Is Energy Consumption Effective to Spur Economic Growth in Pakistan? New Evidence from Bounds Test to Level Relationships and Granger Causality Tests

Muhammad, Shahbaz and Muhammad, Zeshan and Talat, Afza

COMSATS Institute of Information Technology, Lahore, Pakistan, Quaid-i-Azam University, Islamabad, Pakistan, COMSATS Institute of Information Technology, Lahore, Pakistan

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Is Energy Consumption Effective to Spur Economic Growth in Pakistan?
New Evidence from Bounds Test to Level Relationships and Granger Causality Tests

Muhammad Shahbaz
COMSATS Institute of Information Technology,
Defence Road, Off Raiwind,
Lahore, Pakistan, Email: shahbazmohd@live.com

Muhammad Zeshan
School of Economics, Quaid-i-Azam University,
Islamabad, Pakistan, Email:zeshanqau.isb@gmail.com

Talat Afza
COMSATS Institute of Information Technology,
Defence Road, Off Raiwind,
Lahore, Pakistan, Email: talatafza@ciitlahore.edu.pk

Abstract:

The present study investigates the relationship between energy (renewable and nonrenewable) consumption and economic growth using Cobb-Douglas production function in case of Pakistan over the period of 1972-2011. We have used ARDL bounds testing and Gregory and Hansen (1990) structural break cointegration approaches for long run while stationarity properties of the variables are tested applying Clemente-Montanes-Reyes (1998) structural break unit root test.

Our results confirm cointegration between renewable energy consumption, nonrenewable energy consumption, economic growth, capital and labor in case of Pakistan. The findings show that both renewable and nonrenewable energy consumption add to economic growth. Capital and labour are also important determinants of economic growth. The VECM granger causality analysis validates the existence of feedback hypotheses between renewable energy consumption and economic growth, nonrenewable energy consumption and economic growth, economic growth and capital.

Keywords: Energy Consumption, Economic Growth, Pakistan

Introduction

Kyoto Protocol, our environmental responsibilities, volatile energy prices, and energy security are the contemporaneous issues that bind nations to diversify their energy supplies. Kyoto Protocol necessitates its members to maintain the level of greenhouse gas emissions since 1990 to date. It is hoped that this mutual effort, by both the developing and the developed countries, would help to mitigate the detrimental consequences of global warming. In addition, it would also help to dispirit the increasing volume of CO_2 emissions in environment. Of course, the lower level of CO_2 emissions can only be achieved by the lesser consumption of fossil fuels but this solution would also bring severe ailment to economic growth since the economic cost of utilizing the fossil fuels has increased tremendously. Therefore, one cannot overlook the long run consequences of the extensive utilization of the fossil fuels for some short run economic gains.

Volatility in energy prices creates difficulties for oil importing countries in balancing their payments each year. All the major economic recessions are preceded by the rising energy shocks (Hamilton, 1983) and the rise in energy prices invokes the inflationary expectations. Given the commitment of the central bank to the economic stability and to minimize inflationary expectations, central bank raises the interest rate (Harris et al. 2009). As a consequence, although, the overall inflation tends to fall but the rising interest rate also lowers the level of investment (Leduc and Sill, 2004); resultantly, the growth rate is adversely affected. It is worth mentioning that renewable energy emits lower level of CO_2in the environment, and is helpful in solving the environmental problems of climate change (Elliot, 2007 and Ferguson, 2007).

Energy requirements are rapidly increasing in Pakistan and the primary energy requirements in Pakistan have witnessed 80 percent increase in the last 15 years; it rose from 34 million TOE in 1994-95 to 61 million TOE in 2009-10. Indigenous natural gas comprises of 45 percent of the energy mix, oil imports constitutes 35 percent, hydel power covers 12 percent, coal 6 percent and finally nuclear energy constitutes 2 percent of the energy mix respectively (GoP, 2010). Pakistan is heavily dependent on conventional sources of energy to satisfy its energy consumption requirements. Conventional source of nonrenewable energy satisfy more than 99 percent of the energy requirements (Sheikh, 2010). Nonetheless, Government of Pakistan has assigned the target to the Pakistan Alternative Energy Board to generate 5 percent of the total installed power through the alternative/renewable energy up to year 2030 (Khalil et al. 2005).

Pakistan is a country blessed with so many natural sources of energy that, if utilized properly may reduce the dependence on foreign aid for oil imports. These available unexplored energy resources in Pakistan have the potential not only to satisfy the domestic energy requirements but these can also be exported to other energy deficit countries. But unfortunately, these resources have not been explored properly.

Pakistan is located on the high insulation belt which gives it the comparative advantage in the creation of solar energy. This source of energy is much cheaper than the fossil fuels because neither it needs refining nor it requires any transportation cost. It is the most attractive substitute of fossil fuels because it adds no pollution in the environment. It is employed in rural telephone exchanges, emergency telephones at high ways, vaccine and medicine refrigeration utilized in the hospitals etc. In Pakistan, Sindh and Balochistan provinces are the ideal locations for the production and utilization of solar energy. In Balochistan, 77 percent of the population lives in villages and 90 percent of them live without electrification facilities. These villages are located far away from each other; resultantly, there is no scope of the grid stations and solar energy networks are more suitable sources of energy for these location. Recently, a 100 solar energy homes' project has been completed in 9 villages of these provinces which have the potential to enlighten the 26000 homes (Sheikh, 2010).

