Natural Gas Consumption and Economic Growth: The Role of Foreign Direct Investment, Capital Formation and Trade Openness in Malaysia

Solarin, Sakiru Adebola and Shahbaz, Muhammad

Multimedia University Malaysia, Melaka, Malaysia, COMSATS Institute of Information Technology, Lahore, Pakistan

11 October 2015

Natural Gas Consumption and Economic Growth: The Role of Foreign Direct Investment, Capital Formation and Trade Openness in Malaysia

Sakiru Adebola Solarin
Room 5012, Faculty of Business and Law
Multimedia University Malaysia, Melaka, Malaysia
Email: sasolarin@mmu.edu.my, Phone: +6042523025

Muhammad Shahbaz
Department of Management Sciences,
COMSATS Institute of Information Technology,
Lahore, Pakistan. Email: shahbazmohd@live.com
www.ciitlahore.edu.pk, UAN: 0092-42-111-001-007,
Fax: 0092-42-99203100, Mobile: +92334-3664-657

Abstract: The objective of this paper is to reinvestigate the relationship between natural gas consumption and economic growth by including foreign direct investment, capital and trade openness in Malaysia for the period of 1971-2012. The structural break unit root test is employed to investigate the stationary properties of the series. We have applied combined cointegration test to examine the relationship between the variables in the long run. For robustness sake, the ARDL bounds testing method is also employed to test for possible of long run relationship in the presence of structural breaks. We note the validity of cointegration between the variables. Natural gas consumption, foreign direct investment, capital formation and trade openness have positive influence on economic growth in Malaysia. The results support the presence of feedback hypothesis between natural gas consumption and economic growth, foreign direct investment and economic growth, and natural gas consumption and foreign direct investment. The policy implications of these results are provided.

Keywords: Natural gas consumption, Economic growth, Causality

1. Introduction

Natural gas already meets nearly a quarter of the world's energy demand, but recent innovations in exploration and production have made it possible to greatly expand gas supplies. Cleaner than coal and oil (because it generates 20% less emission than oil, and almost 50% less than coal), and more efficient and reliable than renewable energy, natural gas is an essential long-term answer to the world's energy and climate challenges [1]. Gas-fired power plants need less construction time than either nuclear facilities or coal-fired plants. This shorter construction time eases the process of investment decisions in many firms [1]. Given the rising importance of natural gas, many characteristics of this valuable resource have not been properly investigated in the economics literature [2]. The causal relationship between the consumption of natural gas and the economy is one of the areas that have received little attention. Very limited attempts have been made in the literature in this aspect and without a clear consensus among the researchers over the relationship between natural gas consumption and economic growth. Instead, significant part of the causality tests has focused on either aggregate energy consumption or electricity consumption with very vital policy implications [3]. For instance, unidirectional causality flowing from economic growth to energy consumption suggests that the economy is less energy-reliant and conserving energy use is a vital policy option, as such move will not harm economic development. The causality running from energy consumption (with or without feedback) to economic growth implies that energy consumption have a key role in economic growth. Therefore, any attempt to limit energy consumption may impede economic growth and encouragement of energy use will promote economic growth. The nonexistence of causality between natural gas consumption and gross domestic products (GDP) is an indication that any initiative in the energy sector will have no impact on the output, in accordance with the neoclassical model. In many respects, natural gas not only differs from electricity but also other forms of energy. It is not as controversial as nuclear power; more environmentally-friendly, when compared with either coal or oil; and can be stored, unlike electricity [4]. Therefore, ignoring the different characteristics of energy components may not only hide the differential impact related with different forms energy consumption, but also leads to wrong policy implications for each component of energy, especially for natural gas, which is characteristically different from other components of energy [5].

With the exception of Saboori and Sulaiman [6], we are not aware of any study that has undertaken the task of exploring the relationship between natural gas and economic growth in Malaysia. The focus has either been on energy consumption or electricity consumption [7-9]. The purpose of this study is to reinvestigate the causal relationship between natural gas consumption and economic growth for the period spanning 1971-2012. Malaysia is a good case study because as one of the success stories in Asia, the oil and gas sector is thought to play increasing roles in the transformation of the country. Within the ten years that preceded the Asian financial crisis of 1997-1998, the Malaysian economy grew at an average of 7.3% per year. Subsequent to the financial crisis, the country has been almost consistent in generating positive growth rates, averaging 5.5% per year [10]. The oil and gas sector has been the sole biggest provider of revenues to the Malaysian government in the form of dividends and taxes [11]. Investments in the infrastructural facilities of the oil and gas industry are anticipated to benefit the gross domestic product (GDP) in the country [12]. As a result, there were efforts on the part of the government to promote natural gas development in the country. New investment and tax incentives launched in 2010 were aimed at promoting natural gas exploration and development [11]. Therefore, it is timely and important to examine the causal relationship between natural gas and the economy of Malaysia.

Our paper extends the existing literature on natural gas consumption in Malaysia in three different ways. We conduct our research within a multivariate framework, by including three additional variables to the nexus. The inclusion of a single independent series (in bivariate case) is premised on the supposition that such series-natural gas is the only major factor of the total level of output. In the trivariate case (such as the case of Saboori and Sulaiman [6]), an additional regressor is introduced into the equation. However, in the practical economic sense, several variables determine the level of domestic output. The causality and cointegration tests would produce spurious and biased outputs results in the event that relevant variable(s) are ignored [13-14]. In addition, non-inclusion of relevant variables may cause wrong conclusion of no causality [15]. Secondly, beyond the use of capital formation and international trade [16-17], we introduce foreign direct investment into the natural gas and economic growth equation. Foreign direct investment not only accelerates current growth rate by promoting employment and production, but also contributes to the potential growth in the future through the accompanying superior technological know-how practices into the country. In several countries, foreign direct investment takes central stage in the process of enhancing natural gas sub-sector. It supplements the insufficient resources to fund both capital formation and ownership change in the home country. For Malaysian case, the foreign direct investment plays a vital function in the economy and not surprisingly there are several incentives to attract foreign direct investment into several sectors including the oil and gas industry. The majority of the natural gas production is derived from production-sharing schemes managed by foreign companies in association with the state-owned petroleum company-Petronas [11]. The country offers foreign investors a wide range of business opportunities and attractive incentives designed to help them get the most out of Malaysia's dynamic economy. The authorities introduced the Global Incentives For Trading (GIFT) Programme (which include 0% tax rate for Liquidified Natural Gas or LNG trading companies for the first three years of operation, 3% flat corporate tax rate and 50% exemption on personal income tax for foreign professionals) to boost oil and gas industry [18]. In 2012, Petronas signed 13 production sharing contracts (PSC), which is the highest ever-recorded for any calendar year. A foreign company-Shell is the biggest producer of gas in the country [11]. In 2013, the total foreign investments was RM66.3 billion or 44.6% of the total investment with almost RM6.1 billion going to the energy sector [19][1]. Malaysia achieved its highest-ever foreign direct investment in 2013 at RM38.8 billion, surging 3.9% past its previous record of RM37.3 billion in 2011 with oil and gas (and allied sector) accounting for 28.7% [12]. Malaysia has to date attracted thousands of foreign companies from several countries to establish their operations in different kinds of businesses including oil and gas business. There are over 3,500 oil and gas businesses in Malaysia comprising international oil companies, services and manufacturing companies. Thirdly, we use assortments of econometric procedures including the Bayer and Hanck [20] cointegration approach, which is a relatively recent time series method and able to uncover relationships that might otherwise be missed by implementing conventional approaches. We also provide for structural breaks in our estimations. The failure to incorporate break dates in either the unit root tests or the cointegration tests may distort the outcome [21]. Therefore, inclusion of other relevant variables in a multivariate framework and the use of more robust econometric tools should provide better and more reliable results for analyzing the relationship between economic growth and natural gas consumption [17]. The remaining part of this paper is arranged as follows. Section 2 involves the literature review. Section 3 presents a synopsis of the Malaysian economy and Section 4 introduces the methodology employed in this paper. Section 5 deals with empirical findings and Section 6 presents the conclusion of this study.

