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Impact of Energy Consumption on Economic Growth of Malaysia: Crisis Effect

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Abstract
The study aims to examine the impact of energy consumption on the economic growth of Malaysia by considering the 1997 Asian Financial Crisis and 2009 Global Financial Crisis. Autoregressive distributed lag (ARDL) bounds testing method is adopted to estimate the long run and short run impact for the sample period from 1980 to 2019. Empirical findings show that energy consumption has a positive impact on the economic growth of Malaysia in the long run. Furthermore, the impact of energy consumption on growth intensifies during both financial crisis periods.
Keywords: *Energy consumption, ARDL, financial crisis*

Introduction

Energy consumption and economic growth have become the center of attention among researchers. This is due to the role of energy as a catalyst to the economic growth of countries. In the Southeast Asia region, the countries' energy demand showed 70% growth since 2000. This growth accounted for 5% of global energy demand (World Energy Outlook 2017).

Malaysia is one of the open economies in the region and energy become prominent sector in the development of the country. Figure 1 and Figure 2 show the trend of the economic growth and energy usage of Malaysia from 1980 to 2019. Since 1980, the Gross Domestic Product (GDP) of Malaysia was showing an increasing trend from US$45.77 million to US$151.84 million in 1997. The energy consumption level is also showing a rising trend with 92 kg of oil equivalent per capita in 1980 to 240 kg of oil equivalent per capita in 1997. However,

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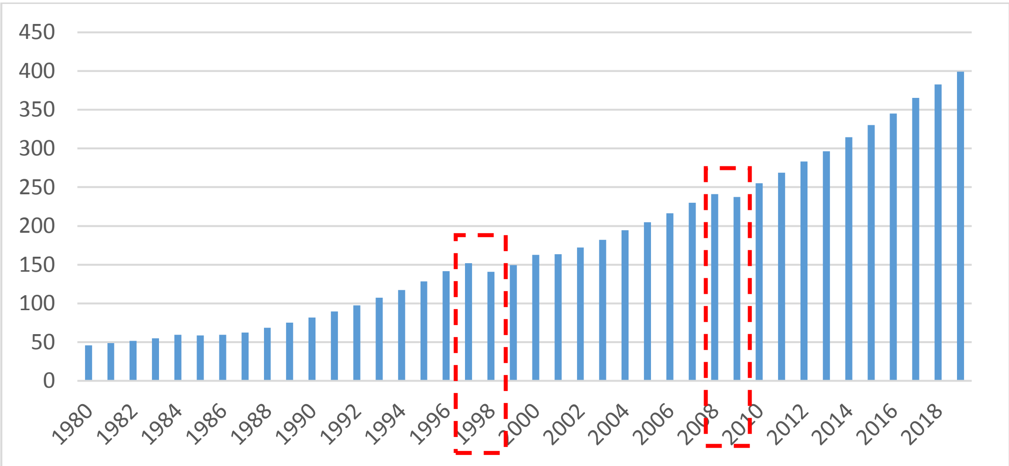
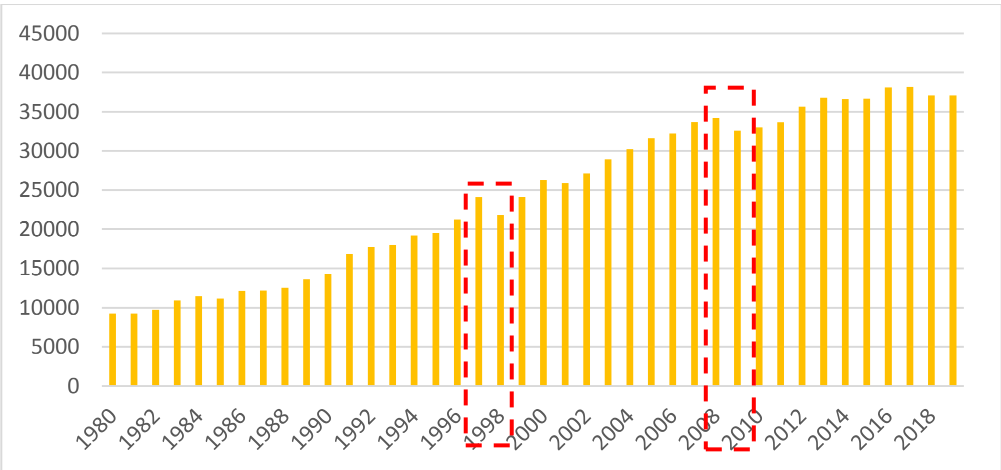
both GDP and energy consumption recorded a downward trend in 1998 due to the Asian Financial crisis. The GDP declined approximately 7% to US$140.66 million and the energy consumption level reduced approximately 9% to 218 kg of oil equivalent per capita. Both indicators indicate an upward trend post-Asian Financial crisis until the 2008 Global Financial crisis. In 2008, the GDP and energy consumption recorded a reduction of 2% from US$241.04 million to US$237.39 million while 5% decline from 342 kg of oil equivalent per capita to 325 kg of oil equivalent per capita, respectively. Subsequently, both GDP and energy consumption are growing and reached US$398.95 million and 370 kg of oil equivalent per capita in 2019.