The coastal areas of Sind and Baluchistan provinces and the desert areas of Punjab and Sind provinces provide the huge potential for the wind energy. The coastal belt has a 60 km wide and 180 km long corridor with a potential to generate the 50,000 MW of the renewable energy through the wind energy. In addition, there are other sites in these areas as well as in Northern areas which are suitable for the micro wind turbines. Although, these wind turbines have the potential to electrify 5000 village in Pakistan but unfortunately just 18 villages have been electrified with this source of energy (Sheikh, 2010). The Northern areas of Pakistan are rich in waterfalls which makes it a suitable candidate for the hydro energy. In addition to the big plants which have the potential to generate 1 MW of renewable energy or greater, there are other sites suitable for the micro hydro energy plants having the potential to produce 100 KW of renewable energy. Altogether, these micro plants may have the potential of producing 300 MW of renewable energy. These areas are densely populated and fossil fuel power plants for producing non-renewable energy might be costly, therefore these micro hydro plants are more suitable for these areas. The canal networks in Punjab have also such sites which provide a great opportunity for the renewable energy production. It is estimated that Punjab comprises of 300 such sites which can produce 350 MW of renewable energy. Whereas, there are only 228 micro plants which just have the potential to produce the 3 MW of renewable energy to the households and small industrial units (Sheikh, 2010).

Biogas is also one of the important sources of energy which not only increases the land fertility but is also used to fulfill the energy requirements. There are 48 million animals in Pakistan comprising of buffaloes, bullocks and cows, as per livestock census of 2002-03. Keeping in view the daily dung dropping and assuming 50 percent collectability, it is estimated that 17.25 million cubic meters of biogas can be produced daily with the help of biogas plants. Cooking requirements of 50 million people can be entertained with it. In addition, it also provides fertility to land through the provision of 35.04 million of bio-fertilizers each year. The formal initiation, for this source of energy, was taken in 1974 and up to 1987, there were 4137 units of biogas plants in the country. Unfortunately, the lack of funds made this project difficult to sustain during 1990s but later on this program was reinitiated with the help of 1700 biogas plants in many villages in the country[1].

Energy (renewable and non-renewable energy consumption) is an important determinant of economic growth like other factors of production such as labour and capital. Existing energy literature provides four competing hypotheses of energy consumption (renewable and nonrenewable energy consumption) and economic growth in case of Pakistan. These competing hypotheses are very important for policy point of view. For instance, reductions in energy would not have adverse impact on economic growth if economic growth Granger causes energy consumption or neutral hypothesis exists between both the variables. If bidirectional causality is found between both the variables or energy consumption Granger causes economic growth then new sources of energy should be encouraged. Energy is an important stimulus of production process and energy must Granger cause economic growth. An expansion in production is linked with energy demand and economic growth might Granger cause energy consumption. The main objective of present study is to investigate the relationship between renewable energy consumption, nonrenewable energy consumption, capital, labour and economic growth in case of Pakistan of using Cobb-Douglas production function over the period of 1972-2011. In case of Pakistan, this study contributed to energy literature by four folds applying: (i) Clemente-Montanes-Reyes (1998) structural break unit root test for stationarity properties of the variables; (ii) ARDL bound testing approach to cointegration for long run relationship; (iii) Gregory and Hansen (1990) structural break test to check the reliability and robustness of the ARDL results, (iv) OLS and ECM for long run and short run impacts of renewable and nonrenewable energy consumption on economic growth; (v) VECM Granger causality approach is to examine causal relationship between the variables.

Our findings reveal that cointegration between renewable energy consumption, nonrenewable energy consumption, economic growth, capital and labor exists in case of Pakistan. Additionally, our empirical evidence also report that renewable and nonrenewable energy consumption has positive impact on economic growth. Capital and labour also adds to the economic growth. Furthermore, estimated results indicate bidirectional causality relationship between renewable energy consumption and economic growth, nonrenewable energy consumption and economic growth, economic growth and capital.

II. Review of Literature on Energy-Growth Nexus

Theorists have divided the literature on energy and growth nexus in four competing hypotheses such as growth hypothesis, conservation hypothesis, feedback hypothesis and neutrality hypothesis. Growth hypothesis asserts the unidirectional causality running from the energy consumption to the economic growth, whereas the conservation hypothesis supports the reverse process of the unidirectional causality running from economic growth to energy consumption. Empirical evidence also supports the interdependence between energy consumption and economic growth, and in some cases there is no relationship (Payne, 2010). The last two cases are formally known as feedback and neutrality hypotheses respectively. The present study tends to review the literature and report the empirical evidence under these four competing hypotheses.