2. Literature review

Although the papers on causal relationship between natural gas consumption and economic growth are finite, they can be divided into four strands. The first strand involves studies that have used cointegration techniques to infer causality. The second set of the papers are bivariate studies which have employed causality tests, while the third category includes the papers that have adopted causality tests, but within a trivariate approach. Arising from the shortcomings of the foregoing works, the fourth category of the literature has implemented causality tests on multivariate series. Starting with the first strand of literature, the studies that have applied the

---

[1] RM is Malaysian ringgit and the average exchange rate is RM3 to a dollar

cointegration techniques to examine the relationship between natural gas and economic growth include Lee and Chang [21], who used Johansen [22], Hansen [23] and Gregory and Hansen [24] cointegration test to examine relationship between natural gas consumption and economic growth for the period, 1954–2003. Using the weak exogeneity in a cointegrated system as a notion of long-run causality, the test results indicated that causality flows from gas consumption to real GDP. Zamani [25] probed the relationship between gas and the economy of Iran for the period covering 1967-2003. Applying the error correction model to infer causality, the paper provided evidence for bidirectional relationships between GDP and natural gas consumption. Hu and Lin [26] utilized the Hansen and Seo [27] cointegration test to examine the connection between natural gas consumption and real GDP in Taiwan. The feedback hypothesis was confirmed for the country. Khan and Ahmad [28] deployed Johansen [22] and Johansen and Juselius [29] tests to investigate the connection between gas consumption per capita, gas price and real GDP per capita in Pakistan for the period, 1972-2007. The result supported the conservation hypothesis. Işik [30] explored the relationship for the natural gas consumption-economic growth nexus in Turkey over the period 1977-2008. The results indicated natural gas consumption as being positively influenced by economic growth in the short-run, but a negative relationship was observed in the long-run. Despite the contributions of the foregoing papers, a major weakness of these studies is that they applied cointegration tests to ascertain the direction of causality, without incorporating a formal Granger causality. However, the existence of cointegration does not specify the direction of causality.

There are bivariate studies that have applied series of causality tests to infer causal relationship between natural gas consumption and economic growth. Yu and Choi [31] used the Sims [32] causality tests on UK, US and Poland with causality flowing from output to natural gas, while there was no causality between the variables in the case of US and Poland. Yang [33] investigated the causality between gas utilisation and GDP in Taiwan for 1954-1997. Single causality running from natural gas consumption to GDP was identified in the findings. Siddiqui [34] applied the Hsiao [35] causality test to probe the causal relationship between natural gas and economic growth in Pakistan for the period, 1970 to 2003. The results revealed no causality between the variables. Adeniran [36] used the Sims [32] causality test to examine the causal relation in Nigeria for the period 1980 to 2006. The results revealed that causality flows from real GDP to natural gas consumption. Payne [37] examined the causal relation between economic growth and gas consumption, for the period covering 1949 to 2006 for the U.S. The findings indicated a positive one-way causality from output to natural gas consumption. In another bivariate study, Zahid [38] examined the nexus in three countries- Bangladesh, Pakistan and India for the period, 1971-2003. Test results demonstrated the presence of one-way causality from natural gas consumption to the economy in Bangladesh, and lack of causality for Pakistan and India. Lim and Yoo [39] explored the short-run and long-run causality between natural gas consumption and economic growth in Korea with quarterly data covering the period 1991-2008. The results provided evidence for two-sided Granger causality between natural gas and growth in Korea. Das et al. [40] investigated the relationship between natural gas consumption and economic growth in Bangladesh for the period, 1980-2010. The authors were able to establish long run relationship and unidirectional causal flow from natural gas consumption to real GDP with the Granger causality test. Bildirici and Bakirtas [41] considered the causality between natural gas (among other types of energy) and economic growth for Brazil, Russia and Turkey.

Test results revealed the incidence of two-way causality relationships between natural gas consumption and economic growth for Brazil, Russia and Turkey. Pirlogea and Cicea [42] looked at the causality between natural gas consumption and real GDP per capita in Romania and Spain for the period, 1990-2010. Using the Granger [43] causality test, the evidence showed that causality flows from natural gas consumption to economic growth in Spain, while no causality was observed for Romania.

Papers with causality framework are known to offer better policy guides than those done with cointegration tests. However, the causality papers that have done their estimations through bivariate approach are susceptible to the problem of omission of relevant variable bias. Hence the third strand of the literature has opted for trivariate framework to examine the relationship between natural gas and economic growth. Aqeel and Butt [44] considered the causal relationship between national output and several components of energy inclusive of natural gas, with employment as a control variable in Pakistan for 1955-1956 to 1995-1996. Utilising the Engle and Granger [45] cointegration and Hsiao [35] causality tests, the findings illustrated no causality between gas and economic growth. Lotfalipour et al. [46] probed the relationships between economic growth, fossil fuels consumption and carbon emission for Iran during the period 1967 to 2007. Using the natural gas, the results showed that unidirectional Granger causality running from natural gas consumption to GDP. Kum et al. [47] investigated the relationship between natural gas consumption and economic growth in the G-7 countries-Canada, France, Germany, Italy, Japan, U.K and U.S for the period 1970–2008. Controlling for capital, the study revealed causality flowing from natural gas consumption to growth for Italy, while the opposite was noted for the U.K. The results further showed that France, Germany, and the U.S experienced bidirectional causality. There was lack of causality for Canada and Japan. Saboori and Sulaiman [6] looked at the relationship between gas consumption and economic growth in Malaysia for the period of 1980–2009. The results provided evidence for long run bidirectional relationship between CO_2 emissions and gas consumption, economic growth and gas consumption. In the short-run, unidirectional causality exists from gas consumption to economic growth.

Trivariate approach reduces the problem of omission of relevant variable, but the inclusion of an additional variable (which in several cases is due to data limitation) does little to actually address the problem. Most of the recent papers have shifted to the use of multivariate frameworks. For instance, Apergis and Payne [16] examined the relationship between natural gas consumption and economic growth for a panel of 67 countries over the period 1992–2005. Using heterogeneous panel cointegration, the study further added labour force, and capital formation to the system, with the estimates revealing long-run relationships in the variables and two-sided causality between economic growth and natural gas consumption. Ighodaro [48] investigated natural gas utilization and economic growth link in Nigeria for the period spanning 1970 to 2005. Adding health expenditure and broad money to the system, the study noted a long-run link in the series and unilateral causality running from gas utilization to economic growth. Shahbaz et al. [49] looked at the nexus in Pakistan for the period, 1972-2010. They included capital, labour and exports in the multivariate model. The authors applied variance decomposition analysis to show that there was causality flowing from natural gas consumption to economic growth. Farhani et al. [17] examined the role of gas in addition to fixed capital formation and trade on economic growth in Tunisia for the period of 1980-2012. Using the Toda and Yamamoto [50] causality test, the result indicated bidirectional causality between natural gas consumption and real output.

3. An Overview of Malaysian Economy.

Malaysia is one of the ten South East Asian nations, with a landmass of 329,847 sq km, which comprises two regions-Peninsular Malaysia and Malaysian Borneo [51]. The country shares borders with Thailand, Indonesia and Brunei, with maritime boundaries with Indonesia, Singapore and the Philippines. With a population of nearly 30 million, the economy is blessed with natural gas, petroleum, tin, copper, iron ore, timber and bauxite. Since gaining independence in 1957, Malaysia has witnessed significant positive changes across all sections of its economy and has advanced from being raw materials producer, in the 1970s to a renowned exporter of natural gas, palm oil and electronics [10]. While the economy has been affected by inevitable external shocks, it has, to a certain degree, fruitfully focused its blueprints on stimulating the country towards sustainable economic development [52]. Malaysia's tremendous economic success is reflected in its impressive GDP growth rate and reduction in the level of absolute poverty. The per capita GDP increased from USD1427.093 in 1971, to USD2318.238 in 1980; USD4861.858 in 2000, and USD6786.185 in 2012 [53]. Growth was followed by a significant decline in poverty from 49.3% in 1970 to 1.7% in 2012 [10]. It has long been recognized that the energy sector is the life provider of the country and as such several energy policies were introduced to stimulate the economy. In the early 1970s, the government introduced the Petroleum Development Act of 1974 which vested Petronas, the exclusive rights to explore, develop and produce petroleum resources in the country. The National Petroleum policy 1975 was later launched to provide a regulatory framework for the downstream oil and gas industry. A more encompassing policy-the National Energy Policy was initiated in 1979 to address supply, utilization and environmental issues associated with energy. In 1980, the government introduced the National Depletion Policy, which was aimed at prolonging the existence of the country's oil reserves [54]. In order to further boost the security of energy supply, enhance the nature of utility services and promote the involvement of the private sector in the development of infrastructural facilities, there was the enactment of Energy Commission Act 2001.

