shin (KPSS) unit root test also performed to test the stationarity of the time series variables. Once the time series variables are stationary with the same order of integration, then we can proceed with the Johansen and Juselius (1990) cointegration test as shown in Equation (2).

$$\Delta Z_t = \Pi \Delta Z_{t-k} + \sum_{i=1}^{k-1} \Gamma_i \Delta Z_{t-i} + \theta + \varepsilon_t \qquad (2)$$

where Z_t denotes $(n \times 1)$ vector of stationary $I(1)$ variables, Γ and Π represent $(i = 1, \ldots, k-1)$ of a $(n \times n)$ coefficients matrices, θ denotes constant, ε_t denotes error term and Δ represents difference operator and k is the optimal lag length. If Π has zero rank, this indicates there is no stationary linear combination and Z_t are not cointegrated. On the other hand, if the rank r of Π is positive, this indicates possible r stationary linear combinations. Thus, Π can be divided into two matrices, α and β where $\Pi = \alpha\beta'$. Meanwhile, β consists of the r cointegration relationship and α refers to the necessary adjustment coefficient matrix.

There are two types of test statistics, which are trace statistics and maximum eigenvalue.

Trace Test

$$T_{trace} = -T\sum_{i}^{k} log(1-\lambda_i) \qquad (3)$$

where T denotes the number of observation, k denotes the number of variables, λ_i is the i^{th} largest estimated eigenvalue. The null hypothesis of the trace test is stated as followed:

H_0: Number of cointegration vector is less or equal to r

H_A: At most r cointegration vectors

Maximum Eigenvalue

$$\lambda_{max} = -Tln(1-\lambda_{r+1}) \qquad (4)$$

where T refers the number of observation and λ_i is the i^{th} largest estimated eigenvalue. The null hypothesis of the maximum eigenvalue is as followed:

H_0: r cointegrating relation

H_A: r + 1 cointegrating relation

With regards to this, the interaction between the energy consumption and economic growth can be estimated based on the different level of public debt as the threshold variable. The determination of the public debt threshold is based on the minimization sum of squared errors. Subsequently, the heterogeneous effects of the energy consumption on economic growth can be examined based on either country has high public debt level (above the threshold level) or low public debt level (below threshold level). Following is the equation of the threshold regression approach:

$$GDP_t = \beta E_t + \partial_1 PD_t(\gamma) + \varepsilon_t \qquad if \ -\infty < PD_t < \gamma_1 \qquad (5)$$

$$GDP_t = \beta E_t + \partial_2 PD_t(\gamma) + \varepsilon_t \qquad if \ \ \gamma_1 < PD_t < \infty \qquad (6)$$

where GDP_t refers to Gross Domestic Product, E_t refers to Energy Consumption, PD_t refers to Public debt as % of GDP and γ refers to Threshold level.

4. Empirical Results

Initially, all the variables are examined via Augmented Dickey-Fuller (ADF) and Kwiatkowski-Philips Schmidt-Shin (KPSS) unit root test to the stationarity of the time series variables. Based on the ADF unit root test results shown in Table 1, the null hypothesis cannot be rejected at level as the *t*-statistic values are negative and greater than the critical value. This indicates that the variable is non-stationary or *I*(0). Nevertheless, null hypothesis can be rejected at 1st difference as the *t*-statistic values are negative and less than the critical value. In terms of KPSS unit root test, the interpretation of unit root is dissimilar due to the null hypothesis of stationarity. The KPSS results indicate non-stationary at level but stationary after first difference. We can conclude that the variables used in this study are stationary at first difference and integrated of order one.

Table 1: Unit Roots Test Results

	Augmented Dickey-Fuller		Kwiatkowski-Philips Schmidt-Shin	
Indonesia	Level	1st Difference	Level	1st Difference
LGDP	-2.028	-3.593***	0.3339	0.3917**
LE	-2.694	-2.946**	0.2050	0.1503***
LGD	1.535	-9.127***	0.2401	0.7267*
Malaysia	Level	1st Difference	Level	1st Difference
LGDP	-2.645	-4.053***	0.2697	0.1958***
LE	-2.676	-4.496***	0.2257	0.1155***
LGD	-2.229	-2.950**	0.5105	0.1402**

Notes: Asterisks *, ** and *** denote significance levels: 10%, 5% and 1%. LGDP = logarithm GDP, LE = logarithm energy consumption and LGD = logarithm government debt. Automatic lag selection by Schwarz Info Criterion (SIC) for ADF. Null hypothesis under ADF test is time series variable is non-stationary while null hypothesis under KPSS test is time series variable is stationary.