Growth hypothesis

Ewing et al. (2007) investigated the correlation between disaggregated energy consumption and real GDP in United Stated by using generalized variance decomposition approach for empirical analysis. They found that coal, natural gas, and fossil fuels explain the maximum variations in output, whereas renewable energy consumption explains a little variation in output. These estimated results were quite consistent with the growth hypothesis. Later on, Payne (2010) employed the Toda-Yamamoto causality tests to examine causal relationship between the biogas energy consumption and real output over the period of 1949-2007 in the US economy. Payne (2010) reported unidirectional causality running from the biogas consumption to real output confirming growth hypothesis. In case of India, Tiwari (2011) postulated the relationship between renewable energy consumption, economic growth and CO2 emissions by applying Johansen-Juselius (1990) long run and structural innovative accounting approach (IAA) within framework of VAR (vector autoregression) to test the direction of causal relationship between these variables. The empirical evidence reported no cointegration between renewable energy consumption, economic growth and CO_2 emissions during the study period of 1965-2009. Furthermore, results showed that renewable energy consumption attributes to economic growth through its positive innovative shocks and economic growth leads to increase CO_2 emissions in response. Therefore it can be concluded that renewable energy consumption Granger causes economic growth. Later on, Tiwari (2011b) applied panel VAR to investigate the relationship between renewable energy consumption, nonrenewable energy consumption, economic growth and CO_2 emissions in case of Europe and Eurasian countries using the data over the period of 1965-2009[2]. The results indicated that the innovative response of economic growth is positive due to one standard shock in renewable energy consumption and thus supporting the growth hypothesis. For Italian economy, Magnani and Vaona (2011) tested the spillover effects of renewable energy generation applying panel cointegration and Granger non-causality within framework of GMM (generalized method of moments) systems. Their results support that renewable energy generation promotes economic growth and policies promoting renewable energy should be encouraged. Similarly, Bobinaite et al. (2011) examined the causal relationship between renewable energy consumption and economic growth by applying Johansen cointegration for long run and Granger causality test for causality between both the variables. Their results reported no evidence of cointegration between renewable energy consumption and economic growth while renewable energy consumption Granger causes economic growth. This implies that energy conservation policies should be discouraged in Lithuanian economy.

Conservation hypothesis

Sari et al. (2008) followed Ewing et al. (2007) by applying different estimation techniques in case of United States. They employed autoregressive distributive lag approach or ARDL bounds testing approach cointegration to test long run relationship between the variables using monthly data over the period of 2001–2005. They used capital and labor the main determinants of fossil fuel, hydroelectric power, solar energy, waste energy and wing energy consumption, whereas these both variables have no long-run relationship with natural gas and wood energy. Their empirical investigation confirmed the existence of conservation hypothesis. Sadorsky (2009a) applied panel cointegration test to explore the causal relationship between renewable energy consumption and economic growth using a panel of 18 emerging countries[3]. Sadorsky (2009a) reported that a 1 percent rise in income per capita increase the energy requirements up to 3.5 percent in long run for the period of 1994-2003. This also tends to support the conservation hypothesis. Chang et al. (2009) focused on the linkages between renewable energy consumption and economic growth using a panel threshold regression model for 30 OECD countries[4] under different economic growth regimes. Their results indicated that economic growth positively granger causes renewable energy consumption but regime with lower economic growth, showed no relationship between economic growth and renewable energy consumption. Sadorsky (2009b) estimated the energy demand model using data of G7 countries. The panel cointegration was applied to test the long run relationship between renewable energy consumption, oil prices, economic growth and energy pollutants. The estimated results reported that economic growth and CO_2 emissions are major determinants of renewable energy consumption while rise in oil prices has negative impact on renewable energy consumption. The causality analysis revealed unidirectional causal relationship running from economic growth to renewable energy consumption.

Feedback hypothesis

Apergis and Payne (2010a) conducted a study to test the causal relationship between renewable energy consumption and economic growth for a panel of thirteen OECD countries applying panel cointegration and error correction mechanism (ECM) over the period of 1985-2005[5]. The empirical investigation revealed the bidirectional causality between renewable energy consumption and economic growth in the long run as well as in short run which confronts the feedback hypothesis. Apergis and Payne (2010b) used the panel cointegration and error correction mechanism (ECM) to examine the causal relationship between renewable energy consumption and economic growth using the data of 13 Eurasian countries[6] for 1992-2007 time period. Their results confirmed that renewable energy consumption and economic growth Granger cause each other. In case of Italy, Vaona (2010) used structural break unit tests for integrating order of nonrenewable energy consumption and economic growth, Johansen cointegration approach for long run and Toda-Yamamoto (1995) for causality analysis. The empirical exercise validated that variables are not cointegrated for long run relationship while nonrenewable energy consumption and economic growth are interdependent supporting feedback hypothesis.

The same empirical exercise was undertaken by Apergis and Payne (2011a) to find the causal relationship between renewable energy consumption and economic growth using the data of 6 Central American countries over the period of 1980-2006[7]. The estimated results revealed the bidirectional causality between the two variables, which also confirm the existence of feedback hypothesis. Later on, Apergis and Payne (2011b) tested the direction of causal relationship between renewable energy consumption and non-renewable energy consumption and economic growth using a panel of 80 countries[8] using data for the period of 1990-2007.The empirical evidence showed bidirectional causal relationship between renewable energy and economic growth, non-renewable energy and economic growth validating the feedback hypothesis. Furthermore, results also provided the evidence of substitution between renewable energy consumption and nonrenewable energy consumption. Apergis and Payne (2012) investigated the impact of renewable and non-renewable energy consumption on economic growth in case of Latin American countries by applying Larsson et al. (2001) panel cointegration test. Their results found cointegration between the series and renewable and nonrenewable energy consumption have positive on economic growth. Causality analysis reveals feedback hypothesis between renewable (nonrenewable) energy consumption and economic growth[9].

