Does Financial Development Intensify Energy Consumption in Saudi Arabia?

Kumar, Mantu and Babu, M Suresh and Loganathan, Nanthakumar and Shahbaz, Muhammad

National Institute of Technology, India, Universiti Malaysia Terengganu, Malaysia, Montpellier Business School, Montpellier, France

1 November 2016

Does Financial Development Intensify Energy Consumption in Saudi Arabia?

Mantu Kumar Mahalik
Department of Humanities and Social Sciences,
National Institute of Technology (NIT), Rourkela-769008, Odisha, India
India. Email: mantu65@gmail.com

M Suresh Babu
Department of Humanities and Social Sciences,
Indian Institute of Technology (IIT), Madras-600036,
Tamil Nadu, India. E-mail: sureshbabum@iitm.ac.in

Loganathan Nanthakumar
Department of Economics, Faculty of Management and Economics
Universiti Malaysia Terengganu, Malaysia.
Email: kumar@umt.edu.my

Muhammad Shahbaz
Montpellier Business School, Montpellier, France
Email: shahbazmohd@live.com

Abstract: Using annual data for the period 1971-2011**,** this study explores the relationship between financial development and energy consumption for Saudi Arabia by endogenizing economic growth, capital and urbanization as additional determinants in the energy demand function. The combined cointegration test proposed by Bayer-Hanck (2013) is used to estimate the long-run and short-run relationships among the series. The robustness of cointegration results is also tested by employing Pesaran's et al. (2001) Autoregressive Distributed Lag (ARDL) model accommodating structural break in the series. Both conventional and structural break unit root tests are applied in order to test the stationarity properties of the series. The causal relationship between the variables is further investigated by applying Innovative Accounting Approach (IAA).

Both Bayer-Hanck's combined cointegration and Pesaran's ARDL bounds testing models confirm the presence of cointegration among the series. After confirming the existence of cointegration among the series, the overall results from the estimation of an ARDL energy demand function reveal that in the long-run, financial development adds in energy demand in Saudi Arabia. Furthermore, while economic growth is negatively related to energy consumption, urbanization and capital are the key factors leading to increased energy demand in the long-run. The findings also confirm the non-linear and inverted U-shaped relationship between financial development and energy demand for the Saudi Arabian economy. Finally, an evidence of unidirectional causality running from financial development to energy demand is found. These results urge for the attention of the policy makers in Saudi Arabia to design a comprehensive energy conservation policy to minimize the consequences of massive energy consumption on environmental quality and energy export-driven revenue by adding financial development, urbanization and capital as main explanatory determinants in the energy demand function.

Keywords: Financial Development, Energy Consumption, Saudi Arabia

1. Introduction

Over the past decades, the relationship between economic growth and energy consumption has been a topic of academic interest among energy economists, environmental scientists and policy makers in the energy-growth literature (Masih and Masih, 1996, 1998; Mazumder and Marathe, 2007; Karanfil, 2008; Ozturk, 2010; Paul and Bhattacharya, 2004; Payne, 2010a, 2010b; Paul and Uddin, 2010; Pradhan, 2010; Sadorsky, 2010, 2011; Stern, 2011; Stern and Enflo, 2013; Bruns et al. 2013; Islam et al. 2013; Tang et al. 2013). The available evidence on the nexus between economic growth and energy consumption has been inconclusive. The lack of consensus evidence in the energy-growth correlation is primarily due to omission of other potential determinants in the modelling of energy demand function (Chang, 2015). However, understanding the determinants of energy demand and its modelling in emerging economies is essential in several reasons. First, the energy growth literature has emphasized the importance of energy in helping emerging economies to grow and prosper. Second, as the space for economic prosperity by many emerging economies intensifies, it also requires a lot of energy as key to the production of almost all goods and services (Sadorsky, 2010, 2011; Stern, 2011; Islam et al., 2013). Third, many emerging economies are growing very rapidly that has created a spurt in the demand for energy and compelled us to manage global emissions of greenhouse gases (CHGs) in the future (Hamilton, 2009; Sadorsky, 2010).

To our knowledge, the energy literature has very little to say about the nexus between financial development in emerging economies, a novel issue that is likely to grow in tandem with the prosperity of emerging economies. Understanding the role of financial development is crucial because it allows a country to promote banking and stock market activities along with attracting the inflows of foreign direct investment that will increase the economic efficiency of a country's financial system and this can affect economic activity and also the demand for energy. If financial development affects the demand for energy, then the nexus between the series can also affect the energy conservation and carbon emissions policies (Sadorsky. 2011). In such circumstance, Karanfil (2009) suggests to augment energy demand function by adding the financial development and other important factors of energy consumption beyond just income variable in order to better understand the dynamics of energy demand and to effectively manage rising energy consumption-related carbon emissions in the future. In the spirit of Karanfil (2009), there has been surprising little research looking into the relationship between financial development and energy consumption. Sadorsky (2010) explores the nexus between financial development and energy demand in a sample of 22 emerging economies and finds the positive effect of financial development on energy demand. He also finds that financial development measured using stock market variables matter a more in affecting energy demand than banking sector variables in emerging economies. Similarly, Sadorsky (2011) also studies the relationship between financial development and energy consumption in a sample of 9 frontier economies located Eastern and Central Europe and finds the positive impact of financial development on energy demand. He further reports that financial development measured using banking variables matter a more than bank variables in affecting energy demand in the case of 9 frontier economies. In the similar fashion, numerous studies have also examined the causal relationship between financial development and energy consumption in emerging economies (See Table-1). The available evidence on the relationship between financial development and energy consumption is found to be mixed.

Moreover, the findings emanating from the use of time series and panel data are country specific and also empirically understood in a panel framework. Hence, it is not easy to generalize the findings based on time series and panel analysis to that of emerging Asian economies like Saudi Arabia. This is because the Saudi Arabian economy is purely different in terms of its open economic policy and energy domination. Furthermore, Saudi Arabia has widely been recognized as energy dominated economy because of its access to huge stock of both primary and secondary energy. Primary energy denotes natural resources in which fuel is one of the vital components comprising crude oil, coal and gas. Secondary energy, on the other hand, is the result of primary energy, tends to be realized over the time by refining the primary energy further for real use in the form of electricity and petroleum products. In addition, the amounts of both primary and secondary energy produced in Saudi Arabia are mainly diverted to exports after domestic consumption. Saudi Arabia's economy is mainly petroleum-based, in which oil actually accounts for "90% of the country's exports and nearly 75% of the government revenues adding to the economy". It is further important to note that the oil industry appears to be playing a vital role in the Saudi Arabian economy as it produces about 45% of their gross domestic product (GDP). Due to the oil industry's contribution towards GDP, Saudi Arabia has reached per capita GDP of $20,700. Saudi Arabian economy has been considered as one of the largest reserves of natural gas in the Gulf region. In accounting sense, it has also been proved that natural gas reserves are over 7 trillion cubic meters (250 trillion cubic feet). However, due to its sizeable domestic gas markets, it is expected that Saudi Arabia is "unlikely to become LNG exporters anytime soon". In such scenario, Saudi Arabia is mainly prioritizing upstream gas investment (see in this linked website www.bp.com).

The previous study by Sadorsky (2010) has only explored the impact of financial development on energy consumption in emerging countries excluding the Saudi Arabian economy within a panel data framework. This is an important novelty gap our paper addresses in the case of emerging Asian economies like Saudi Arabia within a time series framework, a topic that is likely to grow in importance as emerging economies continue to develop, prosper and consume and export a lot of energy. To our knowledge, no study so far has empirically investigated the effect of financial development on energy consumption in Saudi Arabia. The impact that financial development has on the demand for energy is an important topic of interest among energy economists, environmental scientists and policy makers in Saudi Arabia, primality due to increasing economic activities and extraction of oil for revenue generation. The primary significance of doing empirical analysis for the Saudi Arabian economy based on the time series is that the panel findings of emerging Asian countries cannot be generalized for the benefit of a single country. In this context, our study is motivated in the spirit of Sadorsky (2010, 2011) studies and aiming at empirically examining the impact of financial development on energy consumption in Saudi Arabia by incorporating economic growth, urbanization and capital as major factors in energy demand function. The study covers the annual data period of 1971-2011 for the emerging Asian economies like Saudi Arabia. We have applied Ng-Perron (2001) and Zivot-Andrews (1992) unit root tests which accommodate the information about single unknown structural break in the series. The presence of cointegration among the variables is tested by employing the recently developed Bayer-Hanck's (2013) combined cointegration and Pesaran's et al. (2001) ARDL bounds testing approaches while latter model incorporates the information about structural break point present in the series. The extent of casual relation between the series is also examined by employing Shan's (2005) innovative accounting approach (IAA).

Both Bayer-Hanck's combined cointegration and Pesaran's ARDL bounds testing models confirm the presence of cointegration among the series. After confirming the existence of cointegration among the series, the overall results from the estimation of an ARDL energy demand function reveal that in the long-run, financial development adds in energy demand in Saudi Arabia. Furthermore, while economic growth is negatively related to energy consumption, urbanization and capital are the key factors leading to increased energy demand in the long-run. The findings also confirm the non-linear and inverted U-shaped relationship between financial development and energy demand for the Saudi Arabian economy, indicating that initially energy demand increases with a development in financial sector and then declines as financial sector matures. Finally, the results of innovative accounting approach also indicate an evidence of unidirectional causality running from financial development to energy demand is found, indicating that energy consumption is the cause of financial development in Saudi Arabia. In addition, the neutral effect is found between energy consumption and economic growth. Energy consumption is caused by capital. There exists bidirectional causality between financial development and capital, revealing that financial development causes capital while capital causes financial development. These results have implications for energy demand, economic growth and greenhouse gas emissions for the Saudi Arabian economy in particular and other Asian emerging economies in general.

The remaining part of the paper is set as follows. Section-2 analyzes the underlying theoretical framework, data construction, and econometric methodology used in the empirical analysis. Section-3 presents the discussion of findings and results interpretation. Finally, Section-4 concludes with findings and policy implications along with providing future research directions.