Given the government efforts to develop the sector, Malaysia's energy sector is a vital industry for the whole nation and constitutes about one-fifth of the GDP [11]. The value of the upstream activities in oil and gas sector amounts to RM87 billion, while downstream activities, including refining, constitute RM24 billion [55]. It is the single biggest source of revenue to the Malaysian government, (about 45% in 2012), through taxes and dividends [11]. Besides, in the tenth Malaysia plan, oil and gas sector is listed among the twelve National Key Economic Areas (NKEAs)[2]. With the NKEAs, it is believed that limited number of sectors including oil and gas must be prioritized in a bid to accomplish the objective of becoming a developed nation in the year 2020. Natural gas and oil are the principal forms of the energy consumed in Malaysia. As shown in Table-1, natural gas and oil accounted for 32.11% and 46.04% in the total energy mix in 2012. About 18.92% of the nation's energy consumption is through coal. Hydropower

[2] NKEAs are drivers of economic activity in Malaysia that are expected to have the potential to materially and directly account for a sizable level of economic growth to the economy of Malaysia.

constitutes another 2.56%, and biomass contributes 0.14% to total consumption [56][3]. Particularly, natural gas is an important fuel for the Malaysian economy. In the 1970s, oil was the predominant form of energy in the country. To reduce total reliance on oil with the occurrence of the energy crisis of the 1970s and to prevent depletion of the country's oil reserves, Malaysia initiated the "Four-Fuel Diversification Strategy" in 1980 and began to encourage the use of natural gas (in addition to hydropower and coal). A major milestone in the development of the local gas industry was the establishment of the Peninsular Gas Utilisation (PGU) network in 1984, which was completed in 1998. Traversing the length and breadth of the country while extending the pipeline to Singapore in the south and Thailand to the north, the coverage of PGU system is in excess of 880 miles and it is capable of transporting two billion cubic feet per day of natural gas [11,57]. Consistent with its policy to promote wider use of natural gas, the government gazetted the Gas Supply Act 1993 pertaining to gas reticulation to the industrial, commercial and residential sectors [57].

Although natural gas production in the country rose over the past two decades, growth has not been constant in the recent times. As shown in Figure-1, the production of natural gas grew from about 2.2 million tonnes oil equivalent (mtoe) in 1980 to 15.49 mtoe in 1990; and to 62.58 mtoe in 2012. This trend translates to an increase in natural gas production of about 27-fold over the period, 1980-2012. However, there was a 3.77%, 2.38% and 10.41% decrease in the production of natural gas in 2009, 2011 and 2012, respectively. The natural gas consumption has risen at a faster pace relative to the production. As shown in Figure-2, the natural consumption gas increased geometrically from 0.035 mtoe in 1980; to 1.07 mtoe in 1990; 3.86 mtoe in 2000; and 10.21 mtoe in 2012. This trend translates to an increase in natural gas consumption of about 291.66-fold over the period, 1980-2012. The ratio of the domestic consumption to the total production also rose from 1.56% in 1980 to 16.31% in 2012. Besides, evidence provided by Figure-2 shows that large part of natural gas consumption are meant for industrial and non-energy demand. They were collectively responsible for 2.86% of the total consumption in 1980 and 96.91% in 2012. Due to the rise in the utilisation of natural gas by the industrial and non-energy sectors, the demand of natural gas swelled by 19.8% in 2012. The final consumption for natural gas in non-energy use sector rose by 36.6% due to high consumption for petrochemical industry in the country [56].[4] Natural gas plays an important significant part in the electricity generation of the country. With less than 3.19% and 27.19% of the electricity generation mix in 1980 and 1993, natural gas constitutes about 45% of this mix in 2011 (Table-2), and is planned to have a future contribution of 50%-60% in power generation mix [57,58].

TABLE 1 ABOUT HERE

FIGURE 1 ABOUT HERE

FIGURE 2 ABOUT HERE

TABLE 2 ABOUT HERE

---

[3] Oil includes other petroleum resources.

[4] Non-energy sector is the sector that uses fuels including natural gas as raw materials and they are not consumed as a source of energy or transformed into another fuel.

4. Methodology

4.1 Model and data

We conduct our estimations with a model, which augments the Ram and Zhang [59] and Ramirez [60,61] version of the neoclassical model. By doing this, we add natural gas consumption and trade openness to the framework, which already included foreign direct investment and capital formation as determinants of output. Our empirical equation takes the following form:

$$Y_t = F(G_t, F_t, K_t, O_t) \tag{1}$$

where Y is real GDP per capita, G is natural gas consumption (in cubic metres) per capita, K is real capital formation (proxies by real gross fixed capital formation) per capita, F is real foreign direct investment per capita and O is real trade openness (real exports of goods and services plus real imports of goods and services) per capita[5]. We focus on the period, 1971-2012, which is the longest, when it comes to the studies on causal relationship between energy consumption and economic growth in Malaysia. Annual data for natural gas consumption was generated from *British Petroleum Statistical Review of World Energy*, while the trade openness and real GDP per capita data were obtained from *World Bank Development Indicators*. The data for foreign direct investment were extracted from *United Nations Conference on Trade and Development* (UNCTAD) database, while the data for population and consumer price index that were utilised in normalising some of the variables were generated from *World Bank Development Indicators*.

[5] Although labour is included in the original specification, we exclude it in our specification due to lack of availability data and also for the fact that the other variables are expressed in per capita.

We have converted all the series into per capita form. Moreover, we have transformed all the series into logarithmic specification. The log-linear specification of Eq. (1) is as follows:

$$\ln Y_t = \alpha_a + \alpha_G \ln G_t + \alpha_F \ln F_t + \alpha_K \ln K_t + \alpha_o \ln O_t + \mu_t \qquad (2)$$

where $\ln Y_t$ is natural log of real GDP per capita, $\ln G_t$ is natural log of natural gas consumption per capita, $\ln F_t$ is the natural log of real foreign direct investment (stock) per capita, $\ln K_t$ is the natural log of real capital formation per capita, $\ln O_t$ is the natural log of openness per capita. μ_t is residual term.

4.2 Unit root tests

In most cases, knowing the integration properties of the series are needed before the conduct of cointegration and causality tests. However, if structural breaks occur in a time series, the power of traditional unit root tests to reject the null hypothesis is weakened. Consequently, unit root tests with structural breaks have been recently introduced. With the exception of Lee and Strazicich [62,63] tests, several of these tests possess some deficiencies [64]. The current paper uses the Lee and Strazicich [62,63] tests, which are specified as follows:

$$\Delta y_t = \delta' \Delta Z_t + \phi \overline{S}_{t-1} + \sum_{i=1}^{p} \gamma \Delta \overline{S}_{t-i} + \mu_t \qquad (3)$$

Here $\Delta \overline{S}_t = y_t - \hat{\psi}_x - Z_t \hat{\delta}_t, t = 2..,T, \hat{\delta}$ are coefficients in the regression of Δy_t on ΔZ_t and $\hat{\psi}_x = y_t - Z_t \hat{\delta}$ in which y_1 and Z_1 are the first observations of y_t and Z_t, respectively. In a specification that allows for a single change in both level and trend, $Z_t = [1, t, D_{1t}, DT_{1t}]'$ where $DT_{jt} = t$ if $t \geq T_B + 1$, and 0, otherwise. Estimation of single change is given by $\lambda_j = T_{Bj} / T$, $j = 1$. In a specification that provides for double changes in both level and trend, $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$ where $DT_{jt} = t$ if $t \geq T_{Bj} + 1, j = 1,2$ and 0, otherwise. In this study, augmented terms of $\Delta \overline{S}_t$ are incorporated into the estimations to make sure that no serial correlations exists in the errors[6].

---

[6] To estimate the optimal lag length, we employ the method that was introduced by Ng and Perron [65].

4.3. Bayer-Hanck Cointegration Approach

The existing econometric literature reveals that the linear combination of series has lower order of integration if the time series are integrated at I(1) or (2). Engle and Granger [45] pioneered the cointegration approach to examine long run relationship between the series. This test of cointegration requires that all the series must have unique order of integration. The Engle-Granger cointegration approach is suitable when the data sets are of finite size as most economic time-series are. The problem with the Engle-Granger cointegration approach is that it provides biased empirical results due its low explanatory power properties. In late 1980s, Johansen [22] introduced a new test of cointegration titled "*Johansen maximum eigenvalue test*". This test of cointegration is more preferable to researchers because it permits more than one cointegrating relationship between the variables or series. The Error Correction Model (ECM) based F-test is developed by Boswijk [66], and the ECM based *t*-test is by Banerjee et al. [67].

The Bayer-Hanck cointegration approach combines different tests (which ordinarily would have yielded different conclusions) into a single framework. The null of no-cointegration of the most comprehensive Bayer-Hanck cointegration test is based on Engle and Granger, Johansen, Boswijk and Banerjee et al. tests. The Bayer-Hanck test jointly determines test-statistics of Engle and Granger, Johansen, Boswijk, and Banerjee tests. This cointegration approach combines the empirical results of various individual cointegration tests for comprehensive cointegration conclusion. We apply this approach of cointegration to examine whether cointegration is present between natural gas consumption and economic growth in the case of Malaysia. The combination of the estimated significance level (*p*-value) of each cointegration test in Fisher's formulas is presented as follows:

$$EG-JOH=-2\left[\ln(p_{EG})+(p_{JOH})\right] \tag{4}$$

$$EG-JOH-BO-BDM=-2\left[\ln(p_{EG})+(p_{JOH})+(p_{BO})+(p_{BDM})\right] \tag{5}$$

Where p_{EG}, p_{JOH}, p_{BO} and p_{BDM} are the *p*-values of Engle and Granger, Johansen, Boswijk and Banerjee et al. cointegration tests, respectively. It is premised on the assumption that if the computed Fisher statistics is more than the critical values produced by Bayer and Hank [20], we can reject the null hypothesis of no cointegration.