Neutrality Hypothesis

In energy literature, Payne (2009) applied Toda-Yamamoto tests to investigate the nature of causal relationship between renewable energy consumption, nonrenewable energy consumption and real output in case of United States. The study used annual data for the period of 1949-2006. The results showed no causality between the variables and, therefore, supported the existence of neutrality hypothesis. Using panel of 27 European countries, Menegaki, (2011) investigated the causal relation between renewable energy consumption and economic growth over the period of 1997-2007[10]. The study applied random effect model for estimation purpose, and estimated results supported that no causality is found between these two series corroborating the neutrality hypothesis.

Some Mixed Results:

In case of United States, Bowden (2011) also utilized the Toda-Yamamoto long run causality approaches to test the causality between renewable energy consumption, non-renewable energy consumption and real output over the period of 1949-2006.Their results indicated no causal relationship between commercial and industrial renewable energy consumption and real output but bidirectional causal relationship is found between commercial, residential non-renewable energy consumption and real output. Furthermore, empirical evidence confirmed that residential renewable energy consumption and industrial non-renewable energy consumption Granger causes real output. Likewise, Menyah and Wolde-Rufael (2010) also investigated the direction of causal relationship between CO_2 emissions, renewable energy consumption, nuclear energy consumption and real output in case of USA. They used annual data covering the period of 1960-2007. Their empirical exercise revealed that nuclear energy Granger causes CO_2 emissions; however, no causality was found between renewable energy consumption and CO_2 emissions. This implies that nuclear energy is a better candidate to be replaced with fossil fuels. For a thorough investigation of the causal relationship between the energy consumption and the economic growth, Payne (2010) and Ozturk (2010) have performed a remarkable job in accumulating this stream of literature on energy consumption and economic growth nexus[11]. The summary of country specific and multi-country studies is reported in the Table-1.

Table-1: Summary of Existing Empirical Studies

No.	Author(s)	Period	Country	Methodology	Conclusion
Panel-I: Country-Specific Studies					
1.	Wolde-Rufael (2004)	1952-1999	Shanghai (China)	Toda-Yamamoto Causality Approach	$Y \leftrightarrow R$ $Y \leftarrow NR$
2.	Ewing et al. (2007)	2001–2005	United States	Vector Autoregression and Forecast Error Variance Decompositions Approach	$Y \leftarrow R$ $Y \leftarrow NR$
3.	Sari et al. (2008)	2001–2005	United States	ARDL Approach	$Y \rightarrow R$ $Y \leftarrow NR$
4.	Ziramba (2009)	1980-2005	South Africa	ARDL approach	$Y \leftrightarrow R$, $Y \leftrightarrow NR$
5.	Payne (2009)	1949-2006	United States	Toda-Yamamoto Causality Approach	$Y \neq R$ $Y \neq NR$
6.	Payne (2010)	1949-2007	United States	Toda-Yamamoto Causality Approach	$Y \leftarrow R$
7.	Vaona (2010)	1861-2000	Italy	Toda-Yamamoto Causality Approach	$Y \leftrightarrow NR$
8.	Tiwari (2011a)	1985-2005	India	Structural VAR and Forecast Error Variance Decompositions Approach	$Y \leftrightarrow R$
9.	Bowden (2011)	1949-2006	United States	Toda-Yamamoto Causality Approach	$Y \leftarrow R$ $Y \leftrightarrow NR$
10.	Magnani and Vaona (2011)	1997- 2007	Italy	Co-integration and Granger Causality Approach	$Y \leftarrow R$
11.	Bobinaite et al. (2011)	1990-2009	Lithuania	Johansen-Juselies (1990) Cointegration	$Y \leftarrow R$
Panel-II: Multi-Country Studies:					
12.	Sadorsky (2009a)	1994-2003	18 Countries	Panel Cointegration	$Y \rightarrow R$
13.	Sadorsky (2009b)	1980-2005	G7 Countries	Panel Cointegration	$Y \rightarrow R$
14.	Chang et al. (2009)	1997-2006	OECD Countries	Threshold Estimation	$Y \rightarrow R$
15.	Apergis and Payne (2010a)	1885-2005	20 OECD Countries	Panel Co-integration and Error Correction Approach	$Y \leftrightarrow R$
16.	Apergis and Payne (2010b)	1992-2007	13 Eurasia Countries	Panel Co-integration and Error Correction Approach	$Y \leftrightarrow R$
17.	Apergis and Payne (2011a)	1980-2006	6 Central American Countries	Panel Co-integration and Error Correction Approach	$Y \leftrightarrow R$
19.	Apergis and Payne (2011b)	1990-2007	80 Countries	Panel Co-integration and Error Correction Approach	$Y \leftrightarrow R$ $Y \leftrightarrow NR$
20.	Tiwari (2011b)	1965- 2009	16 European and Eurasian Countries	Panel VAR Approach	$Y \leftrightarrow R$
21.	Menegaki (2011)	1997-2007	27 European Countries	Random effect model	$Y \neq R$
22.	Apergis and Payne (2012)	1990-2007	6 Central American Countries	Panel cointegration	$Y \leftrightarrow R$ $Y \leftrightarrow NR$
Note: $Y \rightarrow R$ indiactes unidirectional causaity running from economic growth to renewable energy consumption and					

vise versa is denoted by $Y \leftarrow R$; feedbak hypothesis is shown by $Y \leftrightarrow R$ and $Y \neq R$ is for neutral hypothesis between nonrenewable energy consumption and ecnomic growth. Y, R and NR stands for ecnomic growth, rewneable energy consumption and nonrenewable energy consumption respectively.