Table-1. Summary of results reached by the previous studies

Author	Period	Region/Country	Methods	Results
Al-mulai and Che Sab (2012a)	1980-2008 (panel data)	Sub Saharan African Countries	Pedroni cointegration, VEC panel Granger causality	Financial development is not only cointegrated with energy consumption but also causes energy consumption and CO_2 emissions.
Al-mulai and Che Sab (2012b)	1980-2008 (panel data)	19 developed and developing countries	Pedroni cointegration, VEC panel Granger causality	Financial development is not only cointegrated with energy consumption but also causes energy consumption and CO_2 emissions.
AI-mulali and Lee (2013)	1980-2009 (panel data)	GCC (Gulf Corporation Council) countries	Pedroni cointegration test, panel dynamic OLS and Granger Causality test	a) Energy consumption, financial development, real GDP, urbanization and total trade are cointegrated. b) Financial development, real GDP, urbanization and total trade have long run effects on energy consumption. c) Energy consumption is linked with financial development and urbanization. d) Energy consumption is the cause of financial development of the GCC both in the short and long runs.
Chang (2013)	1999-2008 (panel data)	53 advanced and developing economies	Panel threshold regression approach	a) Energy consumption increases with financial development in emerging and developing economies. b) Energy consumption declines with financial development in advanced economies.
Coban and Topcu (2013)	1990-2011 (annual data)	Twenty Seven European Union members states (EU) (15 old members plus 12 new members)	System-GMM model	a) Financial development remains silent in affecting the energy consumption in the EU27. b) Financial development has substantial effect on energy consumption for old members. c) For new member countries, the effect of financial development on energy use varies with respect to its various measurements.
Islam et al. (2013)	1971-2009 (annual data)	Malaysia	ARDL approach and VEC Granger causality	Energy consumption is influenced by financial development and economic growth.
Jalil and Feridun (2011)	1953-2006 (annual data)	China	ARDL approach	Financial development has a negative effect on CO2 emissions.
Mallick and Mahalik (2014)	1971-2011 (annual data)	India and China	ARDL approach to cointegration model	Energy consumption is adversely linked with financial development in India and China.
Pao and Tsai (2011)	1992-2007 (panel data)	BRIC Countries	Pedroni, Kao, Fisher Cointegration test and VEC panel Granger causality test	a) Financial development is cointegrated with energy and CO_2 emissions. b) Financial development causes CO_2 emissions and energy consumption.
Ozturk and Acaravci (2012)	1960-2007 (annual data)	Turkey	ARDL approach and VEC Granger causality	a) Financial development is cointegrated with CO_2 emissions. b) Financial development causes CO_2 emissions.
Sadorsky (2010)	1990-2006 (panel data)	22 emerging countries	GMM (Generalized method of moments)	a) Financial Development has positive impact on energy consumption when measured in stock markets and banking sector variables. b) Stock market variables matter a more than bank variables in influencing energy consumption.
Sadorsky (2011)	1996-2006 (panel data)	9 Frontiers Economies located in Central and Eastern Europe	Panel GMM (Generalized methods of moments) regression technique and fixed effect model	a) Financial development has positive impact on energy consumption when measured in stock markets and bank sector variables. b) Banking sector variables matter a more than stock market variables in affecting energy demand.
Salman and Atya (2014)	1980-2010 (annual data)	Three North African Countries (Algeria, Egypt and Tunisia)	Error Correction Model and Granger Causality test	a) Both financial development and energy usereveal positive relationship for Algeria and Tunisia. b) Both financial development and energy use also

				reflect negative relationship for Egypt.
Shahbaz and Lean (2012)	1971-2008 (annual data)	Tunisia	ARDL approach, Johansen cointegration and VEC Granger causality	a) Financial development has a positive effect on energy consumption. b) Financial development causes energy consumption.
Shahbaz et al. (2013a)	1975q1-2011q4 (quarterly data)	Indonesia	ARDL bounds testing model and VECM Granger causality technique	a) Given the presence of structural break(s), the long-run relationships between economic growth, energy consumption, financial development, trade openness and CO_2 emissions are found, b) Both energy consumption and economic growth are major contributors of carbon emissions while financial development and trade openness condense CO_2 emissions. c) Financial development is the cause ofCO_2 emissions in Granger sense.
Shahbaz et al. (2013b)	1971-2009 (annual data)	China	ARDL Bounds testing approach, structural break test and Granger causality test	a) Long-run relationship between the series is found. b) Economic growth is positively linked with energy use, financial development and international trade. c) Energy use causes growth and both energy use and financial development influence each other. d) Energy use and international trade are having feedback relationships.
Tang and Tan (2014)	1972-2009 (annual data)	Malaysia	Johansen and Juseliouscointegration test and Bounds testing approach	a) Financial development, energy consumption and GDP are cointegrated. b) CO_2 emission is adversely linked with financial development.
Zhang et al. (2011)	1992-2009 (annual data)	China	Granger causality	Financial development causes energy consumption.
Zeren and Koc (2014)	1971-2010 (panel data)	Seven industrialized countries	Hatemi-J asymmetric causality test	a) Energy consumption causes financial development for Philippines. b) Energy use and financial development cause each other for India, Turkey and Thailand.
Paramati et al. (2016)	1991-2012 (panel data)	20 emerging market economies	Westerlund (2008) panel cointegration technique and Dumitrescu and Hurlin (2012) heterogenous panel causality test	a) Output, FDI inflows and stock markets positively impact clean energy consumption. b) An evidence of unidirectional causality running from FDI to clean energy consumption is found.

2. Theoretical Framework, Data Construction and Methodology

In this section, we begin by discussing the theoretical framework that binds the empirical approach. Understanding the causal linkage between financial development and economic growth assumes greater significance in macroeconomics mainly influenced by the works of Schumpeter (1932), Goldsmith, (1969), McKinnon (1973) and Shaw (1973) and continues to be of interests for many researchers in the economic theory literature (Ang, 2008). There have been voluminous empirical studies linking the relationship between economic growth and financial development (Levin, 1997; Fung, 2009; Shahbaz, 2012, Shahbaz et al. 2015). But an empirical examination of the causal link between financial development and energy use in developing economies appears to be scanty. In this context, it is essential to have an analytical definition of financial development and its larger importance in explaining the behavior of energy demand through different channels. Broadly speaking, financial development refers to a growth enhancing platform of developing economies by allowing foreign direct investments (FDI) and/or promoting both stock market, banking activities and the role of other financial intermediaries. In this line, Mishkin (2009) theoretically argues that the role of financial development is important because financial sector development can improve economic efficiency of a country's financial system and quality institutions as well as enhance the innovations in financial delivery system. It further helps in technological progress, reduction of information and borrowing costs and also brings the institutional quality reforms. As a result of financial liberalization in developing countries, it is expected that financial development has the capacity to mobilize both savings and investment and thereby leading to economic growth in developing and emerging market economies. It is again commonly believed that a rise in economic growth indicates the larger needs of people in society in the form of energy consumption in their day-to-day life. This further implies that rising energy demand is positively linked with increasing economic activity in emerging market economies. Furthermore, financial demand can also affect the demand for energy in emerging market economies (Sadorsky, 2010, 2011). However, it is a topic of interests for energy economists, environmental scientists and policy makers to understand the effects of financial development on energy demand through various channels (seeTable-2).

Table-2.Effects of financial development on energy demand through various channels

Channels	Effects of financial development on energy demand
Consumer effect	Consumers' demand for energy increases with financial development of an economy. A well-developed financial system may provide more opportunities for consumers to spend their saved deposited money with banks in buying energy-consuming big ticket items like automobiles, houses, refrigerators, air conditioners, and washing machines. Consumers also benefit from improved financial development because it makes easier for consumers to access the loans from the financial institutions at affordable interest rates in order to big ticket items for satisfying their day-to-day wants and needs. These big ticket consumer items normally require a greater amount of energy use which can affect a country's total demand for energy (Sadorsky, 2010; 2011; Chang, 2015).
Business effect	Similarly, business firms' demand for energy increases with financial development of an economy. A well-developed financial system may provide the essential function of channeling funds to firms at affordable interest rates for increasing their day-to-day investment and innovation activities. Though the financial development benefits business firms in expanding their existing and new ventures, but the use of plants, machines and labor in the business activity consumes a lot of energy and thereby it affects a country's whole energy demand (Sadorsky, 2010; 2011; Chang, 2015).
Wealth effect	Finally, wealth effect being the result of improved financial development is also responsible for a country's rising energy demand. Though increased stock market activity is considered as a leading indicator of economic growth and prosperity, but it also creates wealth effect in terms of affecting confidence among consumers and business firms. Besides debt financing, both consumers and business firms also benefit from equity financing mainly due to the stock market development of an economy. When the confidence level increases among consumers and business firms, it enables them to access stock market for their additional source of funding. As a result, the equity financing increases economic activity and leads to a country's rising demand for energy (Mankiw and Scarth, 2008; Sadorsky, 2010; 2011; Chang, 2015).