Figure 1: Gross Domestic Product (US$)



Source: World Bank

Figure 2: Energy Usage



Source: World Bank

There are two main hypotheses in this context, which are energy-led growth hypothesis and the growth-led energy hypothesis. The causality effect may be in four forms such as: a) unidirectional causality from energy consumption to growth (growth hypothesis), b) unidirectional causality from growth to energy consumption (conservation hypothesis), c) bi-directional causality between energy consumption and economic growth (feedback

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hypothesis) and d) no causality between energy consumption and economic growth (neutrality hypothesis).

This study intends to examine the impact of energy consumption on the economic growth of Malaysia, considering the effect 1997 Asian Financial Crisis and the 2009 Global Financial Crisis. These two crises are significant financial crises and severely affected most of the countries around the world. The study outcomes are essential in providing insight into the short-term and long-term impact of energy consumption on the growth of Malaysia during the crisis periods. Furthermore, the different impacts of energy on growth during both crises may enable the policymakers to develop strategies on managing the energy consumption level in the event of financial crisis.
The structure of the study is as followed: First section provides an overview of the energy consumption and economic growth of Malaysia, second section discusses on the previous studies, third section discusses the methodology adopted for estimation, fourth section provides discussion on empirical results and lastly the conclusion.

Literature Review
There are a number of studies examining the impact of energy consumption on economic growth. This section will highlight selected studies on the issue. There are numerous studies examining on the impact of energy consumption on economic growth. For example, Ang (2008) examined the relationship between output, energy consumption and emissions in Malaysia from 1971 to 1999. Empirical results indicated the existence of bi-directional causality between GDP growth and growth in energy consumption. Meanwhile, Narayan and Smyth (2008) studied the relationship between energy consumption, capital formation and real GDP for G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom and the United States). They concluded that energy consumption has a positive effect on economic growth in those countries in the long run.

The study by Imran and Siddiqui (2010) on the relationship between energy consumption and economic growth for Bangladesh, India and Pakistan from 1971 to 2008. Their outcomes showed that there is a positive relationship between energy consumption and economic growth for Bangladesh, India and Pakistan. Adhikari and Chen (2012) study the relationship between energy consumption and economic growth for 80 developing countries from 1990 to 2009. The outcome of the study indicated the existence of positive impact of energy on growth only in upper and lower middle income countries. Yildirim, Aslan and Ozturk (2014) conducted a study on the relationship between energy consumption and GDP per capita for Indonesia, Malaysia, the Philippines, Singapore and Thailand. They adopted panel data analysis based on the period 1971 to 2009. Their findings indicated that the conservation hypothesis can be seen in Indonesia, Malaysia and the Philippines.