A number of studies have attempted to investigate the causal relationship between aggregate energy consumption and the economic growth, in the past, however, there is no consensus in the energy literature for the specification of causal relationship between energy consumption and economic growth. Later on, in some of the empirical studies, aggregate energy consumption was replaced with disaggregated energy consumption. Most of the existing studies are based either on aggregated energy consumption, renewable or just nonrenewable energy consumption. Only a few studies have analyzed the impact of renewable and nonrenewable energy consumption on economic growth (Ewing et al., 2007; Sari et al., 2008; Payne, 2009; Apergis and Payne, 2011b; Bowden, 2011). However, to best of our knowledge, none of the empirical studies has focused to investigating the impact of renewable and nonrenewable energy consumption on economic growth. The present study aims to fill this gap by applying ARDL bounds testing approach to cointegration for long run relationship and VECM Granger causality technique for causal relationship between the variables in case of Pakistan.

III. Modeling, Methodological Framework and Data Collection

The objective of present study is to investigate the linkages between energy consumption and economic growth in case of Pakistan using annual data over the period of 1972-2011. For this purpose, we employ Cobb-Douglas production function of the following form to investigate the relationship between energy consumption and economic growth including capital and labour as additional factors of production:

$$Y = AE^{\alpha_1} K^{\alpha_2} L^{\alpha_3} e^{u} \quad (1)$$

Where Y is domestic output in real terms; E, K and L denote energy, real capital and labor respectively. A is for the level of technological advancements and e is the residual term assumed to be identically, independently and normally distributed. The returns to scale is associated with energy consumption, capital and labour and, is shown by α_1, α_2 and α_3 respectively. We have converted all the series into logarithms to linearize the form of nonlinear Cobb-Douglas production. It should be noted that simple linear specification does not seem to provide consistent results therefore to cover this problem, we use log-linear specification to investigate the relationship between energy consumption and economic growth in case of Pakistan. Ehrlich (1977, 1996), Cameron (1994) and Layson (1984) recommended to use log-linear modeling in attaining better, consistent and efficient empirical results[12]. The log-linear functional form of Cobb-Douglas production function is modeled as follows:

$$\log Y_t = \log A + \alpha_1 \log E_t + \alpha_2 \log K_t + \alpha_3 \log L_t + u_t \quad (2)$$

The empirical equation to investigate the relationship between energy consumption and economic growth is modeled by keeping technology constant. Furthermore, we decompose energy consumption into renewable and non-renewable energy consumption in order to measure the impact of individual components of energy on domestic production and hence economic growth. The issue is debatable in case of Pakistan as to which source of energy should be utilized to sustain economic growth. The log-linear specification to explore the relationship between energy consumption and economic growth is as follows:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln R_t + \alpha_2 \ln NR_t + \alpha_3 \ln K_t + \alpha_4 \ln L_t + u_t \quad (3)$$

where $\ln Y_t$, $\ln R_t$, $\ln NR_t$, $\ln K_t$ and $\ln L_t$ is the logarithm of per capita real GDP, renewable energy consumption (kg of oil equivalent per capita),non-renewable energy consumption (kg of oil equivalent per capita), real capital per capita and per capita labor respectively.

The long run relationship between energy consumption (renewable and non-renewable) and economic growth in case of Pakistan over the period of 1972-2011 is investigated by applying ARDL bounds testing approach of Pesaran et al. (2001). Numerous cointegration approaches are available in empirical literature to test cointegration between the series but ARDL bounds testing is considered to be superior and preferable due to its various advantages. For instance, order of integration of the series does not matter for applying the ARDL bounds testing if no variable is found to be stationary at I(2). The approach is more appropriate as compared to conventional cointegration techniques for small sample (Haug, 2002).Within the general-to-specific framework, unrestricted version of ARDL chooses proper lag order to capture the data generating procedure[13]. Appropriate modification of order of the ARDL model is sufficient to simultaneously correct for residual serial correlation and endogeneity problems (Pesaran and Shin, 1999). The equation of unrestricted error correction model (UECM) to investigate the long-and-short runs relations between the series is following:

$$\Delta \ln Y_t = \vartheta_1 + \vartheta_T T + \vartheta_Y \ln Y_{t-1} + \vartheta_R \ln R_{t-1} + \vartheta_{NR} \ln NR_{t-1} + \vartheta_K \ln K_{t-1} + \vartheta_L \ln L_{t-1} + \sum_{i=1}^{p} \vartheta_i \Delta \ln Y_{t-i} + \sum_{j=0}^{q} \vartheta_j \Delta \ln R_{t-j} + \sum_{k=0}^{r} \vartheta_k \Delta \ln NR_{t-k} + \sum_{l=0}^{s} \vartheta_l \Delta \ln K_{t-l} + \sum_{m=0}^{t} \vartheta_m \Delta \ln L_{t-m} + \mu_t \quad (4)$$