Although Table-2 establishes the conceptual framework on the effects of financial development on energy demand in several ways, it further raises an addressed research question: does financial development intensify energy demand in oil producing and emerging markets Asian economies like Saudi Arabia[1]? In this context, our aims at empirically examining the impact of financial development on energy consumption for the Kingdom of Saudi Arabia by incorporating economic growth, capital use and urbanization in the energy demand function. The study uses annual data over the period of 1971-2011. The longitudinal annual time series data for all the series is selected primarily due to its availability for the Saudi Arabian economy.[2] Our empirical analysis limiting to the end data year 2011 for the simple justification is that we carried out this paper work three years before. World Development Indicators (CD-ROM, 2013) are combed to collect the time series data on real GDP (local currency), energy consumption (kg of oil equivalent), real domestic credit to private sector (local currency), real capital use (local currency) and urban population. We have used population data to transform all the variables into per capita units. The functional form of the model is given as follows:

$$EC_t = f(F_t, Y_t, K_t, U_t) \quad (1)$$

$$\ln EC_t = \beta_1 + \beta_2 \ln F_t + \beta_3 \ln Y_t + \beta_4 \ln K_t + \beta_5 \ln U_t + \mu_i \quad (2)$$

$$\ln EC_t = \alpha_1 + \alpha_2 \ln F_t + \alpha_3 \ln F_t^2 + \alpha_4 \ln Y_t + \alpha_5 \ln K_t + \alpha_6 \ln U_t + \mu_i \quad (3)$$

We transformed all the variables into log-linear specification.[3] $\ln EC_t$ refers to natural log of energy consumption (kg oil equivalent) per capita, $\ln F_t$ shows natural log of domestic credit to private sector (per capita) proxy for financial development, $\ln Y_t$ reveals natural log of real GDP per capita proxy for economic growth, $\ln K_t$ implies a natural log of real capital use and urbanization is measured by urban population per capita ($\ln U_t$) while μ_i is error term. We expect $\beta_2 < 0$ if financial development declines energy intensity (Tamazian et al. 2009). Financial development increases energy demand if financial sector does not monitor the projects after allocating the funds (Zhang, 2011) then we expect $\beta_2 > 0$. Energy consumption is positively affected by economic growth (Shahbaz and Lean, 2012; Alkhathlan and Javid, 2013) and we expect that $\beta_3 > 0$. We expect $\beta_4 > 0$ if capital use is energy intensive otherwise $\beta_4 > 0$. We

[1] According to UNCTAD's economic groupings and composition, Saudi Arabia economy is one of the emerging market (Western) Asian economies.
See at http://unctadstat.unctad.org/EN/Classifications/DimCountries_EconomicsGroupings_Hierarchy.pdf

[2] In this study, we use longitudinal dataset on two grounds. First, it increases the total number of observations along with producing higher degrees of freedom. Second, it reduces noise coming from the individual time series cointegrated regressions and also establishes the long-run relationship among the series.

[3] The transformation of data series into natural logarithms helps us to avoid the problems with distributional properties of the data series (Paramati et al., 2016). Furthermore, all of the variables are transformed into natural-logarithmic form for consistent and reliable empirical results along with reducing non-linearity or heteroscedasticity in the time series data set (Shahbaz et al. 2016).

expect $\beta_5 < 0$ if urbanization is positively linked with energy consumption otherwise $\beta_5 > 0$ (Shahbaz and Lean, 2012). We have inserted the squared term of financial development to investigate the non-linear relationship between financial development and energy consumption. It is argued by Shahbaz et al. (2013a, 2013b) that initially energy demand increases with an increase in financial sector's development (credit allocation to firms), but after a threshold level of financial development, financial sector monitors the resource allocation and encourages firms to adopt energy efficient technology for their business purposes which resultantly, declines energy intensity. This entails that association between financial development and energy consumption is inverted U-shaped if $\alpha_2 > 0$ and $\alpha_3 < 0$ otherwise relationship would be U-shaped. As far as capital use and urban population growth are concerned, we theoretically tend to believe that both capital and labor are used as potential inputs in the process of producing real economic output and in turn these inputs are also helping producers of an economy to demand for energy use. It is in the sense that higher the capital use, higher will be the energy consumption. This positive causal linkage between capital use and energy consumption mainly happens due to the very nature of capital intensive. Similarly, the energy consumption is positively linked by higher growth of urban population in the economy is in the sense that the greater degree of growing urban population also need higher amounts of energy for their day-to-day life. Moreover, with the help of above theoretical set up, we have included these variables (e.g. energy demand, financial development, GDP growth, urbanization and capital use) in the analysis which contribute to energy demand in Saudi Arabia and therefore it is expected to provide meaningful insights for policy implications at the aggregate level highlighted in the concluding sections of this study.

2.1. Bayer-Hanck Combined Cointegration Approach

In the field of applied energy economics literature, many studies use traditional cointegration approach proposed by Engle and Granger, (1987) to examine long-run relationship among time series variables. The novelty of such cointegration test requires the equal order of integration for all the variables. Moreover, the suitability of such test is also judged subject to the presence of limited time series data. The Engle-Granger cointegration approach is often criticized for its biased empirical results which are mainly due its low explanatory properties. The Engle-Granger cointegration test has been augmented by Johansen (1991) in introducing the *Johansen maximum eigenvalue test*. Since then, Johansen's (1991) cointegration has been more popular among energy economists and environmental scientists because it normally establishes more than one cointegrating vectors among the series. Subsequently, Phillips and Ouliaris (1990) also developed the *Phillips–Ouliaris* cointegration test. Above all, these batteries of cointegration tests are developed mainly looking at the long-run relationship among the time series. Moreover, the presence of long-run equilibrium also speaks about the presence of short-run disequilibrium in the modelling of econometric equation. In this context, the Error Correction Model (ECM) has some value in reflecting the degree of short-run corrections. Understanding the importance of ECM model as a vital segment of the long-run equilibrium modelling, Boswijk (1994) proposed ECM based *F-test* and Banerjee et al. (1998) also developed the ECM based *t*-test.

Bayer-Hanck (2013) combined cointegration approach is a single test of recent one which not only combines the empirical results of existing individual cointegration test, but also provides efficient and comprehensive single cointegration result for the purpose of robustness checking. Furthermore, the Bayer-Hanck test jointly determines the test-statistics of Engle and Granger, Johansen, Boswijk, and Banerjee et al. tests. The Bayer-Hanck cointegration test based on Engle and Granger (EG, 1987), Johansen (JOH, 1995), Boswijk (BO, 1994), and Banerjee et al. tests (BDM, 1998) also establishes the null hypothesis of no-cointegartion among the time series. Given that we use the combined cointegration test proposed by Bayer-Hanck (2013) in the context of the Saudi Arabian economy. Finally, Bayer and Hanck (2013) combined cointegration technique is computed with the help of Fisher's (1932) estimated formulas, enabling us to estimate the single cointegration test result along with estimating the statistical significance level (i.e. p-values) and the formula is given below:

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

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

Moreover, p_{EG}, p_{JOH}, p_{BO} and p_{BDM} represent the significance *p*-values of individual cointegration tests followed by Engle and Granger (1987), Johansen (1995), Boswijk (1994), and Banerjee et al. (1998). These individual *p*-values of various individual cointegration tests are based on the estimations of Fisher equation. We further believe the rejection of no cointegration under null-hypothesis if the estimated Fisher's statistics exceed the critical values estimated by Bayer and Hanck estimation.

2.2. Innovative Accounting Approach (IAA)

As far as econometric theory is concerned, the Granger causality test only provides information about the direction of causality between the macroeconomic variables, and fails to provide potential information on the relative strength of causality when we draw inference out of the sample period (Shan, 2005). To overcome this problem, the Innovative Accounting Approach (IAA) has been employed in this study as one of the suitable econometric tools in order to investigate the relative strength of causality between financial development and energy consumption for Saudi Arabia. The IAA mainly deals with measuring the dynamics of energy consumption for Saudi Arabian economy by employing the Variance Decomposition Analysis (VDA) and Impulse Response Function (IRF) as both VDA and IRF are integral part of the IAA. Conceptually, VDC technique focuses on the dynamics of series due to innovative shocks stemming from other series along with its own shock and also reflecting that whether the series is strongly impacted each other over the time periods. For example, using VDC analysis shows that if financial development assumes to cause energy consumption by 40% over the certain time horizons, the rest 60% of energy consumption variation will be explained by shocks of other series including its own shock. In this way, the use of VDC analysis could be more beneficial for the researchers to isolate the relative dynamic effects of its own shock and innovative shocks stemming from other independent variables towards dependent variable of the estimation process.

Subsequently, Shan (2005) also enriched the IAA by adding the IRF and argued that IRF likely to occur, when we use a system of equation in order to evaluate the effects of standard deviation shockscausing each other.For instance, if a shock to financial development is assumed to be statistically significant and affecting energy demand but at the same time, we also find the insignificant effect of energy demand on financial development, indicating that we have a situation showing financial development causes energy demand. From this scenario, we tend to believe the advantage of IRF as it enables us to identify the impacts of shocks on variables over the time in a Vector Autoregressive (VAR) framework. From this, one can also conclude the dynamic causal relationship between financial development and energy consumption. Putting it differently, one can also be much sure that financial development causes energy demand if the IRF indicates significant response of energy demand to shocks in financial development. Similarly, energy demand causes financial development if a strong and significant reaction of financial development to shocks in energy demand. In this regard, a VAR system takes the following form:

$$V_t = \sum_{i=1}^{k} \delta_i V_{t-1} + \eta_t \qquad \text{Where, } V_t = (EC_t, F_t, Y_t, \mathrm{K}_t, U_t)$$

$$\eta_t = (\eta_{EC}, \eta_F, \eta_Y, \eta_K, \eta_U)$$

$\delta_1 - \delta_k$ are four by four matrices of coefficients, and η is a vector of error terms.

3. Discussion of Findings and Results

Table-3 presents the results of descriptive statistics and correlation matrix. The idea of using both descriptive statistics and correlation matrix is to enable us to know existence of normal distribution occurring among the series of energy demand function and also to gauge the degree of association between the level variables considered in the analysis. In other words, correlation matrix plays a vital role in assessing the probability of higher auto-correlation between series. We find the positive correlation between financial development and energy consumption. Capital use is positively associated with energy consumption. Urbanization and energy consumption are correlated positively. Economic growth is inversely correlated with energy consumption and financial development. Capital and urbanization are positively associated with financial development. The correlation between capital use and economic growth are positively linked but urbanization is inversely linked with economic growth. Capitaland urbanization are also positively associated.