4.4 The VECM Granger Causality Approach

After investigating the long run relationship between the variables, we utilize the Granger causality test to estimate the causal relationship between the variables. If there is cointegration between the series then the vector error correction method (VECM) can be utilised as follows:

$$\begin{bmatrix}\Delta \ln Y_t \\ \Delta \ln G_t \\ \Delta \ln K_t \\ \Delta \ln F_t \\ \Delta \ln O_t\end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} + \begin{bmatrix} B_{11,1} & B_{12,1} & B_{13,1} & B_{14,1} & B_{15,1} \\ B_{21,1} & B_{22,1} & B_{23,1} & B_{24,1} & B_{25,1} \\ B_{31,1} & B_{32,1} & B_{33,1} & B_{34,1} & B_{35,1} \\ B_{41,1} & B_{42,1} & B_{43,1} & B_{44,1} & B_{45,1} \\ B_{51,1} & B_{52,1} & B_{53,1} & B_{54,1} & B_{55,1} \end{bmatrix} \times \begin{bmatrix}\Delta \ln Y_{t-1} \\ \Delta \ln G_{t-1} \\ \Delta \ln K_{t-1} \\ \Delta \ln F_{t-1} \\ \Delta \ln O_{t-1}\end{bmatrix} + \ldots + \begin{bmatrix} B_{11,m} & B_{12,m} & B_{13,m} & B_{14,m} & B_{15,m} \\ B_{21,m} & B_{22,m} & B_{23,m} & B_{24,m} & B_{25,m} \\ B_{31,m} & B_{32,m} & B_{33,m} & B_{34,m} & B_{35,m} \\ B_{41,m} & B_{42,m} & B_{43,m} & B_{44,m} & B_{45,m} \\ B_{51,m} & B_{52,m} & B_{53,m} & B_{54,m} & B_{55,m} \end{bmatrix} \times \begin{bmatrix}\Delta \ln Y_{t-1} \\ \Delta \ln G_{t-1} \\ \Delta \ln K_{t-1} \\ \Delta \ln F_{t-1} \\ \Delta \ln O_{t-1}\end{bmatrix} + \begin{bmatrix}\zeta_1 \\ \zeta_3 \\ \zeta_3 \\ \zeta_4 \\ \zeta_5\end{bmatrix} \times (ECM_{t-1}) + \begin{bmatrix}\mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \\ \mu_{5t}\end{bmatrix} \quad (6)$$

where difference operator is $(1-L)$ and ECM_{t-1} is the lagged error correction term, generated from the long run equation. The t-statistic of lagged error correction terms is used to determine the causality in the long run. The short run causality relationship is notified by statistical significance of χ^2 for differences of the variables. For example, $B_{12,i} \neq 0 \forall_i$ shows that natural gas consumption Granger causes economic growth and economic growth Granger causes natural gas consumption if $B_{21,i} \neq 0 \forall_i$.

5. Results and their Interpretations

Table-3 details about the descriptive statistics and correlation matrix between the variables. We find that all the variables have normal distributions confirmed by Jarque-Bera test reported in Table-3. The correlation analysis reveals the positive association between natural gas consumption and economic growth. A positive correlation is found between foreign direct investment and economic growth. The correlation between capital and economic growth is positive. Trade openness is positively correlated with economic growth. Foreign direct investment, capital and trade openness are inversely correlated with natural gas consumption. Capital and foreign direct investment are positively correlated and same inference is found between trade openness and foreign direct investment. There is positive correlation in capital formation and trade openness.

TABLE 3 ABOUT HERE

It is necessary to have information about the order of integration of variables. The reason is that cointegration approaches are sensitive to order of integration, especially higher order of integration. The knowledge of the integration properties of the variable is also required to find out the correct specification of Granger causality test (i.e. if the variables are I(0), then variables in Granger causality are specified in level, but if the variables are I(1), then variables are specified in first difference with or without the error correction term depending on cointegration). Results of stationarity tests are reported in Table 4. Lee and Strazicich [63] one structural break results are reported in the upper panel. Starting with Models A and C of Lee and Strazicich [63], we observe that the null hypothesis of unit root cannot be rejected for any of the series in levels at the 10% level. When the series are expressed in the first difference, we can reject the null hypothesis at 5% level or better. In reality, power of Lee and Strazicich [62] one structural break becomes weakened in case of more than one structural break, a problem ameliorated with Lee and Strazicich [62] two-time structural breaks approach. Lee and Strazicich [62] results are presented in the lower panel of Table-4, which indicate that for any of the series in levels, the null hypothesis of unit root cannot be rejected at the 10% level. When the series are expressed in the first difference, we can reject the null hypothesis at 10% level or better. We note that almost 40% of the structural breaks lie within the late 1990s, which was the period of Asian Financial crisis, in which most of the economies in South-East Asia including Malaysia faced an unprecedented financial and economic crises.

TABLE 4 ABOUT HERE

With the stationarity properties of the series, the combined cointegration tests developed by Bayer and Hanck [20] are suitable to examine whether cointegration exists. Table-5 presents the combined cointegration tests including the EG-JOH, and EG-JOH-BO-BDM. We find that test statistics for EG-JOH and EG-JOH-BO-BDM tests exceed the critical values at 5% level of significance as we use real GDP, natural gas consumption, foreign direct investment, capital formation and openness as dependent variables. This rejects the null hypothesis of no cointegration among the variables and confirms the cointegration among the variables. We may conclude that there is long run relationship between natural gas consumption, economic growth, foreign direct investment, capital formation and trade openness in the case of Malaysia.

TABLE 5 ABOUT HERE
TABLE 6 ABOUT HERE

Bayer and Hanck [20] combined cointegration approach provides efficient empirical results but fails to accommodate structural breaks while investigating the cointegration between the variables. This issue is solved by applying the ARDL bounds testing approach to cointegration in the presence of structural breaks following Shahbaz et al. [68]. The ARDL bounds test is sensitive to lag length selection and we have used the Akaike information criterion (AIC) to select appropriate lag order of the variables. It is reported by Lütkepohl, [69] that the dynamic link between the series can be captured if appropriate lag length is chosen. The results are reported in Table-6. We use critical bounds from Narayan [70] to make decision on whether cointegration exists or not. Our results show that the calculated F-statistic is greater than upper bounds as we use real GDP, natural gas consumption, foreign direct investment and capital formation as dependent variables. This shows that the ARDL bounds testing analysis confirms our established long run among the series (See Table-6).

Now we examine the long run impact of natural gas consumption, foreign direct investment, capital formation and trade openness on economic growth with the results presented in Table-7. We find that there is positive and significant relationship of natural gas consumption on real GDP per capita. It is statistically significant at 5%. This indicates that a 1% increase in natural gas consumption will raise economic growth by 0.0239%, keeping other things constant. This validates energy-led growth hypothesis. The impact of foreign direct investment on economic growth is positive and statistically significant. According to the estimates, a 1% increase in foreign direct investment will improve economic growth by 0.0726%, all else is same. The relationship between capital and economic growth is positive with the results showing that 1% increase in capital is positively linked with economic growth by 0.0696%, all else is same. The impact of trade openness on economic growth is positive and statistically significant at 1% level of significance. All else is constant, 0.4555% increase in economic growth is linked with 1% rise in trade openness.

TABLE 7 ABOUT HERE

The short run results are also shown in the lower segment of Table-7. We find that natural gas consumption leads economic growth and it is statistically significant. The impact of foreign direct investment is positive on economic growth and significant at 10% level. The relationship between capital and economic growth is positive and it is statistically significant at 1% level of significance. The impact of trade openness on economic growth is positive and statistically significant. The negative and statistically significant estimates for ECM_{t-1}, -0.0865 lend support to long run relationship among the series in the case of Malaysia. The coefficient is statistically significant at 10% level. The diagnostic tests suggest we can accept he null hypothesis of normally distribution, and that the model is devoid of serial correlation and AutoRegressive Conditional Heteroskedasticity (ARCH) problems. The Ramsey reset test demonstrates that functional form for the specifications of the short run models is adequate. We find that graphs of cumulative sum (CUSUM) and cumulative sum of squares CUSUMsq are within critical bounds at 5% level of significance (Figures. 3-4). This ensures the stability of long run and short run coefficients.