On the other hand, some findings from previous studies showed that there is no significant impact of energy on growth. For example, studies by Masih and Masih (1997 & 1998),

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Ozturk & Acaravci (2010), Magazzino (2011) and Shahbaz, Khan, and Tahir (2013) indicated that there is no relationship between energy consumption and growth.
Therefore, the findings on the impact of energy consumption on economic growth remain ambiguous. In addition, the crisis effect is one of the element that was not studied extensively on the relationship between energy consumption and growth.

Methodology

The annually data from 1980 to 2019 was utilized in this study. Autoregressive distributed lag (ARDL) bounds testing approach was adopted to examine the long run and short run impact of the energy consumption on economic growth of Malaysia. In addition, the crisis effect such as 1997 Asian Financial Crisis and 2008 Global Financial Crisis are added in the model to capture the crisis effect. All variables are obtained from World Development Indicators (WDI) World Bank.

The model specification is shown in Equation (1). The dependent variable is gross domestic product (GDP) constant value, the main independent variable is energy consumption measured in kg of oil equivalent per capita and followed by control variables trade measured percentage of GDP and domestic investment. All the variables are transformed into logarithm form.

$$lnGDP_t = \beta_0 + \beta_1 lnEC_t + \beta_2 In\, T_t + \beta_3 In\, DI_t + \varepsilon_t \qquad (1a)$$

$$lnGDP_t = \beta_0 + \beta_1 lnEC_t + \beta_2 In\, T_t + \beta_3 In\, DI_t + \beta_4 D_{1997} + \beta_5 D_{2009} + \varepsilon_t \qquad (1b)$$

where
$lnGDP_t$ = logarithm of gross domestic product
$lnEC_t$ = logarithm of energy consumption
$In\, T_t$ = logarithm of trade
$In\, DI_t$ = logarithm of domestic investment
D_{1997} = 1997 Asian Financial crisis
D_{2009} = 2009 Global Financial crisis
β_s = parameter of estimates
ε_t = error term

Autoregressive Distributed Lag (ARDL) Bounds Testing Approach

The ARDL bounds testing approach is developed by Pesaran et al. (2001) to cater the of long run and short run simultaneously among the series. There are two steps that involve in ARDL bounds testing to examine the long run relationship. The ARDL model for the long run relationship between energy consumption, trade, domestic investment and GDP follows as:

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$$\Delta lnGDP_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} \Delta lnGDP_{t-i} + \sum_{j=0}^{q} \emptyset_{1j} \Delta lnEC_{t-j} + \sum_{k=0}^{r} \varphi_{1k} \Delta lnT_{t-p} + \sum_{m=0}^{t} \delta_{1m} \Delta lnDI_{t-l} + \gamma_{GDP} lnGDP_{t-1} + \gamma_{EC} lnEC_{t-1} + \gamma_T lnT_{t-1} + \gamma_T lnDI_{t-1} + \varepsilon_{1t} \quad (2)$$

where Δ is the first difference operator and ε_t is the error term. The optimal lag structure of the first difference regression is selected based on Akaike Information Criteria (AIC). *F*-test is suggested for joint significance of the coefficients of the lagged level of the variables (Pesaran et al., 2001). The null hypothesis of no long-run relationship between the variables in Equation (2) is:

$$H_0: \gamma GDP = \gamma EC = \gamma T = \gamma DI = 0$$
$$H_A: \gamma GDP \neq \gamma EC \neq \gamma T \neq \gamma DI \neq 0$$

The long run relationship is occurred if the *F*-statistic exceeds the upper critical value. The null hypothesis of no co-integration cannot be rejected if the *F*-statistic is below the lower critical value. However, the inference is inconclusive if the *F*-statistic lies between the two bounds. The long-run and short-run models represented in Equation (3) and Equation (4) are estimated if there is evidence of cointegration (long-run relationship) between these variables.