Table-3: Descriptive Statistics and Pair-wise Correlation

Variables	$\ln EC_t$	$\ln F_t$	$\ln Y_t$	$\ln K_t$	$\ln U_t$
Mean	8.2036	8.6388	10.4886	8.8922	4.2840
Median	8.4027	8.7128	10.3821	8.7672	4.3465
Maximum	8.8599	9.7356	10.8981	9.6131	4.4127
Minimum	6.8932	7.2388	10.254	7.5540	3.9240
Std. Dev.	0.5734	0.6690	0.2107	0.4794	0.1375
Skewness	-1.1456	-0.3296	0.8253	-0.4899	-1.1745
Kurtosis	3.0338	2.3523	2.1929	3.2444	3.2151
Jarque-Bera	2.1898	1.4948	1.9084	1.7848	1.7373
Probability	0.2101	0.4735	0.3521	0.4096	0.2976
$\ln EC_t$	1.0000				

$\ln F_t$	0.9367	1.0000			
$\ln Y_t$	-0.4631	-0.4141	1.0000		
$\ln K_t$	0.5137	0.3188	0.4629	1.0000	
$\ln U_t$	0.9600	0.2299	-0.5124	0.4432	1.0000

For investigating cointegration among the variables, testing the stationarity of the variables is necessary condition. For this purpose, we apply Ng-Perron (2001) unit root test.[4] Table-4 shows the results of unit root analysis. We find that financial development, energy consumption, economic growth, capital and urbanization are non-stationary at levels. From Table-4, we find the stationary nature of allvariables at first difference with intercept and trend. Ng-Perron unit root test provides ambiguous and spurious results due to their low explanatory power. This unit root test does not accommodate information about unknown structural break(s) dates stemming in the series which further weakens the stationarity hypothesis. To overcome this shortcoming, Zivot-Andrews (1992) unit root test has been employed in this study because of that fact that it primarily accommodates the necessary information relating tosingle unknown structural break(s) present in the series level data.[5] The results of Zivot-Andrews structural break(s) unit root test are reported in lower segment of Table-4, empirically indicating that all the level variables are found to be stationary despite having the presence of structural break(s). The structural breaks i.e. 1981, 1979, 1985, 1994 and 1984 are found in the series of energy consumption, financial development, economic growth, capital and urbanization. We note that all the variables are stationary at I(1). This indicates that all the series are integrated at I(1) process.

Table-4: Unit Root Analysis

Ng-Perron Unit Root Test				
Variables	MZa	MZt	MSB	MPT
$\ln EC_t$	-2.83337 (1)	-1.1283	0.3982	30.3379
$\ln F_t$	-11.6888 (2)	-2.4149	0.2066	7.8096
$\ln Y_t$	-5.13182 (2)	-1.5226	0.2967	17.4096

[4]The reason for not using unit root tests such as Augmented Dickey Fuller (ADF, 1979), Phillips-Perron (PP, 1988) and Kwiatkowski et al. (KPSS, 1992) is that these tests may likely to produce spurious results on account of not possessing any information on structural break(s) present in the series. For the sake of brevity, we have only used Ng and Perron (2001) unit root test to test the stationarity properties of the variables.

[5]Zevot-Andrews (1992) single structural break test has been employed in predicting the existence of structural break in the level series or not as because the time series variables we use in the empirical testing are subject to several random shocks (e.g., economic policy related to financial sector, energy related policy, global economic financial crisis, and other external policies). Without using this test, we may not be able to know the actual fluctuation of the level series in a particular time period. Therefore, the use of structural break(s) unit root test enables us to know in which period the structural break exists. Then only we can control easily this break while testing the structural break unit root test. Another potential advantage of using single structural break unit root test is that the structural break test is highly associated with cointegration process among the time level series. Unless we effectively capture the structural break stemming in the time level series data used in the analysis, we may fail to gauge the true nature of stationarity behaviour in the level series data while testing the unit root tests in the model. The further consequence of not knowing the true knowledge of stationarity behaviour among the series, we may not also be able to predict the long-run behaviour of level series used in the present analysis.

$\ln K_t$	-13.6533 (1)	-2.6089	0.1910	6.6962
$\ln U_t$	-1.82447 (3)	-0.7622	0.4178	36.9535
$\Delta \ln Y_t$	-33.3601 (3)*	-4.0827	0.1223	2.7392
$\Delta \ln F_t$	-34.3449 (2)*	-4.1405	0.1205	2.6722
$\Delta \ln Y_t$	-24.77746 (2)*	-1.5206	0.3182	18.9163
$\Delta \ln K_t$	-29.21518 (3)*	-2.1461	0.2328	9.8901
$\Delta \ln U_t$	-22.1110 (3)**	-2.4440	0.5464	4.9103
Zivot-Andrews Unit Root Test				
Variables	**At Level**		**At 1st Difference**	
	T-statistic	Time Break	T-statistic	Time Break
$\ln EC_t$	-4.404(2)	1981	-5.454(1)*	1990
$\ln F_t$	-4.431 (1)	1979	-6.577 (2)*	1990
$\ln Y_t$	-4.030 (2)	1985	-4.918 (3)**	1982
$\ln K_t$	-4.135 (1)	1994	-4.438 (1)**	1983
$\ln U_t$	-3.725 (3)	1984	-4.458 (1)**	1992

Note: Both 1% and 5% levels of significance are represented by asterisks * and ** and parentheses reveal lag length of variables . For detail description of MZa, MZt, MSB, and MPT, please follow the study of Ng and Perron (2001).

From the above unit roots testing evidence, we find that all the variables appear to be first difference stationary reflecting the order of integration i.e. $I(1)$ process. In this regard, we claim that Bayer and Hanck, (2013) combined cointegration approach appears to be suitable one to examine the process of cointegration whether it exists among series in the long run. The advantage of employing Bayer and Hanck (2013) combined cointegration is that it provides efficient results. The results of Bayer and Hanck combined cointegration are presented in Table-5. The results from Table-5 indicate that the computed values of Fisher-statistics for EG-JOH and EG-JOH-BO-BDM tests exceed the critical values of EG-JOH and EG-JOH-BO-BDM at 5% level of significance when we use economic growth, energy consumption, financial development, and urbanization as dependent variables in the model estimation. This evidences the rejection of no cointegration among the variables under null hypothesis which in turn corroborates the cointegration between the variables for long-run. More interestingly, we find that although the computed value of Fisher-statistics for EG-JOH test exceed the critical values of EG-JOH at 5% level of significance when use capital as dependent variable in the model estimation, but we do not find any similar evidence for capital used as dependent variable when check the Fisher computed value with its critical value suggesting the lack of cointegration among the series in the long run. Overall, we find the long run cointegration evidence between economic growth, energy consumption, financial development, capital and urbanization over the period of 1971-2011 in the case of Saudi Arabia.

Table-5: Bayer and Hanck Cointegration Analysis

Estimated Models	EG-JOH	EG-JOH-BO-BDM	Lag Order	Cointegration
$Y_t = f(F_t, EC_t, K_t, U_t)$	59.0817**	130.5672**	2	Yes
$EC_t = f(F_t, Y_t, K_t, U_t)$	55.2762**	62.7204**	2	Yes

$F_t = f(Y_t, EC_t, K_t, U_t)$	18.0348**	20.3648**	2	Yes
$K_t = f(Y_t, EC_t, F_t, U_t)$	18.0259**	18.9642	2	No
$U_t = f(Y_t, EC_t, K_t, K_t)$	19.5053**	130.0293**	2	Yes

Note: The suggested critical values at 5% level include 10.576 (EG-JOH) and 20.143 (EG-JOH-BO-BDM). The minimum value of Akaike Information Criteria (AIC) is used to decide the lag length of the estimation.

Bayer and Hanck, (2013) combined cointegration approach provides efficient empirical results but fails to accommodate structural break(s) while investigating the cointegration between the macroeconomic variables. This issue is solved by applying the recently developed ARDL[6]bounds test to cointegration by Pesaran et al. (2001) for large sample sizes especially in the presence of structural break(s) following the recent studies of Shahbaz et al. (2013a, 2013b). The AIC criteria is being used to chose appropriate lag order of the series as ARDL bounds test is sensitive to lag length selection. This procedure is followed as it is reported by Lütkepohl, (2006) that the dynamic link between the series can be truly captured if appropriate lag length is chosen. The empirical findings are reported in column-2 of Table-6. We use both lower and upper critical bounds values from Narayan (2005) to effectively make decision whether cointegration exists or not among the series. Our results show that upper critical bund exceeds the computed ARDL F-statistic as we use energy consumption (EC_t), economic growth (Y_t), financial development (F_t) and urbanization (U_t) as dependent variables in the model estimation. This also shows that the ARDL bounds testing analysis confirms the long-run relationship among the series (See Table-6).

Table-6: The ARDL Cointegration Test Analysis

Bounds Testing to Cointegration				Diagnostic tests			
Estimated Models	Optimal lag length	Structural Break	F-statistics	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}	χ^2_{SERIAL}
$EC_t = f(F_t, Y_t, K_t, U_t)$	2, 1, 2, 2, 2	1981	8.323*	0.3463	[1]: 0.3191	[1]: 0.0018	[2]: 3.0147
$Y_t = f(EC_t, F_t, K_t, U_t)$	2, 2, 2, 2, 2	1979	6.019**	0.4173	[2]: 0.0703	[2]: 2.2913	[1]: 0.3312
$F_t = f(EC_t, Y_t, K_t, U_t)$	2, 2, 2, 1, 2	1985	5.678**	0.3264	[1]: 2.9540	[2]: 4.0109	[2]: 1.1627
$K_t = f(EC_t, Y_t, F_t, U_t)$	2, 2, 2, 1, 2	1994	0.9558	0.4224	[1]: 2.2348	[2]: 0.9945	[1]: 0.0326
$U_t = f(EC_t, Y_t, F_t, K_t)$	2, 1, 2, 1, 1	1984	7.758*	3.6235	[1]: 0.4424	[1]: 0.7086	[1]: 2.2557
	Critical values (T= 40)#						
	Lower bounds $I(0)$	Upper bounds $I(1)$					
1 % significance level	6.053	7.458					
5 % significance level	4.450	5.560					
10 % significance level	3.740	4.780					

Note:[ ] shows the order of diagnostic tests. # denotes critical values which are collected from Narayan (2005) following the unrestricted intercept and trend. T shows the total number of observations used in the analysis.