FIGURE 3 ABOUT HERE
FIGURE 4 ABOUT HERE

If the long run relationship is ascertained, there must be some forms of causal relationship among the variables. We investigate this relation within the framework of the VECM. Table-8 reports results on the nature of long and short run causality. The results suggest a two-way causal relation between natural gas consumption and economic growth. The relationship between foreign direct investment and economic growth is bidirectional. The bilateral causality is found between capital and economic growth and similar inference is drawn between natural gas consumption and capital formation.

Foreign direct investment Granger causes natural gas consumption and in resulting, natural gas consumption Granger causes foreign direct investment. There is bidirectional causality between capital and foreign direct investment. Trade openness Granger causes economic growth, natural gas consumption, foreign direct investment and capital. In short run, natural gas consumption and foreign direct investment Granger cause economic growth. The feedback effect is found between capital and economic growth and same inference is drawn for trade openness and economic growth. Trade openness Granger causes natural gas consumption. The bidirectional causality is found between capital and trade openness. Foreign direct investment Granger causes capital formation. Our results of bidirectional causality between natural gas consumption and economic growth are consistent with the works of Lim and Yoo [39] for Korea; Bildirici and Bakirtas [41] for Brazil, Russia and Turkey; and Farhani et al. [17] for Tunisia.

TABLE 8 ABOUT HERE

6. Conclusion and Policy Implications

This paper reinvestigated the neo-classical production function by incorporating foreign direct investment and trade openness as potential determinants of natural gas consumption and economic growth in Malaysia for the period, 1971-2012. We applied Bayer-Hanck combined cointegration approach to examine the long run relationship between the variables. We further implement the ARDL bounds testing approach, which accommodates structural break to check for the robustness of the long run results. The causal relationship between the series is investigated by employing the VECM Granger causality. Our empirical exercise reveals the presence of cointegration between the variables. Moreover, natural gas consumption adds in economic growth. Foreign direct investment trade openness and capital increase domestic output and hence economic growth. The causality analysis indicates the feedback effect between the series.

The bidirectional causality observed for the relationship between natural gas consumption and economic growth supports the feedback hypothesis between the two series. This implies that though energy policies tailored towards implementing energy efficiency is appropriate in achieving the considerable benefit from natural gas usage, the adoption of polices to conserve the use of natural gas will limit the Malaysian domestic output. Any shortage of the natural gas will also retard economic growth. On the other hand, reduction in the output will adversely affect the demand for natural gas in return. Shock to one of these variables will be passed to the other and that the chain will persist via the feedback flow. Therefore, expansionary natural gas policies are beneficial to the Malaysian economy. Substituting other kinds of fossil fuels with gas should be regarded as a viable policy as this will reduce emission problems in the country. Being a country with abundant natural gas resources, pursuing such policies is not insurmountable. Malaysia's gas reserve currently stands at about 89 trillion cubic feet and at the current production rate; it has a life of about 38 years. It was also the world's second largest exporter of liquefied natural gas after Qatar in 2012 [11]. However, the biggest risk to ensuring the efficient consumption of natural gas and discourage wasteful energy consumption is the market distortion caused by the under-pricing of resources including the natural gas. The government has initiated energy policy that will ensure that the prices of gas will be reviewed biannually to steadily reflect market prices. It is expected that a decoupling method for energy pricing will be embarked on to overtly detailed subsidy value in consumer energy bills and eventually remove subsidy from energy use. The implementation of a market-based pricing for energy resources will also draw new investors in the energy supply chain and ensures energy security [71]. However, there is a need, at least in the short run, to introduce a scheme to reduce the negative effect of deregulating prices of energy on the poor and unemployed.

Further results show evidence of feedback hypothesis between natural gas consumption with foreign direct investment, capital formation and trade openness; and also economic growth with foreign direct investment, capital formation and trade openness. This implies that the decline in domestic output will negatively impact hence trade openness, foreign direct investment and capital formation. On the other hand, any negative shocks to foreign direct investment, capital formation and trade openness will adversely affect the economy. Reduction in natural gas activities will decline trade openness, foreign direct investment and capital formation. On the other hand, any negative shocks to foreign direct investment, capital formation and trade openness will adversely affect the economy. Blueprints aimed at promoting foreign direct investment, capital formation and trade openness will improve natural gas activities and the economy. Malaysia has been doing well in attracting foreign direct investment, such as those in projects in the oil and gas sector including the USD20 billion Refinery and Petrochemical Integrated Development (Rapid) project in Johor, and the USD1.2 billion Sabah Oil and Gas Terminal in Kimanis [72]. However, in light of aggressive competition from its neighbours (such as Myanmar, Vietnam and Indonesia) as well as developed markets, which are looking for foreign direct investment, the country needs to increase its efforts [73]. Implementation of reforms in the form of market liberalisation, human capital enhancement including skills enhancement, combating brain drain and creating favourable business terrain are vital to improve foreign direct investment in the country and consequently natural gas activities and economic activities.

A limitation of this study is the utilisation of aggregated data. The study can be augmented by utilizing disaggregated data, in such a way that natural gas consumption utilised in commercial, non-energy, industrial sectors are all given empirical considerations, as some of the underlying relationships in disaggregated data may not be evident in aggregated data. More variables may still be included in the analysis as this may serve the purpose of reducing the problem of omission variable bias further in addition to incorporating more information that may affect output.

References

[1] Advocacy Messages for the Natural Gas Sector, International Gas Union, 2010. http://www.malaysiangas.com/portal/document/publication/1309564614_Advocacy%20f.pdf
[2] Banks F. An introduction to the economics of natural gas. OPEC Rev 2003; 27(1): 25-63.
[3] Ozturk I. A literature survey on energy–growth nexus. Energy Policy 2010; 38(1):340-9.
[4] Percebois J. The supply of natural gas in the European Union-strategic issues. OPEC Energy Rev 2008; 32(1):33-53.
[5] Payne JE. A survey of the electricity consumption-growth literature. Appl Energy 2010; 87(3):723–31.
[6] Saboori B, Sulaiman J. Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia. Energy Policy 2013; 60: 892-905.
[7] Chandran VGR, Sharma S, Madhavan K. Electricity consumption–growth nexus: the case of Malaysia. Energy Policy 2013; 38(1): 606-12.
[8] Lean HH, Smyth R. On the dynamics of aggregate output, electricity consumption and exports in Malaysia: Evidence from multivariate Granger causality tests. Appl Energy 2010; 87(6): 1963-71.

[9] Tang CF, Tan BW. The linkages among energy consumption, economic growth, relative price, foreign direct investment, and financial development in Malaysia. Qual Quant 2014; 48: 781-97.
[10] Malaysia Overview, 2014. Malaysia overview, 2014 http://www.worldbank.org/en/country/malaysia/overview (last accessed 18.3.14)
[11] Energy International Administration Country Brief-Malaysia, Energy International Administration: 2013 http://www.eia.gov/countries/cab.cfm?fips=MY (last accessed 18.3.14)

[12] The Malay Online, 2014. Malaysia's FDI hit record high in 2013. The Malay Online, 13 February.
[13] Miller S. Monetary dynamics: an application of cointegration and error-correction modelling. J Money, Credit and Bank 1991; 23(2): 139-54.
[14] Stern DI. Energy and economic growth in the USA: A multivariate approach. Energy Econ 1993; 15(2): 137-50.
[15] Lütkepohl H. Non-causality due to omitted variables. J Econom 182; 19(2), 367-78.
[16] Apergis N, Payne JE. 2010. Natural gas consumption and economic growth: A panel investigation of 67 countries. Appli Energy 2010; 87(8): 2759-63.
[17] Farhani S, Shahbaz M, Arouri M, Teulon F. 2014. The role of natural gas consumption and trade in Tunisia's output. Energy Policy 2014; 66: 677-84.
[18] Malaysian Investment Development Authority, 2013. Meet Malaysia; Investment opportunities in Asia's oil and gas hub. Kuala Lumpur: Malaysian Investment Development Authority.
[19] Mohamed M. Malaysia: Investment Performance 2011, 2012. http://www.mida.gov.my/env3/uploads/PerformanceReport/2011/MediaStatement(web).pdf (last accessed 18.3.14)
[20] Bayer C, Hanck C. Combining non-cointegration tests. J Time Ser Anal 2013; 34(1): 83-95.
[21] Lee CC, Chang CP. Structural breaks, energy consumption and economic growth revisited: Evidence from Taiwan. Energy Econ 2005; 27(6): 857-72.
[22] Johansen S. Statistical analysis of cointegration vectors. J Econ Dyn Control 1988;12:231-54.
[23] Hansen BE. Testing for parameter instability in linear models. J Policy Model 1992; 14(4): 517-33.
[24] Gregory A. Hansen B. Residual-based tests for cointegration in models with regime shifts. J Econ 1996; 70(1): 99-126.
[25] Zamani, M., Energy consumption and economic activities in Iran. Energy Econ. 2007; 29(6): 1135-1140.
[26] Hu JL, Lin CH. Disaggregated energy consumption and GDP in Taiwan: A threshold cointegration analysis. Energy Econ 2008; 30: 2342-58.
[27] Hansen B, Seo B. Testing for two-regime threshold cointegration in vector error-correction models. *J Econ 2002; 110*(2): 293-318.
[28] Khan M, Ahmad U. Energy demand in Pakistan: A disaggregate analysis. Pak Dev Rev 2008; 47: 437–55.
[29] Johansen S, Juselius K. Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxf Bull Econ Stat 1990; 52*(2): 169-210.
[30] Işik C. Natural gas consumption and economic growth in Turkey: A bound test approach. Energy Syst 2010; 1:441–56.