$$\Delta \ln R_t = \alpha_1 + \alpha_T T + \alpha_Y \ln Y_{t-1} + \alpha_R \ln R_{t-1} + \alpha_{NR} \ln NR_{t-1} + \alpha_K \ln K_{t-1} + \alpha_L \ln L_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \ln R_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta \ln NR_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta \ln K_{t-l} + \sum_{m=0}^{t} \alpha_m \Delta \ln L_{t-m} + \mu_t \quad (5)$$

$$\Delta \ln NR_t = \beta_1 + \beta_T T + \beta_Y \ln Y_{t-1} + \beta_R \ln R_{t-1} + \beta_{NR} \ln NR_{t-1} + \beta_K \ln K_{t-1} + \beta_L \ln L_{t-1} + \sum_{i=1}^{p} \beta_i \Delta \ln NR_{t-i} + \sum_{j=0}^{q} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \beta_k \Delta \ln R_{t-k} + \sum_{l=0}^{s} \beta_l \Delta \ln K_{t-l} + \sum_{m=0}^{t} \beta_m \Delta \ln L_{t-m} + \mu_t \quad (6)$$

$$\Delta \ln K_t = \rho_1 + \rho_T T + \rho_Y \ln Y_{t-1} + \rho_R \ln R_{t-1} + \rho_{NR} \ln NR_{t-1} + \rho_K \ln K_{t-1} + \rho_L \ln L_{t-1} + \sum_{i=1}^{p} \rho_i \Delta \ln K_{t-i} + \sum_{j=0}^{q} \rho_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \rho_k \Delta \ln R_{t-k} + \sum_{l=0}^{s} \rho_l \Delta \ln NR_{t-l} + \sum_{m=0}^{t} \rho_m \Delta \ln L_{t-m} + \mu_t \quad (7)$$

$$\Delta \ln L_t = \sigma_1 + \sigma_T T + \sigma_Y \ln Y_{t-1} + \sigma_R \ln R_{t-1} + \sigma_{NR} \ln NR_{t-1} + \sigma_K \ln K_{t-1} + \sigma_L \ln L_{t-1} + \sum_{i=1}^{p} \sigma_i \Delta \ln L_{t-i} + \sum_{j=0}^{q} \sigma_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \sigma_k \Delta \ln R_{t-k} + \sum_{l=0}^{s} \sigma_l \Delta \ln NR_{t-l} + \sum_{m=0}^{t} \sigma_m \Delta \ln K_{t-m} + \mu_t \quad (8)$$

Where Δ is the differenced operator and μ_t is residual term in period *t*. The akaike information criterion (AIC) is followed to choose appropriate lag length of the first differenced regression. The appropriate computation of F-statistic depends upon the suitable lag order selection of the series to be included in the model[14]. The joint significance of the coefficients of lagged variables is investigated by applying an F-test of Pesaran et al. (2001).The null hypothesis of no long run relationship between the variables in equation (3) is $H_0: \vartheta_Y = \vartheta_R = \vartheta_{NR} = \vartheta_K = \vartheta_L = 0$ against alternate hypothesis of long run relationship i.e. $H_0: \vartheta_Y \neq \vartheta_R \neq \vartheta_{NR} \neq \vartheta_K \neq \vartheta_L \neq 0$. Two asymptotic critical values have been generated by Pesaran et al. (2001).These bounds are upper critical bound (UCB) and lower critical bound (LCB) and are used to decide whether variables are cointegrated for long run relationship or not. If all the variables are stationary at I(0) then we use LCB to test cointegration between the series. We use UCB to examine long run relationship between the series if the variables are integrated at I(1) or I(0) or I(1)/I(0). We compute the value of F-test applying following models such as $F_Y(Y/R, NR, K, L)$, $F_R(R/Y, NR, K, L)$, $F_{NR}(NR/Y, R, K, L)$, $F_K(K/Y, R, NR, F, L)$ and $F_L(L/Y, R, NR, F, K)$ for equations (4) to (8) respectively. There is a cointegration between the series if upper critical bound (UCB) is less than our computed F-statistic. If computed F-statistic does not exceed lower critical bound then no cointegration exists between the variables. The decision about cointegration between the series is questionable if computed F-statistic is found between LCB and UCB[15]. In such a situation, error correction method is an easy and suitable way to test the existence of cointegration between the variables.

Since our sample is small and consists of 40 observations i.e. 1972-2011 and critical values generated by Pesaran et al. (2001) are inappropriate. Therefore, we have used lower and upper critical bounds generated by Narayan (2005). The critical bounds generated by Pesaran et al. (2001) are suitable for large sample size (T = 500 to T = 40, 000). It is pointed out by Narayan and Narayan (2004) that the critical values computed by Pesaran et al. (2001) may provide biased decision regarding cointegration between the series. The critical bounds by Pesaran et al. (2011) are significantly downwards (Narayan and Narayan, 2004). The upper and lower critical bounds computed by Narayan (2005) are more appropriate for small samples rages from T = 30 to T = 80.