Table-7 reports the impact of financial development, economic growth, capital and urbanization on energy consumption in long run. We find that financial development adds in energy consumption at 10%significance level. Keeping other things constant, a 1% increase in financial

[6]The justification of using Pesaran's et al. (2001) ARDL model is that it is applicable for small sample sizes and also produces parsimonious efficient results.

development leads energy demand by 0.1696%. Our results are consistent with the findings of Sadorsky, (2010) for emerging countries, Sadorsky (2011) for Central and Eastern Europe, Shahbaz and Lean (2012) for Tunisia, Coban and Topcu (2013) for European countries, Tang and Tan (2014) and Islam et al. (2013) for Malaysia and, Mallick and Mahalik (2014) for India, Shahbaz (2015) for Pakistan. Economic growth appears to be significant at 1% level and it isinversely linked with energy consumption. This implies a 1% increase in economic growth declines energy consumption by 0.7748% if all is same. This finding is in contradiction with Sbia et al. (2014) for UAE and Tang et al. (2013) for Portugal who reported that energy (electricity) consumption positively influences economic growth. Capital is positively and significantly linked energy consumption. We find that if other things remain same, a 0.3924% of energy consumption is stimulated with 1% increase in capital. The impact of urbanization on energy demand is found to be positive and significant at 1% level. Further, the squared term of financial development is used to examine its impact on energy consumption. We find the evidence of inverted U-shaped relationship between financial development and energy demand. This shows that a 1 percent increase real domestic credit to private sector per capita increases energy consumption by 2.67% while negative sign of non-linear term seems to confirm the delinking of energy consumption and financial development at higher level of financial system development. This indicates that initially financial sector adds in energy demand by the allocation of financial resources to productive ventures. But after a threshold level of financial development, financial sector monitors her allocated funds and encourages the firms to adopt energy efficient technology to decline energy intensity. In such situation, energy intensity or energy consumption is declined (Shahbaz, 2013a, b).

Finally, we have incorporated the dummy variable to examine the impact of oil Glut of 1981. Oil Glut in Saudi Arabia was due to slowdown in economic activity in industrialized economies in 1973 and 1979. This oil Glut temporarily created the oil surplus and oil prices fell down. We find the insignificant negative effect ofoil Glut (dummy variable) on energy consumption. The R^2 shows that more than 90% of linear and non-linear models are elucidated by financial development, economic growth, capital and urbanization. These models are indicative of the 1 percent level of significance.

Table-7: Long Run Analysis

Dependent Variable = $\ln EC_t$				
Variables	**Linear Specification**		**Non-Linear Specification**	
	Coefficient	**T-statistics**	**Coefficient**	**T-statistics**
Constant	2.7194	0.7876	-7.6180	-1.1554
$\ln F_t$	0.1696***	1.8481	2.6667***	1.9399
$\ln F_t^2$	…..	…..	-0.1338***	-1.8203
$\ln Y_t$	-0.7748*	-2.9067	-0.5012***	-1.6757
$\ln K_t$	0.3924*	3.3745	0.2803**	2.1809
$\ln U_t$	2.0206*	4.0375	1.3059**	2.0916
D_{1981}	-0.0151	-0.0922	0.0522	0.3203
R^2	0.9511		0.9552	
F-Statistic	179.0659*		153.6386*	

Prob. value	0.0000		0.0000	

Note: *** shows 10% level of significance.

In the short run (Table-8), we find that financial development adds to energy consumption but it is statistically insignificant. Economic growth declines energy consumption significantly. The relationship of capital and urbanization with energy consumption is positive insignificantly. The U-shaped association is noted between financial development and energy consumption but insignificant. The impact of oil Glut is negative but significant. This shows that oil Glut decreased energy consumption is short run significantly. The coefficients of error correction terms are -0.3657 and -0.4328 for linear and non-linear models and significant at 1 percent significance level. It entails that the established long run relationship between the variables is robust. We conclude that the speed of adjustment from short run towards long run for both models is modest. It can be noted that a 36.57 percent and 43.28 percent are deviations are corrected from short run to long run equilibrium path for both models in the case of Saudi Arabian economy.

Table-8: Short Run Analysis

Dependent Variable = $\Delta \ln EC_t$				
Variables	**Linear Specification**		**Non-Linear Specification**	
	Coefficient	**T-statistics**	**Coefficient**	**T-statistics**
Constant	0.0149	0.638570	0.0124	0.7314
$\Delta \ln F_t$	0.1309	1.150417	0.2051***	1.8768
$\Delta \ln F_t^2$	…..	…..	-0.1530	-0.2783
$\Delta \ln Y_t$	-0.5035***	-1.689462	-0.4934***	-1.7601
$\Delta \ln K_t$	0.1731	1.140487	0.2111	1.2735
$\Delta \ln U_t$	1.3437	0.878755	1.3159	0.7487
D_{1981}	-0.3166	-4.3573*	0.3034	-3.9196*
ECM_{t-1}	-0.3657*	-2.815481	-0.4328*	-2.8778
R^2	0.2677		0.3260	
F-Statistic	2.5590**		2.7418**	
Prob. value	0.0448		0.0278	

It has been argued in the econometric theory that the estimated parameters will be affected due to model misspecification. From this point on, we tend to test the constancy of ARDL parameters in the estimation process. In such circumstance, Brown et al. (1975) suggested to use cumulative sum of recursive residuals (CUSUM) and the CUSUM of squares (CUSUMsq) for estimating ARDL model parameters. Figures-1 and 2 reveal the plot of CUSUM and CUSUMsq at 5 percent level of significance. The results indicate that plot of CUSUM test is not within critical bounds at 5 percent level of significance. It shows the significance of structural break started from 2006 to 2011. This relates to the first municipal electricians in Saudi Arabia which may affect economic activity. Moreover, the plot of CUSUMsq lies within the range of critical bounds at 5% level of significance, indicating that the empirical evidence confirms the absence of structural break and shows the reliability and stability of our estimated parameters.

Figure-1: Plot of Cumulative Sum of Recursive Residuals

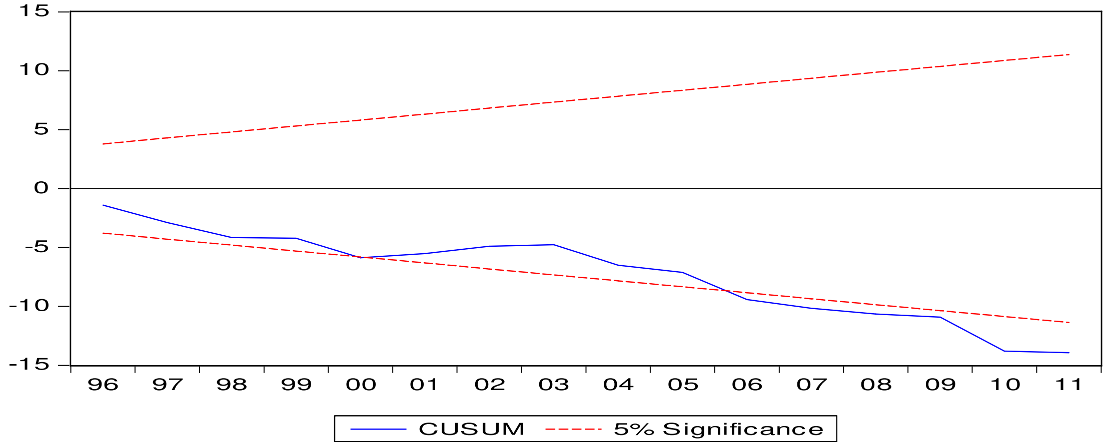
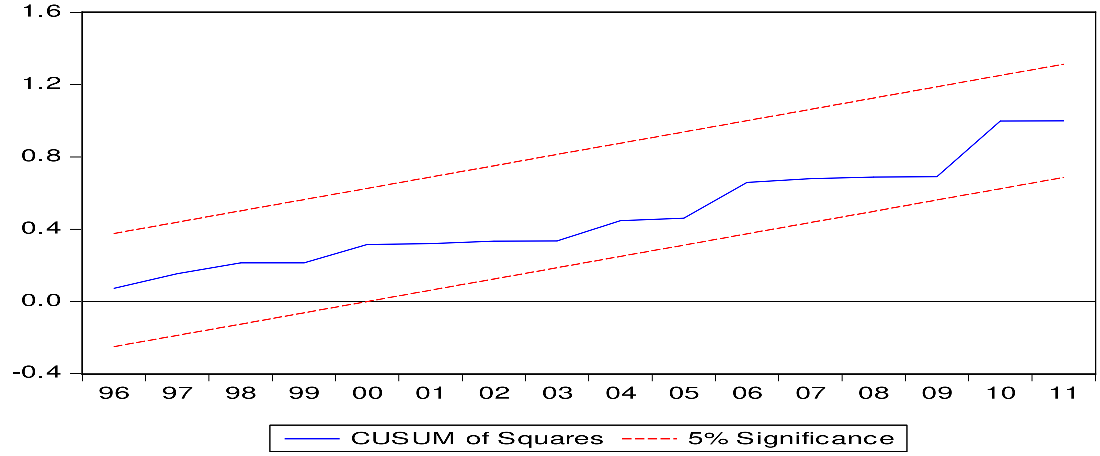


Figure-2: Plot of cumulative sum of squares of recursive residuals.



We have further employed the Chow forecast test to examine whether structural break indicated in CUSUM and CUSUMsq plot is robust or not. Because Chow test provides more consistent results compared to graphical CUSUM and CUSUMsq tests suggested by Brown et al. (1975). The results reported in Table-9 confirm the absence of structural break as likelihood ratio test is found to be significant at percent level, further indicating that our estimates are reliable and stable.