[31] Yu E, Choi J. The causal relationship between energy and GNP: an international comparison. J Energy Develop 1985; 10: 249-72.
[32] Sims CA. Money, income, and causality. Am Econ Rev 1972; 62: 540-52.
[33] Yang H. A note on the causal relationship between energy and GDP in Taiwan. Energy Econ 2000; 22(3): 309-317.
[34] Siddiqui R. Energy and economic growth in Pakistan. The Pak Dev Rev 2004; 43:175–200.
[35] Hsiao C. Autoregressive modelling and money-income causality detection. *J Monetary Econ 1981; 7*(1): 85-106.
[36] Adeniran O. Does energy consumption cause economic growth? An empirical evidence from Nigeria. A thesis submitted in fulfillment of the requirements for the degree of Masters, of University of Dundee; 2009
[37] Payne JE. US disaggregate fossil fuel consumption and real GDP: an empirical note. Energy Sources, Econ, Plan and Policy 2011; 6(1): 63–8.
[38] Zahid A. Energy–GDP relationship: A causal analysis for the five countries of South Asia. Appl Econom and Int Dev 2008; 8(1):167-80.
[39] Lim HJ, Yoo SH. 2012. Natural gas consumption and economic growth in Korea: A causality analysis. Energy Sources Part B Econ Plan Policy 2012; 7(2); 169-76.
[40] Das A, McFarlane A, Chowdhury M. The dynamics of natural gas consumption and GDP in Bangladesh. *Renew and Sustain Energy Rev 2013; 22:* 269-274.
[41] Bildirici M, Bakirtas T. The relationship among oil, natural gas and coal consumption and economic growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) countries. *Energy 2014; 65*: 134-144.
[42] Pirlogea C, Cicea C. Econometric perspective of the energy consumption and economic growth relation in European Union. Renew Sustain Energy Rev *2012; 16*(8): 5718-26.
[43] Granger CW. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica 1969;* 424-438.
[44] Aqeel A, Butt MS. The relationship between energy consumption and economic growth in Pakistan. Asia–Pacific Dev J 2001; 8:101-10.
[45] Engle R, Granger C. Cointegration and error correction: representation, estimation and testing. Econometrica 1987; 55: 251-76.
[46] Lotfalipour MR, Falahi M Ali, Ashena M. Economic growth, CO2 emissions, and fossil fuels consumption in Iran. Energy 2010; 35: 5115-20.
[47] Kum H, Ocal O, Aslan A. The relationship among natural gas energy consumption, capital and economic growth: bootstrap-corrected causality tests from G-7 countries. Renew Sustain Energy Rev 2012; 16(5):2361-5.
[48] Ighodaro C. Co-integration and causality relationship between energy consumption and economic growth: Further empirical evidence for Nigeria. J Bus Econ and Manag 2010; 11(1): 97-111.
[49] Shahbaz M, Lean H, Farooq A. Natural gas consumption and economic growth in Pakistan. Renew Sustain Energy Rev 2013; 18: 87-94.
[50] Toda, H., Yamamoto T., 1995. Statistical inference in vector autoregressions with possibly integrated processes. J Econ 1995; 66(1): 225-250.
[51] Central Information Agency, 2014. The world factbook-Malaysia. https://www.cia.gov/library/publications/the-world-factbook/geos/my.html (last accessed 18.3.14)
[52] Ching P. Malaysian economy, 2008. Selangor: Prentice Hall.

[53] World Bank. World Development Indicators, 2014. data.worldbank.org (last accessed 18.3.14)
[54] Oh TH, Pang SY, Chua SC. Energy policy and alternative energy in Malaysia: issues and challenges for sustainable growth. Renew Sustain Energy Rev 2010; 14(4): 1241-52.
[55] Inside Malaysia. Energising Malaysia, 2012. http://etp.pemandu.gov.my/upload/Inside%20Investor%20-%20Energising%20Malaysia.pdf (last accessed 18.3.14)
[56] National Energy Commission. National Energy Balance, 2012 http://meih.st.gov.my/documents/10620/717f207d-1308-4d2c-b5e1-9f84b24d2e0b (last accessed 18.3.14)
[57] Malaysian Gas Association. Powering Growth, 2007. http://www.malaysiangas.com/portal/modules/publication/publication/document/ (last accessed 18.3.14)
[58] Department of Statistics. Electricity, 2014. http://www.statistics.gov.my/portal/index.php?option=com_content&view=article&id=1251&Itemid=109&lang=en (last accessed 18.3.14)
[59] Ram R, Zhang KH. Foreign direct investment and economic growth: Evidence from cross-country data for the 1990s. Econ Dev Cultural Change, 2002; 51, 205-15.
[60] Ramirez MD. The impact of public investment on private investment spending in Latin America: 1980-95. Atl Econ J 2000; 28: 210-25.
[61] Ramirez MD. Is foreign direct investment beneficial for Mexico? An empirical analysis, 1960–2001. World Dev 2006; 34(5): 802-17.
[62] Lee J, Strazicich MC. Minimum Lagrange multiplier unit root test with two structural breaks. Rev Econ Stat 2003, 85(4), 1082-1089.
[63] Lee J, Strazicich MC. Minimum LM unit root test with one structural break. Manuscript, Department of Economics, Appalachian State University, U.S, 2004.
[64] Lee J, Strazicich MC. Break point estimation and spurious rejections with endogenous unit root tests. Oxford Bulletin of Economics and statistics 2001; 63(5): 535-58.
[65] Ng S, Perron P. Unit root tests in ARMA models with data-dependent methods for the selection of the truncation lag. J Ame Stat Association 1995; 90(429):, 268-81.
[66] Boswijk HP. Efficient inference on cointegration parameters in structural error correction models. J Econom 1995; 69(1): 133-58.
[67] Banerjee A, Dolado J, Mestre R. Error-correction mechanism tests for cointegration in a single-equation framework. J Time Ser Anal 1998; 19(3): 267-83.
[68] Shahbaz M, Shabbir MS, Butt MS. Effect of financial development on agricultural growth in Pakistan: New extensions from bounds test to level relationships and Granger causality tests. Int J Soc Econ 2013; 40(8): 707-28.
[69] Lütkepohl H. Structural vector autoregressive analysis for cointegrated variables. AStA Adv in Stat Anal 2006; 90: 75-88.
[70] Narayan PK. The saving and investment nexus for China: evidence from cointegration tests. Appl Econ 2005; 37(17): 1979-90.
[71] Economic Planning Unit,. Tenth Malaysia Plan, 2010. Putrajaya: Economic Planning Unit.
[72] Investvine, 2012. Malaysia braces for huge FDI inflows. Investvine, 26, December.
[73] The Star Online 2013. More effort needed to attract foreign direct investment due to stiff regional competition, The Star, 19 June.