Once, it is confirmed that cointegration exists between renewable energy consumption, non-renewable energy consumption, capital, labour and economic growth then we should move to investigate the causal relation between the series over the period of 1972-2011. Granger (1969) argued that once the variables are integrated at I(1) then vector error correction method (VECM) is suitable approach to test the direction of causal rapport between the variables. Comparatively, the VECM is restricted form of unrestricted VAR (vector autoregressive) and restriction is levied on the presence of long run relationship between the series. All the series are endogenously used in the system of error correction model (ECM). This shows that in such an environment, response variable is explained both by its own lags and lags of independent variables as well as the error correction term and residual term. The VECM in five variables case can be written as follows:

$$\Delta \ln Y_t = \alpha_{\circ 1} + \sum_{i=1}^{l} \alpha_{11} \Delta \ln Y_{t-i} + \sum_{j=1}^{m} \alpha_{22} \Delta \ln R_{t-j} + \sum_{k=1}^{n} \alpha_{33} \Delta \ln NR_{t-k} + \sum_{r=1}^{o} \alpha_{44} \Delta \ln K_{t-r} + \sum_{s=1}^{p} \alpha_{55} \Delta \ln L_{t-s} + \eta_1 ECT_{t-1} + \mu_{1i} \quad (9)$$

$$\Delta \ln R_t = \beta_{\circ 1} + \sum_{i=1}^{l} \beta_{11} \Delta \ln R_{t-i} + \sum_{j=1}^{m} \beta_{22} \Delta \ln Y_{t-j} + \sum_{k=1}^{n} \beta_{33} \Delta \ln NR_{t-k} + \sum_{r=1}^{o} \beta_{44} \Delta \ln K_{t-r} + \sum_{s=1}^{p} \beta_{55} \Delta \ln K_{t-s} + \eta_2 ECT_{t-1} + \mu_{2i} \quad (10)$$

$$\Delta \ln NR_t = \phi_{\circ 1} + \sum_{i=1}^{l} \phi_{11} \Delta \ln NR_{t-i} + \sum_{j=1}^{m} \phi_{22} \Delta \ln R_{t-j} + \sum_{k=1}^{n} \phi_{33} \Delta \ln Y_{t-k} + \sum_{r=1}^{o} \phi_{44} \Delta \ln K_{t-r} + \sum_{s=1}^{P} \phi_{55} \Delta \ln L_{t-s} + \eta_3 ECT_{t-1} + \mu_{3i} \quad (11)$$

$$\Delta \ln K_t = \varphi_{\circ 1} + \sum_{i=1}^{l} \varphi_{11} \Delta \ln K_{t-i} + \sum_{j=1}^{m} \varphi_{22} \Delta \ln Y_{t-j} + \sum_{k=1}^{n} \varphi_{33} \Delta \ln R_{t-k} + \sum_{r=1}^{o} \varphi_{44} \Delta \ln NR_{t-r} + \sum_{s=1}^{p} \varphi_{55} \Delta \ln L_{t-s} + \eta_4 ECT_{t-1} + \mu_{4i} \quad (12)$$

$$\Delta \ln L_t = \delta_{\circ 1} + \sum_{i=1}^{l} \delta_{11} \Delta \ln L_{t-i} + \sum_{j=1}^{m} \delta_{22} \Delta \ln Y_{t-j} + \sum_{k=1}^{n} \delta_{33} \Delta \ln R_{t-k} + \sum_{r=1}^{o} \delta_{44} \Delta \ln NR_{t-r} + \sum_{s=1}^{p} \delta_{55} \Delta \ln K_{t-s} + \eta_4 ECT_{t-1} + \mu_{4i} \quad (13)$$

Where Δ indicates differenced operator and u_{it} are residual terms and assumed to be identically, independently and normally distributed. The statistical significance of lagged error term i.e. ECT_{t-1} further validates the established long run relationship between the variables. The estimates of ECT_{t-1} also shows the speed of convergence from short run towards long run equilibrium path in all the models. The VECM is superior to test the causal relation once series are cointegrated and causality must be found at least from one direction. Further, VECM helps to distinguish between short-and-long runs causal relationships. The VECM is also used to detect causality in long run, short run and joint i.e. short-and-long runs respectively.

A negative coefficient of the error correction term assures the convergence of system, it also indicates the long-run causality among the variables. However, short-run causality is gauged with the help of given differenced variables. In the present context, $\alpha_{22,i} \neq 0 \forall_i$ indicates that renewable energy consumption causes the economic growth while $\beta_{22,i} \neq 0 \forall_i$ portrays that causality is running from economic growth of renewable energy consumption and vice versa. In the final stage, Wald test is applied on the lagged values of given variables along with error correction term which leads to the final conclusion about the presence of short-run and long-run causality in the variables (Shahbaz et al. 2011; Oh and Lee, 2004).

The data span of present study is 1971-2011. The data on renewable and non-renewable energy consumption is collected from GoP (2010-11). We have used world development indicators (CD-ROM, 2011) to collect data on real GDP, real capital and labour. The variable of population is also used to convert all the series into per capita (see Lean and Smyth, 2009).