Table-9: Chow Forecast Test

Chow Forecast Test			
	Value	Degrees of Freedom	Probability
F-statistic	1.9480	(6, 10)	0.1678
Likelihood ratio	29.4195	6	0.0001

Given the above short and long runs analysis followed by stability test, it is important to gauge the direction of short and long run Granger causality test. In doing this, the robustness of empirical results can be verified. We have employed the Vector Error Correction Method (VECM) Granger causality test to examine both the short-and-long runs causal relationships between the variables. The VECM model assumes relevance from policy makers' perspective, but it is difficult to draw efficient conclusive inferences to design policy package due anunderlying potential demerit behind the VECM Granger causality. This is because it only captures the relative strength of causality within a sample period and fails to derive the additional inference out of the selected time period. In such situation, Shan (2005) argues that given the demerit of VECM Granger causality approach, it is unable to identify the exact magnitude of the feedback relationship from one variable to another variable in both short and long runs. In solving this issue, Shan (2005) developed IAA comprising both VDC and IRF.

It is instructive to investigate the relative importance of different shocks affecting the fluctuation of energy consumption in Saudi Arabia. The results of variance decomposition method are provided in Table-10. It is found in Table-10 that its own shock explains 91.87% and 48.98% variation of energy consumption in 3 years and 15 years. This shows that the fluctuation of energy consumption for Saudi Arabia is greater in the short run than in the long run. We also find that a change in demand for energy consumption is 1.14% and 22.71% which is explained by innovative shock of financial development in 3 years and 15 years indicating the dominant role of financial development illuminating the dynamics of energy demand for Saudi Arabia in the long run. We also find the capital use plays a more important role and renders a pronounced contribution of 23.93% towards energy demand in the long run. We further find that both economic growth and urbanization play a very lessor role in the dynamics of energy demand in Saudi Arabia as these contribute to energy demand minimally, expounding 2.41% and 1.94% of the variance in the fifteenth years after shocks occur. More specifically, the results inferred from forecast error variance decomposition disclose that apart from its own shock, both financial development and capital use are the main potential long run determinants of energy demand in Saudi Arabia.

Looking at other way round both short-sun and long-run causal dynamics reported in Table-10, we also find that energy consumption, economic growth and urbanization contribute to financial development by 2.35%, 0.71% and 0.48%, respectively in the long run. Almost 61.29% portion of financial development is contributed by its innovative shock and capital use adds in financial development by 35.05% in the long run. The innovative shocks of energy demand, capital use and urbanization add in economic growth by 12.25%, 17.94% and 0.42% in the long run. Financial development significantly contributes in economic growth by 56.90% through its innovative shock also in the long run. The contribution of energy demand, economic growth and urbanization is negligible in economic growth. Financial development adds in capital use by 48.98% and rest of capital use i.e. 38.97% is also contributed by its own innovative shock in the long run. Overall, we find that energy consumptionis cause of financial development in Saudi Arabia. Capital also causes energy consumption. Economic growth is causing capital and financial development. Capital causes financial development and financial development causes capital i.e. feedback effect. Financial development and capital cause urbanization.

Table-10: Variance Decomposition Analysis

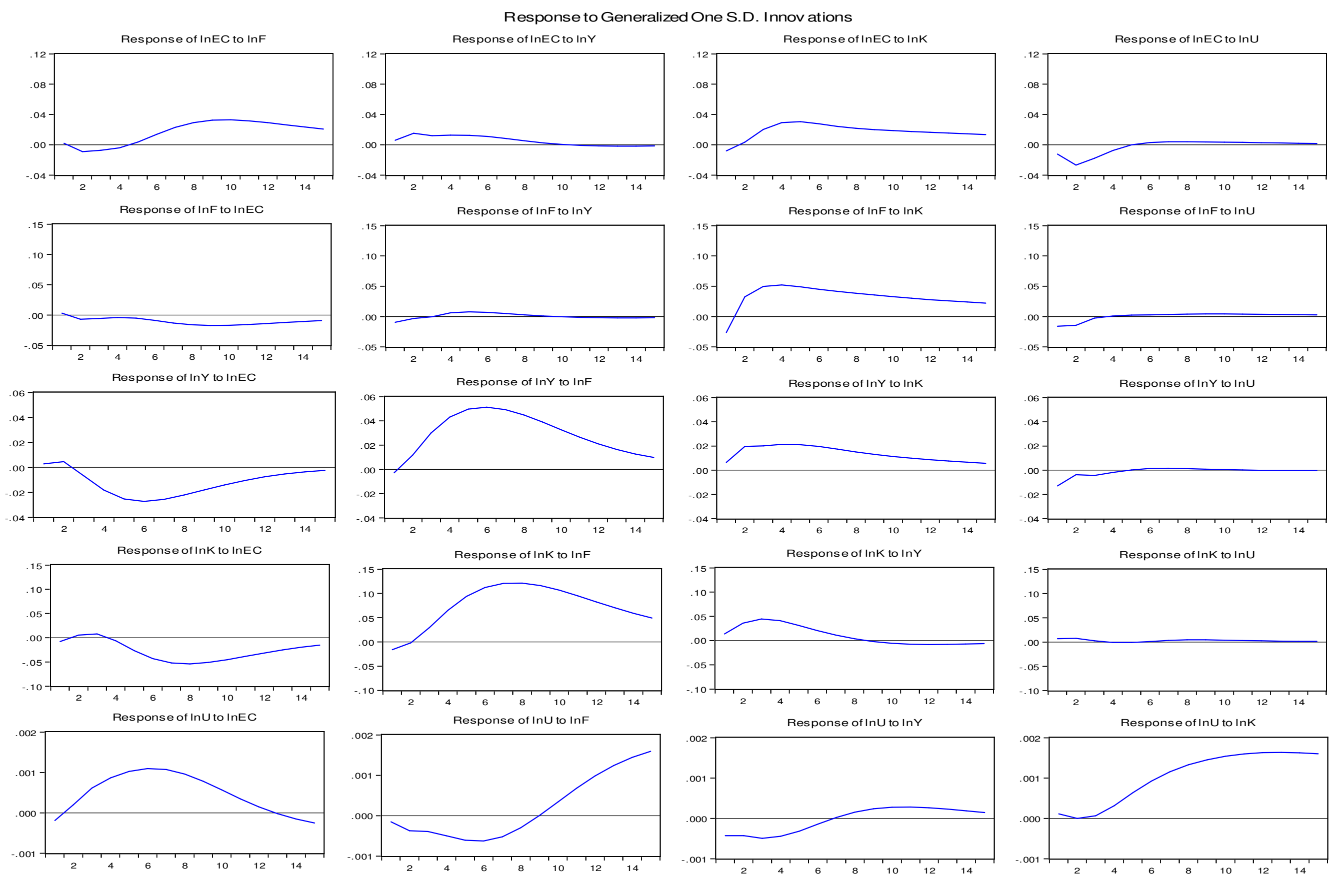
Variance Decomposition of $\ln EC_t$					
Period	$\ln EC_t$	$\ln F_t$	$\ln Y_t$	$\ln K_t$	$\ln U_t$
1	100.0000	0.0000	0.0000	0.0000	0.0000
2	96.1751	0.8677	0.6326	0.4036	1.9207

3	91.8704	1.1459	0.9354	3.4574	2.5907
4	86.6257	1.1717	1.5231	8.1697	2.5095
5	81.4609	1.1666	2.2283	12.7636	2.3805
6	76.4764	2.0469	2.8364	16.2381	2.4020
7	71.4359	4.3878	3.1558	18.5824	2.4379
8	66.5185	7.7944	3.1992	20.0757	2.4120
9	62.1067	11.4277	3.0860	21.0418	2.3376
10	58.4255	14.6764	2.9240	21.7269	2.2469
11	55.4872	17.3075	2.7700	22.2746	2.1604
12	53.1934	19.3239	2.6432	22.7531	2.0861
13	51.4181	20.8216	2.5446	23.1897	2.0257
14	50.0441	21.9162	2.4694	23.5921	1.9779
15	48.9740	22.7129	2.4120	23.9602	1.9407
Variance Decomposition of $\ln F_t$					
Period	$\ln EC_t$	$\ln F_t$	$\ln Y_t$	$\ln K_t$	$\ln U_t$
1	0.0554	99.9445	0.0000	0.0000	0.0000
2	0.2235	90.6302	0.0213	8.4905	0.6343
3	0.2811	80.8036	0.0683	18.3276	0.5192
4	0.2839	73.6126	0.3114	25.3387	0.4532
5	0.3044	68.9878	0.5706	29.6851	0.4519
6	0.4282	66.1657	0.7613	32.1816	0.4629
7	0.6974	64.4291	0.8535	33.5462	0.4736
8	1.0615	63.3344	0.8769	34.2445	0.4824
9	1.4297	62.6346	0.8632	34.5833	0.4889
10	1.7408	62.1816	0.8345	34.7508	0.4922
11	1.9757	61.8749	0.8026	34.8544	0.4922
12	2.1403	61.6481	0.7734	34.9478	0.4902
13	2.2494	61.4624	0.7486	35.0521	0.4873
14	2.3182	61.2984	0.7286	35.1702	0.4844
15	2.3597	61.1483	0.7126	35.2970	0.4822
Variance Decomposition of $\ln Y_t$					
Period	$\ln EC_t$	$\ln F_t$	$\ln Y_t$	$\ln K_t$	$\ln U_t$
1	0.4877	0.5299	98.9822	0.0000	0.0000
2	0.9786	4.8428	81.3670	11.3529	1.4584
3	1.4801	20.6327	60.6255	15.9503	1.3111
4	4.8589	35.1133	41.2368	17.7648	1.0259
5	8.3949	43.8329	29.0781	17.8782	0.8157
6	10.6996	48.8656	22.1387	17.6108	0.6851
7	11.9129	51.9788	18.1634	17.3496	0.5950
8	12.4470	53.9844	15.8295	17.2089	0.5300
9	12.6178	55.2626	14.4388	17.1953	0.4853
10	12.6140	56.0427	13.6084	17.2774	0.4572
11	12.5394	56.4909	13.1148	17.4134	0.4412
12	12.4481	56.7295	12.8223	17.5671	0.4328