Table-1: Energy mix in Malaysia

Year	Oil	Natural gas	Coal	Hydropower	Biodiesel	Biomass
1980	75.55	20.46	0.48	3.50	-	-
1985	64.48	26.36	2.40	6.76	-	-
1990	57.90	31.67	6.17	4.26	-	-
1995	49.49	41.20	4.76	4.55	-	-
2000	39.96	52.05	4.91	3.08	-	-
2005	36.55	51.09	10.38	1.98	-	-
2010	31.94	47.17	18.87	2.01	-	-
2011	33.93	45.08	18.63	2.33	0.03	-
2012	32.11	46.04	18.92	2.56	0.14	0.22
Note: The figures are in percentages						

Table-2: Source of electricity generated in Malaysia

Year	Coal	Diesel	Hydro	Natural gas	Others
1980	67.77	15.32	13.72	3.19	-
1985	45.94	10.70	25.17	18.18	-
1990	51.05	6.00	15.76	27.19	-
1995	30.82	4.31	13.22	50.86	0.79
2000	18.79	3.31	10.25	66.65	1.00
2005	22.65	3.09	6.54	67.53	0.19
2010	39.44	1.75	5.35	52.61	0.85
2011	41.82	4.26	6.44	43.95	3.54
Note: The figures are in percentages					

Table-3: Descriptive Statistics and Correlation Matrix

Variables	$\ln Y_t$	$\ln F_t$	$\ln F_t$	$\ln K_t$	$\ln O_t$
Mean	9.4616	5.7660	4.9151	6.7206	9.2881
Median	9.4794	6.4205	5.0038	6.9326	9.3779
Maximum	10.1542	7.1557	6.0444	7.5900	10.3390
Minimum	8.5950	1.9815	3.2141	5.4997	7.91921
Std. Dev.	0.4606	1.5003	0.7682	0.5897	0.8383
Skewness	-0.1893	-1.1472	-0.3947	-0.4544	-0.1676

Kurtosis	1.7791	3.1790	2.1880	2.0086	1.4964
Jarque-Bera	2.8594	1.2692	2.2443	3.1654	4.1527
Probability	0.2393	0.3457	0.3255	0.2054	0.1253
$\ln Y_t$	1.0000				
$\ln G_t$	0.0779	1.0000			
$\ln F_t$	0.0544	-0.0560	1.0000		
$\ln K_t$	0.8484	-0.0014	0.4261	1.0000	
$\ln O_t$	0.7163	-0.06915	0.5605	0.5069	1.0000

Table-4: Lee and Strazicich unit root test

	Panel A: Lee and Strazicich (2004) tests									
	Panel AA: Lee and Strazicich (2004) test					Panel AB: Lee and Strazicich (2004) test				
Model	$\ln Y_t$	$\ln G_t$	$\ln F_t$	$\ln K_t$	$\ln O_t$	$\ln Y_t$	$\ln G_t$	$\ln F_t$	$\ln K_t$	$\ln O_t$
T-stat	-2.57	-3.70	-3.71	-3.38	-3.50	-	-5.71***	-4.89**	-4.48**	-8.19***
Lag	0	1	1	1	2	0	3	0	0	0
TB1	1998	1988	1996	1996	1998	1987	1999	1995	1990	1997
DU1	0.12	0.48	1.97*	0.18	1.18	1.62	5.78***	-0.32	0.57	-1.39
DT1	-2.05**	-5.16***	-3.92***	0.65	-2.50**	-0.42	-4.57***	-0.85	-2.16**	1.56
	Panel B: Lee and Strazicich (2003) tests									
	Panel BA: Lee and Strazicich (2003) test					Panel BB: Lee and Strazicich (2003) test				
Model	$\Delta \ln Y_t$	$\Delta \ln G_t$	$\Delta \ln F_t$	$\Delta \ln K_t$	$\Delta \ln O_t$	$\Delta \ln Y_t$	$\Delta \ln G_t$	$\Delta \ln F_t$	$\Delta \ln K_t$	$\Delta \ln O_t$
T-stat	-4.35	-4.07	-4.74	-4.70	-4.85	-	-8.03***	-6.32**	-7.03***	-8.68***
Lag	1	0	3	1	0	0	0	3	2	0
TB1	1984	1978	1984	1983	1985	1987	1982	1986	1982	1987
TB2	1993	1984	1996	1998	1992	1996	1987	1996	1990	1997
DU1	-1.53	-0.11	0.51	-0.61	-4.86***	1.34	3.31***	-2.22**	-0.14	1.23
DT1	-	1.18	-1.41	-1.20	-0.81	0.41	1.10	3.31***	-3.71***	-0.77
DU2	0.83	-	3.00***	0.33	-0.52	-0.07	1.35	2.78**	2.32**	-1.49
DT2	1.39	0.68	-4.73***	-2.90**	0.79	-1.25	0.41	-5.65***	-4.12***	2.28**

TB is the estimated break points. *, **, *** imply 10%, 5% and 1% levels of significance. Critical values are in Lee and Strazicich (2003: 2004). *TB1 and TB2* are the structural break dates. DU1 and DU2 are the dummy variables for breaks in intercept, while DT1 and DT2 are the dummy variables for trend breaks. Critical values for the other coefficients are based on the standard t-distribution 1.65, 1.96, 2.58

Table-5: The Results of Bayer and Hanck Cointegration Analysis

Estimated Models	EG-JOH	EG-JOH-BO-BDM	Cointegration
$\ln Y_t = f(\ln G_t, \ln F_t, \ln K_t, \ln O_t)$	18.4208***	22.1569**	Yes
$\ln G_t = f(\ln Y_t, \ln F_t, \ln K_t, \ln O_t)$	55.3079***	110.8256***	Yes
$\ln F_t = f(\ln Y_t, \ln G_t, \ln K_t, \ln O_t)$	21.3977***	40.7406***	Yes
$\ln K_t = f(\ln Y_t, \ln G_t, \ln F_t, \ln O_t)$	19.099***	27.7353**	Yes
$\ln O_t = f(\ln Y_t, \ln G_t, \ln F_t, \ln K_t)$	9.425*	19.688*	Yes
*, **, *** imply 10%, 5% and 1% levels of significance. Critical values at 10%, 5% and 1% levels are 8.301, 10.576, 15.845 for (EG-JOH) and 15.938, 20.143, 30.774 for (EG-JOH-BO-BDM) respectively.			

Table-6: The ARDL Cointegration Analysis

	Bounds Testing to Cointegration			Diagnostic tests		
Estimated Models	Lag length	Structural Break	F-statistics	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}
$\ln Y_t = f(\ln G_t, \ln F_t, \ln K_t, \ln O_t)$	2, 1, 1, 2, 2	1996	9.669***	0.5575	0.2814	2.6250
$\ln G_t = f(\ln Y_t, \ln F_t, \ln K_t, \ln O_t)$	2, 2, 2, 1, 2	1986	5.995**	4.0349	1.6975	6.3821
$\ln F_t = f(\ln Y_t, \ln G_t, \ln K_t, \ln O_t)$	2, 1, 1, 2, 2	1993	5.777**	0.8316	1.8605	0.0707
$\ln K_t = f(\ln Y_t, \ln G_t, \ln F_t, \ln O_t)$	2,2, 1, 2, 2	1995	5.490*	1.6153	0.9173	3.3802
$\ln O_t = f(\ln Y_t, \ln G_t, \ln F_t, \ln K_t)$	2, 2, 2, 2, 2	2001	3.540	1.5040	0.0128	1.1559
Significant level	Critical values (T= 42)#					
	Lower bounds $I(0)$	Upper bounds $I(1)$				
1% level	6.053	7.458				
5% level	4.450	5.560				
10% level	3.740	4.780				

*, **, *** imply 10%, 5% and 1% levels of significance, respectively. The optimal lag length is determined by AIC. [ ] is the order of diagnostic tests. # Critical values are collected from Narayan (2005).

Table-7: Long Run and Short Run Analysis

Dependent variable = $\ln Y_t$				
Long Run Analysis				
Variables	Coefficient	Std. Error	T-Statistic	Prob. Values
Constant	4.6169***	0.1319	34.9883	0.0000
$\ln G_t$	0.0239**	0.0100	2.3928	0.0221
$\ln F_t$	0.0726**	1.4927	0.0486	0.0015
$\ln K_t$	0.0696*	0.0370	1.8784	0.0684
$\ln O_t$	0.4555***	0.0290	15.681	0.0000
Short Run Analysis				
Variables	Coefficient	T-statistic	Coefficient	T-statistic
Constant	0.0163***	0.0033	4.8760	0.0000
$\Delta \ln G_t$	0.0202*	0.0118	1.7112	0.0961
$\Delta \ln F_t$	0.0060*	0.0031	1.9264	0.0624
$\Delta \ln K_t$	0.1639***	0.0117	14.002	0.0000
$\Delta \ln O_t$	0.1716***	0.0390	4.4006	0.0001
ECM_{t-1}	-0.0865***	0.0439	-1.9697	0.0571
R^2	0.8721			
F-statistic	46.3932			
D. W	1.9155			
Short Run Diagnostic Tests				
Test	F-statistic	Prob. Value		

$\chi^2 NORMAL$	0.2044	0.9028		
$\chi^2 SERIAL$	1.4676	0.2456		
$\chi^2 ARCH$	0.2695	0.6067		
$\chi^2 WHITE$	1.4207	0.2297		
$\chi^2 RAMSEY$	2.9525	0.1006		
*, **, *** imply 10%, 5% and 1% levels of significance, respectively.				