Table 2: Johansen and Juselius Cointegration Test Result

Null	Alternative	Trace Statistic	Critical Value	Max-Eigen Value	Critical Value
Indonesia					
r = 0	r = 1	20.164**	15.495	16.895**	14.265
r ≤ 1	r = 2	3.269	3.841	3.269	3.841
Malaysia					
r = 0	r = 1	42.519**	15.495	42.518**	14.265
r ≤ 1	r = 2	0.001	3.841	0.001	3.841

Asterisk ** denotes rejection of the null hypothesis at 0.05 significance level.

Since all the variables are stationary or integrated at order one, we can proceed to Johansen and Juselius (1990) cointegration test with the aim to determine the existence of equilibrium in the long-run. Table 2 shows the cointegration test results between economic growth and energy consumption for all the four countries. The null hypothesis of none cointegrated vector can be rejected at 5% significant level for both maximum eigen value and trace statistic value as they are greater than their respective critical values. However, the null hypothesis of two cointegrated vectors cannot be rejected due to the smaller values of both maximum eigen value and trace statistic value than their critical values. Hence, this indicates that there is a single cointegrating vector or long-run equilibrium between economic growth and energy consumption.

The threshold regression results are depicted in Table 3. The overall results indicate existence significant relationship of energy consumption and economic growth from the perspective of public debt threshold for Indonesia and Malaysia. Specifically, For the case of Indonesia, the empirical result shows that higher level of public debt will lead to greater impact of energy consumption on economic growth. The public debt threshold for Indonesia case is approximately 34% of GDP. There is a significant positive association between energy consumption and economic growth with coefficient of 5.89% when the public debt is below the threshold level. Nevertheless, the coefficient of the energy consumption of growth increase to 7.76% when the public debt level exceeds the threshold level of 34% of GDP. This might due to the debt accumulation is used for the development purpose which lead to more energy consumption for economic growth in Indonesia. On the other hand, the empirical result for Malaysia shows that higher level of public debt will only lead to minimal

impact on the energy consumption and economic growth nexus. In the case of Malaysia, the public debt threshold is approximately 52% of GDP. There is a declining effect from 2.89% to 1.68% of energy consumption on growth when the public debt is above the threshold level. This might due to not all public debt is used for the development purpose but used for debt repayment. The empirical result shows the existence of significant relationship between energy consumption and economic growth for the case of Indonesia and Malaysia is consistent with the findings of Ang (2008), Loganathan et.al (2010) and Razzaqi et.al (2011). This signified that public debt play certain roles in both countries to influence the energy consumption and growth nexus especially Indonesia.

Table 3: Result of Threshold Regression Analysis

Country	Above/Below Threshold Level	Coefficients	Standard Error	Observations	Threshold Level
Indonesia	Public Debt < 34.0217	**5.899*** **	0.789	28	**34.0217**
	Public Debt ≥ 34.0217	**7.755*** **	0.823	28	
Malaysia	Public Debt < 51.6763	**2.898*** **	0.137	38	**51.6763**
	Public Debt ≥ 51.6763	**1.684*** **	0.367	18	

Notes: Gross Domestic Product as dependent variable. Asterisk *** indicates significant at15% level.

5. Policy implications and conclusions

Energy consumption is key factor to stimulate economic development and growth in most of the developing countries as suggested by some literatures such as Ang (2008), Sharma (2010), Loganathan et.al (2010) and Razzaqi et.al (2011). In order to provide new insight to the existing literature on the energy consumption and growth nexus, this study aims to investigate the relationship between energy consumption and economic growth from public debt perspective for Indonesia and Malaysia. This study adopts secondary data for the period of 2000 to 2013 and analyzes the heterogeneous impacts of different debt levels toward energy consumption and growth nexus via threshold regression analysis. Our findings indicate the existence of significant relationship between the energy consumption and growth from the public debt threshold perspective in Indonesia and Malaysia. This means that the public debt plays important role in mediating the energy–growth nexus. In detail, the empirical result for Indonesia shows that higher level of the public debt or when the public debt exceeds the threshold level, this will lead to greater impact on energy consumption and economic nexus. In contrast, the results for Malaysia case show different outcomes where there is a diminishing trend of the impact of energy consumption on economic growth when the public debt exceed the threshold level. This indicates that higher level of public debt have minimal impact to energy consumption and growth nexus in Malaysia. The important policy implication from this study suggests that Indonesia and Malaysia should be more careful in formulating the energy consumption related policy by considering from different perspective such as public debt level of the nation. Debt has become unavoidable options for a country due to the need to cushion any severe external economic shocks such as oil price and currency fluctuations. Nevertheless, managing optimal debt position remains a challenge for Indonesia and Malaysia in order to ensure sustainable growth. Besides that, both countries should consider reducing their dependence on the non-renewable energy resources and shifting to renewable energy resources such as solar, hydro, landfill gas for their economic development in the future.

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