13	12.3652	56.8441	12.6479	17.7140	0.4285
14	12.2994	56.8904	12.5420	17.8417	0.4262
15	12.2508	56.9021	12.4755	17.9466	0.4248
Variance Decomposition of $\ln K_t$					
Period	$\ln EC_t$	$\ln F_t$	$\ln Y_t$	$\ln K_t$	$\ln U_t$
1	0.8906	3.7307	2.4200	92.9585	0.0000
2	0.5079	1.4562	7.9286	89.5007	0.6064
3	0.4947	3.5839	11.5675	83.4305	0.9231
4	0.4124	11.5608	12.2869	74.8295	0.9103
5	1.3480	21.5194	11.0134	65.3259	0.7930
6	3.0443	29.9643	9.2261	57.0792	0.6858
7	4.6997	36.1277	7.6791	50.8856	0.6076
8	5.9324	40.4510	6.5270	46.5405	0.5489
9	6.7246	43.4577	5.7162	43.5992	0.5021
10	7.1821	45.5247	5.1605	41.6678	0.4646
11	7.4162	46.9167	4.7858	40.4451	0.4360
12	7.5127	47.8298	4.5354	39.7068	0.4151
13	7.5314	48.4118	4.3684	39.2877	0.4004
14	7.5112	48.7721	4.2561	39.0701	0.3903
15	7.4758	48.9886	4.1793	38.9728	0.3833
Variance Decomposition of $\ln U_t$					
Period	$\ln EC_t$	$\ln F_t$	$\ln Y_t$	$\ln K_t$	$\ln U_t$
1	2.1719	1.3047	10.7888	1.1050	84.6293
2	2.0465	4.4461	10.8471	0.5089	82.1512
3	7.7231	5.7063	12.5507	0.6440	73.3757
4	14.9301	7.4873	12.7416	2.3992	62.4416
5	21.0000	9.3277	11.3490	6.4317	51.8914
6	24.9692	10.3364	9.3374	11.9679	43.3889
7	26.8713	10.0940	7.5869	18.2166	37.2310
8	27.0032	8.9548	6.3711	24.7927	32.8780
9	25.7266	7.6848	5.6086	31.3764	29.6033
10	23.4922	7.0617	5.1214	37.4842	26.8402
11	20.8103	7.5582	4.7563	42.5932	24.2818
12	18.1348	9.2051	4.4234	46.3895	21.8469
13	15.7597	11.6913	4.0915	48.8788	19.5785
14	13.8027	14.5874	3.7635	50.3024	17.5437
15	12.2585	17.5258	3.4534	50.9800	15.7821

The impulse response function serves the pivotal role in assessing how and to what extent shocks in financial development influence energy demand in Saudi Arabia. Figure-3 displays the dynamic effects of a one standard deviation of a particular shock (financial development shock, economic growth shock, capital use shock and urbanization shock) on Saudi Arabia's energy consumption over a range of 15 years period. From Figure-3, the results of impulse response functions show that response in energy consumption is inverted U-shaped due to forecast error stems in financial development. This entails that energy consumption rises initially with financial development but starts to decline after a threshold level of financial sector's development in Saudi Arabia. Energy consumption responds positively till 10th (after 2nd) time horizon due to forecast error in economic growth (capital). Urbanization affects energy consumption but is effect is minimal. The response in energy consumption, economic growth and urbanization due to forecast error in financial development is negligible. Financial development adds in capital. Financial development and capital are positively influenced by economic growth. Energy consumption (urbanization) adds negatively (minimal) in economic growth. An inverted U-shaped linkage is found between financial development and capital. Economic growth contributes to capital positively till 8th time horizon then it becomes negative. Similarly, inverted U-shaped is found between urbanization and energy consumption. Urbanization responds positively after 11th time horizon and capital adds in urbanization. Economic growth contributes in urbanization after 7th time horizon.

Figure-3: Impulse response functions analysis



4. Conclusion, policy implications and future directions

Our study is motivated in the spirit of Sadorsky (2010, 2011) studies and aiming at empirically examining the impact of financial development on energy consumption in Saudi Arabia by incorporating economic growth, urbanization and capital as major factors in the energy demand function. The study covers the annual data period of 1971-2011. We have applied Ng-Perron

(2001) and Zivot-Andrews (1992) unit root tests which accommodate the information about single unknown structural break in the series. The presence of cointegration among the variables is tested by employing the recently developed Bayer-Hanck's (2013) combined cointegration and Pesaran's et al. (2001) ARDL bounds testing approaches while latter model incorporates the information about structural break point present in the series. The extent of casual relation between the series is also examined by employing Shan's (2005) innovative accounting approach (IAA).

Both Bayer-Hanck's combined cointegration and Pesaran's ARDL bounds testing models confirm the presence of cointegration among the series. After confirming the existence of cointegration among the series, the overall results from the estimation of an ARDL energy demand function reveal that in the long-run, financial development adds in energy demand in Saudi Arabia. Furthermore, while economic growth is negatively related to energy consumption, urbanization and capital are the key factors leading to increased energy demand in the long-run. The findings also confirm the non-linear and inverted U-shaped relationship between financial development and energy demand for the Saudi Arabian economy, indicating that initially energy demand increases with a development in financial sector and then declines as financial sector matures. Finally, the results of innovative accounting approach also indicate an evidence of unidirectional causality running from financial development to energy demand is found, indicating that energy consumption is the cause of financial development in Saudi Arabia. In addition, the neutral effect is found between energy consumption and economic growth. Energy consumption is caused by capital. There exists bidirectional causality between financial development and capital, revealing that financial development causes capital while capital causes financial development. These results have implications for energy demand, economic growth and greenhouse gas emissions.

The empirical results in this study reveal that financial development, urbanization and capital increase energy demand in Saudi Arabia. These results further show that the Saudi Arabian economy that continues to develop her financial system, stimulate urbanization and massively use capital will experience an increase in energy demand, reduce in oil export revenue and increase in the loss of environmental quality. From a policy perspective, we suggest that energy demand projections in Saudi Arabia which do not include financial development, urbanizations and capital as potential explanatory variables in the energy demand function may underestimate actual energy demand, oil-based exporting revenue and loss of environmental quality. Energy conservation policies in emerging Asian economies like Saudi Arabia are one area where the findings of this study have numerous consequences on energy demand, oil revenue and environmental quality. It is high probability that energy conservation policies only based on relationship between economic growth and energy consumption may fall short of their intended targets of reducing energy use, improving environmental quality and increasing oil-export revenue if comprehensive policy does not include the additional effects of financial development, urbanization and capital on energy demand for the Saudi Arabian economy. Moreover, meeting greenhouse gas emissions targets may become very hard for the Saudi Arabian economy if the comprehensive policy solely based on the role of income on energy demand were constructed with omitting the effects of financial development, urbanization and capital on energy consumption in the energy demand function.

However, the result in this study also indicates non-linear and inverted U-shaped relationship between financial development and energy demand in Saudi Arabia. This finding further suggests that the Saudi Arabian government could induce financial institutions to play an important role of investing in research and development (R&D) sectors in order to innovative technology related to green energy sources, such as solar, biomass and biogas. This approach has been practiced in Malaysia by some leading local and foreign financial institutions. This will promote the equity funds for investors mainly focusing on environmental friendly projects and also motivate domestic financial institutions to be involved in creating awareness of environmental issues especially on reducing energy use (Shahbaz et al. 2013a). Besides that, financial institutions could also look into the environmental degradation aspects of loans approved for the developmental projects in the Saudi Arabian economy. Moreover, we strongly feel that priority and special loan discounts should be given to a business firm in Saudi Arabia who has efficient energy utilization and saving technologies to reduce the environmental and energy export-driven revenue loss consequences of massive energy use. In other words, it can be said that Saudi Arabian government must direct growing financial institutions to offer credit to a business firm at low financing costs which has basically environmentally friendly projects. Recently, Saudi Arabian government has launched public awareness program naming ‘‘Tarsheed’’. The novelty of this program reveals that Saudi Arabian government needs to educate and encourage households and business firms mainly pushing them to be rational use of available energy especially in the residential and commercial sectors. In order to make this program more successful and to be celebrated country wide, the Saudi Arabian government has also begun to invest heavily on R&D sectors to realize better renewable energy options for a greater power generation (Trasheed, 2014). Without doing this, it may also be harder for the Saudi Arabian government to achieve the intended targets of higher energy export-driven revenue and better environmental quality in the long-run.

On a final note, this study opens up new avenues for researchers in the case of Saudi Arabian economy in exploring the effects of financial development measured in bank variables, stock market variables and FDI inflows on energy demand function by incorporating globalization, economic growth, urbanization and capital within a time series framework. In doing so, it may not become a harder for policy makers in Saudi Arabia to evolve an augmented comprehensive energy conservation policy while modelling the effects of broader financial development (e.g. banking variables, stock market variables and FDI inflows) on energy consumption in the energy demand function. Finally, this also leaves for researchers in Saudi Arabia and other emerging Asian economies to empirically study the effects of broader financial development on CO2 emissions by endogenizing globalization, economic growth, energy consumption, urbanization and capital use in the carbon emissions function.

References

A1-mulai, U. and Lee, J.Y.M. (2013). Estimating the impact of the financial development on energy consumption: evidence from the GCC (Gulf Corporation Council) Countries. *Energy*, 60, 215-221.

Alkhathlan, K., and Javid, M., (2013). Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. *Energy Policy*, 62, 1525-1532.

Al-mulali U. and Che Sab, C.N. (2012a). The impact of energy consumption and CO2 emission on the economic growth and financial development in the Sub Saharan African countries. *Energy*, 39,180-6.

Al-mulali U., and Che Sab, C.N. (2012b). The impact of energy consumption and CO2 emission on the economic and financial development in 19 selected countries. *Renewable and Sustainable Energy Reviews*, 16, 4365-9.