$$lnGDP_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} lnGDP_{t-i} + \sum_{j=0}^{q} \emptyset_{2j} lnEC_{t-j} + \sum_{k=0}^{r} \varphi_{2k} lnT_{t-p} + \sum_{m=0}^{t} \delta_{1m} \Delta lnDI_{t-l} + \varepsilon_{2t} \quad (3)$$

$$\Delta lnGDP_t = \alpha_3 + \sum_{i=1}^{p} \beta_{3i} \Delta lnGDP_{t-i} + \sum_{j=0}^{q} \emptyset_{3j} \Delta lnEC_{t-j} + \sum_{k=0}^{r} \varphi_{2k} lnT_{t-p} + \sum_{m=0}^{t} \delta_{1m} \Delta lnDI_{t-l} + \gamma ECM_{t-1} + \varepsilon_{3t} \quad (4)$$

where γ is the coefficient of error correction term. ECM_t is defined as:

$$ECM_t = lnGDP_t - \alpha_2 - \sum_{i=1}^{p} \beta_{2i} lnGDP_{t-i} - \sum_{j=0}^{q} \emptyset_{2j} lnEC_{t-j} - \sum_{k=0}^{r} \varphi_{2k} lnT_{t-p} - \sum_{m=0}^{t} \delta_{1m} \Delta lnDI_{t-l} \quad (5)$$

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Results Discussion

In order to examine the effect of the crisis periods on the relationship between energy consumption and economic growth, the structural break of the energy consumption variable is determined using the Breakpoint Unit Root test based on additive outliers and innovative outliers approach. Table 1 shows that the structural break dates are 1997 and 2009. The t-statistic values of 8.129 and 8.049 (ignoring the negative sign) are greater than the t-critical value of 4.949 (ignoring the negative sign) at a 1% significance level. Figure 3 and Figure 4 show the break dates in graphical form.

Table 1: Breakpoint Unit Root test

Variable	*t*-statistic	*t*-critical	Significance level	Break Date
LEC	-8.1286***	-4.9491	1%	1997
		-4.4436	5%	
		-4.1936	10%	
	-8.0489***	-4.9491	1%	2009
		-4.4436	5%	
		-4.1936	10%	

Notes: *** indicate significance level at 1%.

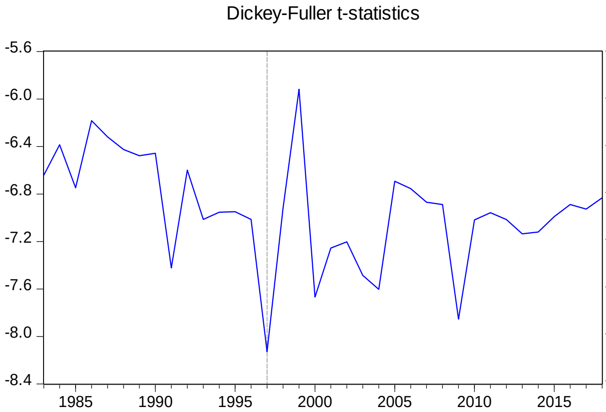

Figure 3: Break Date at 1997

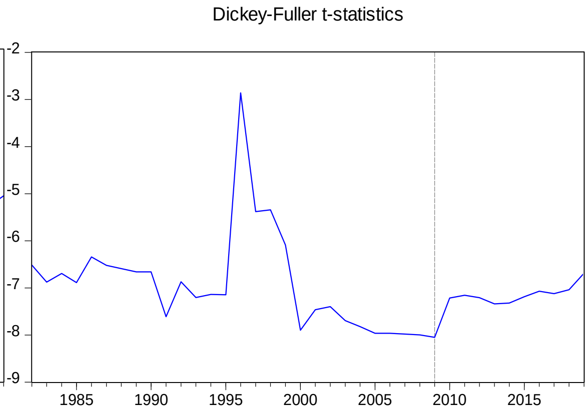

Figure 4: Break Date at 2009

Under the ARDL estimation bounds test shown in Table 2, the *F*-statistic values of 9.4185 in Model 1 and 8.4918 in Model 2 are above the upper bounds of 4.66 in Model 1 and 4.21 in Model 2, respectively at 1% significance level. This indicates that existence of long run equilibrium among the variables on the model.