Table-8: The VECM Granger Causality Analysis

Dependent Variable	Direction of Causality										
	Short Run					Long Run	Joint Long-and-Short Run Causality				
	$\Delta \ln Y_{t-1}$	$\Delta \ln G_{t-1}$	$\Delta \ln F_{t-1}$	$\Delta \ln K_{t-1}$	$\Delta \ln O_{t-1}$	ECT_{t-1}	$\Delta \ln Y_{t-1}, ECT_{t-1}$	$\Delta \ln G_{t-1}, ECT_{t-1}$	$\Delta \ln F_{t-1}, ECT_{t-1}$	$\Delta \ln K_{t-1}, ECT_{t-1}$	$\Delta \ln O_{t-1}, ECT_{t-1}$
$\Delta \ln Y_t$	….	2.68822*** [0.0853]	2.5618*** [0.0945]	7.1885* [0.0001]	11.1374* [0.0000]	-0.1420** [-2.3923]	….	7.3474* [0.0008]	3.5008** [0.0287]	49.1684* [0.0000]	10.8315* [0.0001]
$\Delta \ln G_t$	2.2204 [0.1267]	….	0.5636 [0.5793]	1.5406 [0.2313]	3.2716** [0.0523]	-0.1949* [-3.1265]	3.5339** [0.0269]	….	3.8084** [0.0204]	3.4106** [0.0305]	3.4183** [0.0303]
$\Delta \ln F_t$	0.6526 [0.5281]	2.1055 [0.1400]	….	1.2491 [0.3010]	1.2401 [0.3041]	-0.7310* [-4.0890]	5.9556* [0.0027]	….	10.6957* [0.0001]	7.1385* [0.0010]	7.5620* [0.0007]
$\Delta \ln K_t$	10.6250* [0.0003]	1.4065 [0.2612]	5.3227** [0.0107]	….	2.3555*** [0.0952]	-0.2767* [-3.6925]	10.7852* [0.0001]	7.3814* [0.0008]	5.2670* [0.0050]	….	7.2197* [0.0009]
$\Delta \ln O_t$	12.4056* [0.0001]	0.5668 [0.5618]	2.3200 [0.1162]	3.4659** [0.0447]	….	-0.1391 [-1.5610]	….	….	….	….	….

Note: *, ** and *** show significance at 1, 5 and 10% levels respectively.

Figure-1: Natural gas production in Malaysia (in thousand tonnes oil equivalent), 1980-2012

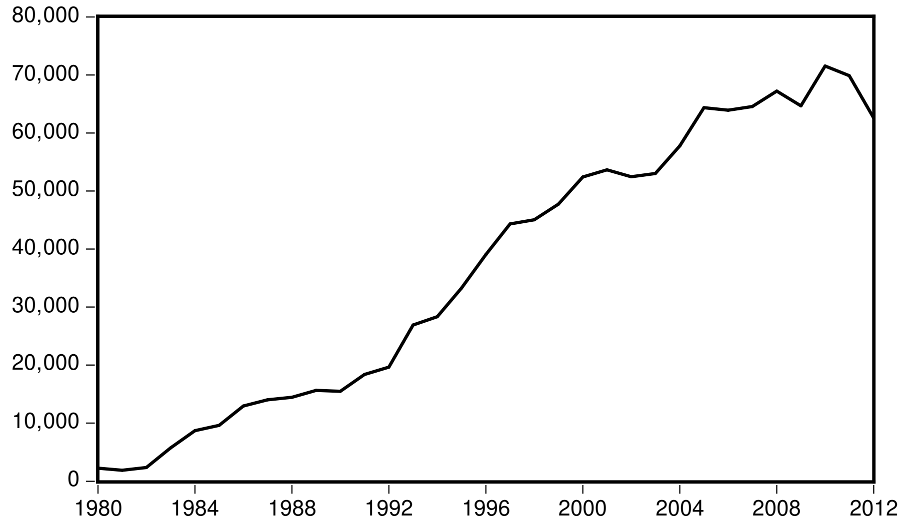


Figure-2: Natural Gas Consumption in Malaysia (in thousand tonnes oil equivalent), 1980-2012

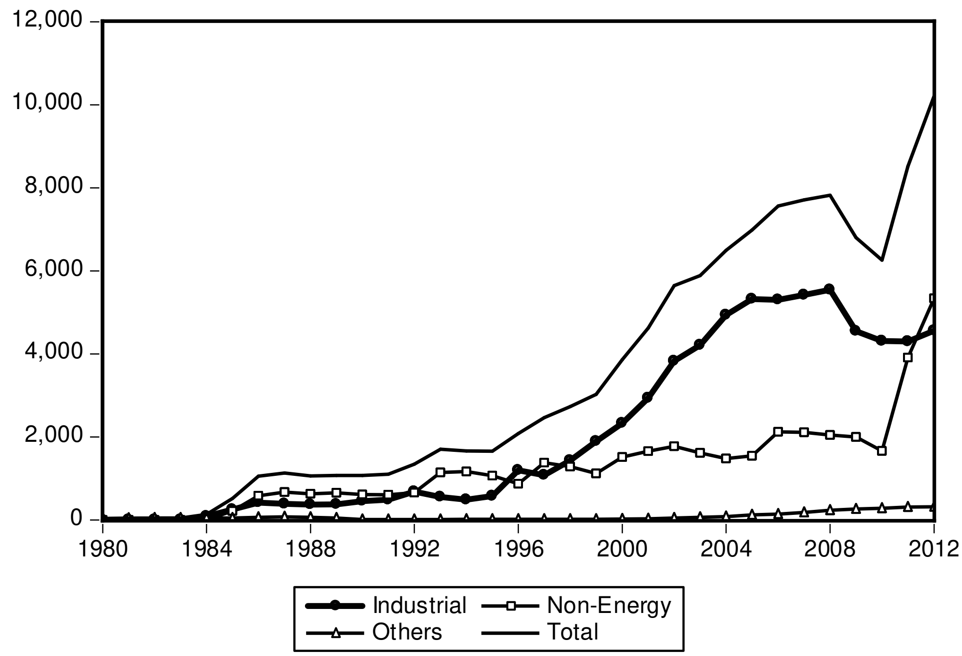
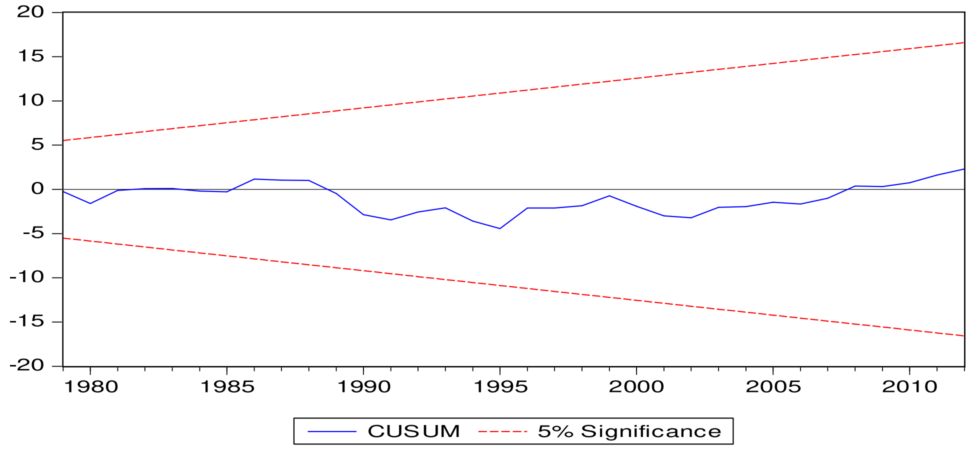
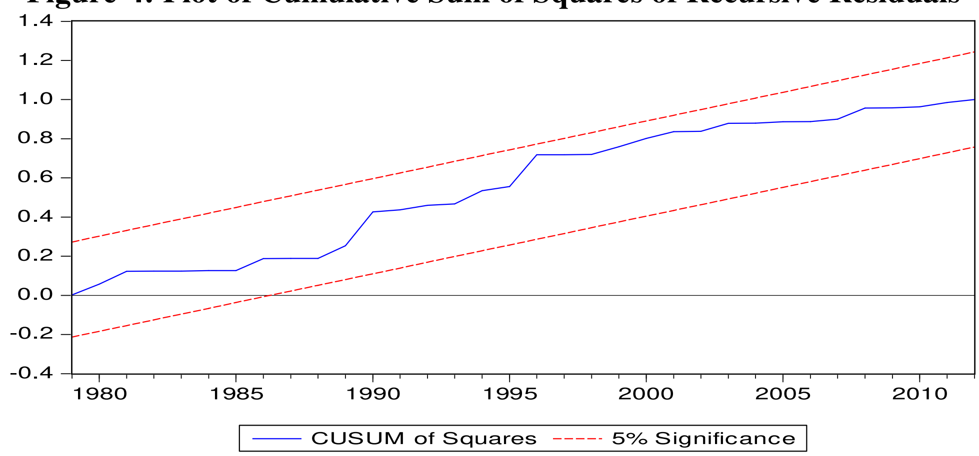


Figure-3: Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure-4: Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level