Ang, J. (2008). A Survey of Recent Developments in the Literature of Finance and Growth. *Journal of Economic Surveys*, 22 (2), 536-576.

Banerjee, A., Dolado, J., and Mestre, R. (1998). Error-Correction Mechanism Tests for Cointegration in A Single-Equation Framework. *Journal of time series analysis*, 19(3), 267-283.

Bayer, C. and Hanck, C. (2013). Combining Non-Cointegration Tests. *Journal of Time Series Analysis*, 34(1), 83-95.

Boswijk, P. H. (1994). Testing for an Unstable Root in Conditional and Structural Error Correction Models. *Journal of Econometrics*, 63(1), 37-60.

Brown, R., Durbin, L. J. and Evans, J. M. (1975). Techniques for Testing the Constancy of Regression Relationships over Time. *Journal of the Royal Statistical Society*, 37, 149-192.

Burns, S.B., Gross, C., and Stern, D.I. (2013). Is there really Granger causality between energy use and output? FCN working paper no. 11/2013, Institute for Future Energy Consumer Needs and Behaviour.

Chang, S-C. (2013). Effects of financial development and income on energy consumption. *International Review of Economics and Finance*, 35, 28-44.

Coban, S. and Topcu, M. (2013). The nexus between financial development and energy consumption in the EU: A dynamic panel data analysis. *Energy Economics*, 39, 81-88.

Dickey, D. A., and Fuller, W. A. (1979). Distribution of the estimation for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366), 427-431.

Engle, R. F. and Granger, C. W. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 251-276.

Fisher, R. (1932). Statistical methods for research workers. Oliver and Boyd, London.

Fung, H.K., 2009. Financial development and economic growth: convergence or divergence? *Journal of International Money and Finance*, 28, 56–78.

Goldsmith R. (1969). Financial structure and development. New York: Yale University Press.

Ghosh, S. (2009). Electricity supply, employment and real GDP in India: evidence from cointegration and Granger causality tests. *Energy Policy*, 37(8), 2926-2929.

http://www.bp.com

http://www.trasheed.gov.sa, 2014.

Hamilton, J.D. (2009). Causes and consequences of the oil shock of 2007-08. *Brookings Paper on Economic Activity,* (1), 215-261.

Islam F, Shahbaz M, Ahmed AU, and Alam MM (2013). Financial development and energy consumption nexus in Malaysia: a multivariate time series analysis. *Economic Modelling*, 30, 435-41.

Jalil A, and Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: a cointegration analysis. *Energy Economics*, 33, 284-91.

Johansen, S. (1991).Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, 59(6), 1551-1580.

Johansen, S., and Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics, 52(2),* 169-2010.

Johansen, S. (1995). A statistical analysis of cointegration for I(2) variables. *Econometric Theory*, 11(1), 25-59.

Karanfil, F. (2008). Energy consumption and economic growth revisited: does the size of unrecorded economy matter? *Energy Policy*, 36(8), 3029-3035.

Karanfil, F. (2009). How many times again will we examine the energy-income nexus using a limited range of traditional econometric tools? *Energy Policy*, 37, 1191–1194.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., and Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root. *Journal of Econometrics*, 54(1-3), 159-178.

Levine, R. (1997). Financial development and economic growth: Views and agenda. *Journal of Economic Literature*, 35, 688-726.

Lütkepohl, H., (2006). Structural vector autoregressive analysis for cointegrated variables. *AStA Advances in Statistical Analysis*, 90, 75-88.

Mankiw, N.G. and Scarth, W. (2008). Macroeconomics: Third Canadian Edition. Worth Publishers, New York.

Mallick, H. and Mahalik, M.K. (2014). Energy consumption, economic growth and financial development: A comparative perspective on India and China. *Bulletin of Energy Economics*, 2(3), 72-84.

Masih, A.M.M., and Masih, R. (1996). Energy consumption, real income and temporal causality: results from a multi-country study based on cointegration and error correction modeling techniques. *Energy Economics*, 18(3), 165-183.

Masih, A.M.M., and Masih, R. (1998). A multivariate cointegrated modeling approach in testing temporal causality between energy consumption, real income and prices with an application to two Asian LDCs. *Applied Economics*, 30(10), 1287-1298.

McKinnon R. (1973). Money and capital in economic development. Washington, DC: Brookings Institution.

Mishkin, F.S. (2009). Globalization and financial development.*Journal of Development Economics*, 89(2), 164-169.

Mozumder, P., and Marathe, A. (2007). Causality relationship between electricity consumption and GDP in Bangladesh. *Energy Policy*, 35(1), 395-402.

Narayan, P.K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics*, 17, 1979-1990.

Narayan, P.K. (2007). Are shocks to energy consumption permanent or temporary? Evidence from 182 countries. *Energy Policy*, 35(1), 333-341.

Narayan, P.K., and Smyth, R. (2008). Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks. *Energy Economics*, 30(5), 2331-2341.

Ng, S., and Perron, P. (2001). Lag length selection and the construction of unit root test with good size and power. *Econometrica*, 69, 1519-1554.

Ozturk, I. (2010). A literature survey on energy-growth nexus. *Energy Policy*, 38(1), 340-349.

Ozturk, I., and Acaravci, A. (2012).The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics*, 36, 262-267.

Paramati, S. R., Ummalla, M., and Apergis, N. (2016). The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies. *Energy Economics*, 56, 29-41.

Payen, J. (2010a). A survey of the electricity consumption-growth literature. *Applied Energy*, 87, 723-731.

Payne, J. (2010b). Survey of the international evidence on the causal relationship between energy consumption and growth. *Journal of Economics Studies*, 37(1), 53-95.

Pao H.T., and Tsai, C.M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, 36, 685-693.

Paul, S., and Bhattacharya, R.N. (2004). Causality between energy consumption and economic growth in India: a note on conflicting results. *Energy Economics*, 26(6), 977-983.

Paul, S., and Uddin, D. (2010).Energy and output dynamics in Bangladesh. *Energy Economics*, 33(3), 480-487.

Pesaran, M.H., and Shin, Y., and Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics,* 16, 289-326.

Pradhan, R. (2010). Energy consumption-growth nexus in SAARC countries. Using cointegration and error correction model. *Modern Applied Science*, 4(4), 74-90.

Phillips, P. C., and Perron, P. (1988). Testing for a unit root in time series regression. *Biometrica*, 75(2), 335-346.

Phillips, P. C., and Ouliaris, S. (1990). Asymptotic Properties of Residual Based Tests for Cointegration. *Econometrica*, 165-193.

Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy*, 38, 2528-2535.

Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Energy Policy*, 39, 999-1006.

Salman, D.M. and Atya, E.M. (2014). What is the role of financial development and energy consumption on economic growth? New evidence from North African Countries. International Journal of Finance and Banking Studies 3(1), 137-149.

Sbia, R., Shahbaz, M. and Hamdi, H. (2014).A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic Modelling*, 36, 191–197.

Shahbaz, M. (2012). Does trade openness affect long run growth? cointegration, causality and forecast error variance decomposition tests for Pakistan. *Economic Modelling*, 29, 2325-2339.

Shahbaz, M. (2015). Electricity Consumption, Financial Development and Economic Growth Nexus in Pakistan: A Visit. *Bulletin of Energy Economics*, 3(2), 48-65.

Shahbaz, M. and Lean, H. H. (2012). Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. *Energy Policy*, 40, 473-9.

Shahbaz, M., Hye, Q.M.A., Tiwari, A.V. and Leitao, N.C. (2013a).Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews*, 25, 109-121.

Shahbaz, M., Khan, S. and Tahir, M.I. (2013b). The dynamic links between energy consumption, economic growth, financial development, and trade in China: Fresh evidence from multivariate framework analysis. *Energy Economics*, 40, 8-21.

Shahbaz, M., Rehman, I., Muzaffar, T. A. (2015). Re-visiting financial development and economic growth nexus: The role of capitalization in Bangladesh. *South African Journal of Economics*, doi: 10.1111/saje.12063.

Shahbaz, M., Mallick, H., Mahalick, M.K., and Sadorsky, P. (2016). The role of globalization on the recent evolution of energy demand in India: Implications for sustainable development. *Energy Economics,* 55, 52-68.

Shan, J. (2005). Does financial development 'lead' economic growth? a vector autoregression appraisal? *Applied Economics*, 37, 1353-1367.

Shaw E. (1973). Financial deepening in economic development. New York: Oxford University Press.

Schumpeter J. (1932). The theory of economic development. Cambridge, MA, US: Harvard University Press.

Stern, D.I. (2011). The role of energy in economic growth. Annals of New York Academic of Sciences, 1219, 26-51.

Stern, D.I., and Enflo, K. (2013).Causality between energy and output in the long run. *Energy Economics*, 39, 135-146.

Tamazian, A., Chousaa, J.P., Vadlamannatia, K.C., 2009. Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. *Energy policy* 37, 246–253.

Tang CF, and Tan BW (2014). The linkages among energy consumption, economic growth, relative price, foreign direct investment, and financial development in Malaysia. *Quality and Quantity* 48, 781-797.

Tang, C. F., Shahbaz, M. and Arouri, M. (2013). Re-investigating the electricity consumption and economic growth nexus in Portugal. *Energy Policy*, 62, 1515–1524.

Zeren, F. and Koc M. (2014). The nexus between energy consumption and financial development with asymmetric causality test: new evidence from newly industrialized countries. *International Journal of Energy Economics and Policy*, 4(1), 83-91.

Zivot, E. and Andrews, K. (1992). Further evidence on the great crash, the oil price shock, and the unit root hypothesis. *Journal of Business and Economic Statistics*, 10, 251–270.

Zhang YJ, Fan JL, and Chang HR (2011). Impact of China's stock market development on energy consumption: an empirical analysis. *Energy Procedia*, 5, 1927-31.

Zhang, Y-J. (2011). The impact of financial development on carbon emissions: An empirical analysis in China. *Energy Policy*, 39, 2197–2203.