Table 2: Bounds Test

Variable	Model 1	Model 2
Optimal lag	(3, 0, 2, 3)	(3, 0, 3, 3, 3, 0)
F-statistics	9.4185***	8.4918***
Lower bounds $I(0)$		
1 percent	3.65	2.82
5 percent	2.79	2.14

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10 percent	2.37	1.81
Upper bounds $I(1)$		
1 percent	4.66	4.21
5 percent	3.67	3.34
10 percent	3.20	2.93

Notes: Asterisks *, ** and *** denote the significance level at 10%, 5% and 1% level respectively. The optimal lag structure is determined by Akaike information criterion (AIC).

Table 3 shows the long run and short run estimation of the variables in the study. In the long run result, energy consumption positively impacts growth with a coefficient of 1.686 in Model 1 (without crisis effect). Both trade and domestic investment have significant impact on growth with coefficient of -0.413 and 0.789, respectively. Meanwhile in Model 2 (with crisis effect), energy consumption has a positive impact on growth with a larger coefficient of 2.078. In addition, the coefficient of the domestic investment is statistically significant but not for trade. These results are consistent with previous studies such as Ang (2008), Narayan and Smyth (2008), Imran and Siddiqui (2010), Adhikari and Chen (2012) and Yildirim, Aslan and Ozturk (2014). The results also supported the growth hypothesis where energy consumption contributes to growth. Energy consumption has a positive impact on economic growth of Malaysia and the effect becomes greater during the crisis periods. The 1997 crisis has a negative impact on growth with coefficient of 3.939, while the positive impact of 2009 crisis on growth with smaller coefficient of 0.447. In the short run estimate, the impact of energy consumption on growth is not significant in both Model 1 and Model 2. The ECT or the convergence rate in Model 1 is about 9.15% and Model 2 is 4.5%. It shows the speed of adjustment of any short term deviation from the equilibrium.

Table 3: Long-run and Short-run Result

Variables	Model 1	Model 2	Variables	Model 1	Model 2
	Long run estimate			*Short run estimate*	
LEC_t	1.6855***	2.0779***	ΔLEC_t	-	0.0903
	[14.2023]	[15.7776]			[1.4300]
LT_t	-0.4133**	-0.10467	ΔLT_t	-0.0361	0.0930*
	[-2.4155]	[-0.4473]		[-0.6822]	1.7609]
LDI_t	0.7898*	2.2909***	ΔLDI_t	0.2029***	0.1774***
	[1.7769]	[9.1654]		[8.9268]	[6.4544]
$Crisis_{1997}$	-	-3.9396***	$\Delta Crisis_{1997}$	-	-0.0218
		[-4.3490]			[-1.5563]
$Crisis_{2009}$	-	0.4474***	$\Delta Crisis_{2009}$	-	0.0206**

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		[3.5923]			[2.1631]
Constant	9.1257*** [4.8685]	-5.1245 [-0.9296]	-	-	-
ECT_{t-1}				- 0.0915*** [-7.3910]	- 0.0454*** [-7.4170]

Notes: Asterisks ***, ** and * show the significane level at 1%, 5% and 10%, respectively. [ ] represent the *t*-statistic. Δrefers to short run estimate.

Table 4 shows the diagnostic tests performed on the model. All the results indicate non-rejection of the null hypothesis of respective tests. This means that the model passes all the diagnostic tests where the residuals are normally distributed, no serial correlation problem, variances are homoscedastic, and there is no misspecification. In addition, the model also is stable based on the CUSUM and CUSUM^2 test in Table 5 and Figure 6.

Table 4: Diagnostic Test

Tests	**Model 1**	**Model 2**
Normality	0.3861 (0.8245)	0.2097 (0.9005)
Serial Correlation	1.0092 (0.6037)	2.1698 (0.1431)
Heteroscdasticity: Breusch-Pagan-Godfrey	7.4721 (0.7597)	0.6080 (0.8463)
Ramsay Reset	0.0247 (0.8763)	0.0319 (0.8600)
CUSUM	Stable	Stable
CUSUM^2	Stable	Stable

Notes: Values in parenthesis show the probability values.

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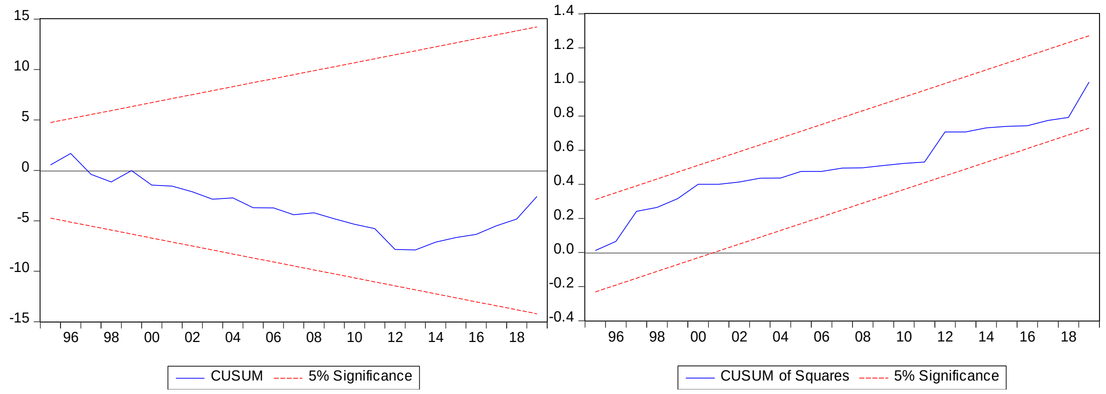

Figure 5: CUSUM and CUSUM of Squares for Model 1

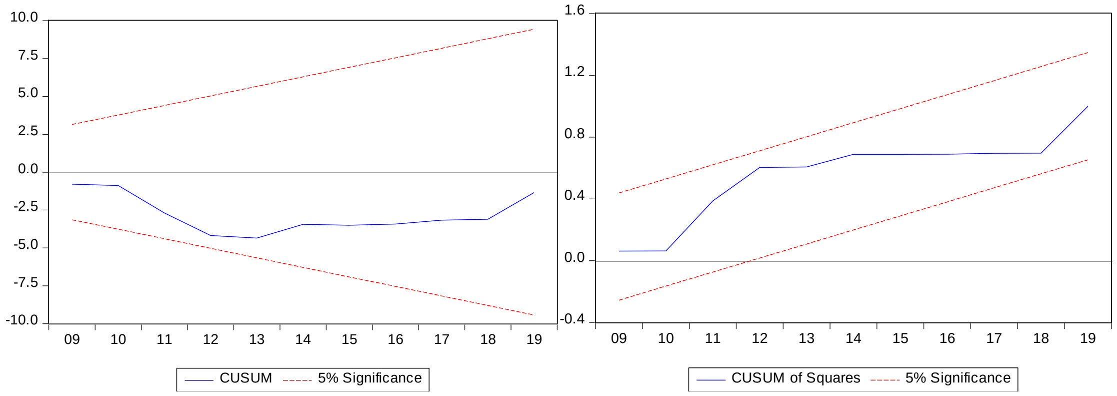

Figure 6: CUSUM and CUSUM of Squares for Model 2

Conclusion

This study aims to investigate the impact of energy consumption on the economic growth of Malaysia by considering the effect of the 1997 Asian Financial crisis and the 2009 Global Financial crisis. The breakpoint unit root test was adopted in order to verify the structural break of both crisis periods. Empirical results show that there is long run equilibrium relationship among the variables under the bounds test. The long run result indicates there is a positive impact of energy consumption on growth. This support the growth hypothesis where energy consumption remains as an important element in contributing to growth of the country. The magnitude of the energy consumption effect becomes larger when considering both 1997 Asian Financial crisis and 2009 Global Financial crisis. In terms of policy perspective, energy remain important sector in Malaysia, even during crisis periods. Optimal level usage of energy is a concern to avoid environmental issues such as CO2 emission. Therefore, the policymakers need to adopt energy conservation policies to ensure sustainable economic growth and safeguard the environment.

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