IV. Results and Discussions

To insure that no variable is found to be stationary at 2nd difference or beyond that order of integration, we applied Ng-Perron unit root test to examine the order of integration. Ng-Perron is suitable for small sample data set like in our case i.e. Pakistan. This test is superior and more powerful as compared to traditional unit root tests such ADF, DF-GLS, KPPS etc. It is pointed out by Baum (2004) that it is necessary condition to test the integrating order of the variables before applying ARDL bounds testing approach to cointegration relationship between the series. The assumption of ARDL bounds testing is that the variables should be integrated at I(0) or I(1) or I(0)/I(1) and no series is stationary at I(2). If any variable is integrated at I(2) then the computation of ARDL F-statistic becomes invalid. The results of Ng-Perron unit root test are reported in Table-2. This empirical exercise indicates that all the series are non-stationary at level. At 1st difference, all the variables are integrated. This implies that the variables have unique order of integration i.e. I(1). The findings by Ng-Perron unit root test may be biased because this test does not seem to have information about structural break stemming in the series.

Table-2: Ng-Perron Unit Root Test

Variables	MZa	MZt	MSB	MPT
$\ln Y_t$	-3.6623(1)	-1.3192	0.3602	24.349
$\Delta \ln Y_t$	-61.7313 (5)*	-5.5535	0.0899	1.4859
$\ln R_t$	-9.36974(3)	-2.0217	0.2157	10.2882
$\Delta \ln R_t$	-21.9638(1)**	-3.3078	0.1506	4.1850
$\ln NR_t$	-1.6774 (1)	-0.5801	0.3458	30.2654
$\Delta \ln NR_t$	-17.8476(0)**	-2.9395	0.1647	5.3918
$\ln K_t$	-7.2320(3)	-1.7635	0.2438	12.8153
$\Delta \ln K_t$	-22.3213(1)**	-3.1632	0.1417	5.1214
$\ln L_t$	-11.0485(2)	-2.2334	0.2021	8.8183
$\Delta \ln L_t$	-23.9588(4)*	-3.4423	0.1436	3.9148
Note: * indicates significant at 1% level of significance.				

We investigated order of integration of the series by applying Zivot-Andrews (1992) and Clemente-Montanes-Reyes (1998) de-trended structural break unit root tests. Both tests are superior to Ng-Perron unit root test. Zivot-Andrews (1992) unit root has information about one structural break point stemming in the variables. Clemente-Montanes-Reyes (1998) unit root test allows having information about two structural break points arising in the series. Clemente-Montanes-Reyes (1998) unit root test follows an additive outliers (AO) model to plug out sudden changes in the mean of a series as well as gradual changes in the mean of the variables is tested by innovational outliers (IO) model. But, the additive outlier model is preferable for series having sudden structural deviations as compared to gradual shifts. Our decision regarding the order of integration of the variables is based on Clemente-Montanes-Reyes (1998) unit root test. The results of Zivot-Andrews (1992) unit root test are reported in Table-3 and Table-4 reports the results provided by Clemente-Montanes-Reyes (1998) unit root test. Both tests show unit root problem in renewable energy consumption, nonrenewable energy consumption, capital, labour and economic growth at level with intercept and trend. All the variables are found to be integrated at 1st differenced form. Therefore, the series are integrated at I(1) leading to test cointegration between these variables by applying ARDL bounds testing approach.

Table-3: Zivot-Andrews Structural Break Trended Unit Root Test

Variable	At Level		At 1st Difference	
	T-statistic	Time Break	T-statistic	Time Break
$\ln Y_t$	-3.705 (2)	1997	-6.515 (1)*	1993
$\ln R_t$	-3.411 (1)	1986	-8.316 (0)*	2002
$\ln NR_t$	-2.568 (1)	2000	-8.797 (1)*	1994
$\ln K_t$	-4.608 (1)	1997	-5.670 (2)*	2006
$\ln L_t$	-3.228 (1)	2001	-6.595 (0)*	1980
Note: * and *** represent significant at 1%, and 10% level of significance. Lag order is shown in parenthesis.				

Table-4: Clemente-Montanes-Reyes Detrended Unit Root Test

Variable	Innovative Outliers			Additive Outlier		
	t-statistic	TB1	TB2	t-statistic	TB1	TB2
$\ln Y_t$	-4.921 (2)	1978	2002	-6.769 (3)*	1991	2003
$\ln R_t$	-4.175 (3)	1976	1999	-7.334 (3)*	1994	2001
$\ln NR_t$	-3.784 (2)	1977	1983	-7.763 (3)*	1979	1992
$\ln K_t$	-3.827 (2)	1980	2003	-8.533 (3)*	1995	2003
$\ln L_t$	-2.536 (6)	1994	2001	-8.011 (3)*	1978	2001
Note: * indicates significant at 1% level of significance.						

The ARDL bounds testing approach to cointegration tests the existence of cointegration between the variables for long run relationship. The appropriate lag order selection is necessary to precede the ARDL bounds testing approach to cointegration. To overcome this problem, we have used akaike information criterion (AIC) to choose suitable lag length that helps us in capturing the dynamic relationships to select the best ARDL model to estimate. Our decision about appropriate lag length is based on AIC in this study. It is argued by Lütkepohl (2005) that AIC has superior predicting properties when data sample is small like in our case of Pakistan.

Table-5: The Results of ARDL Cointegration Test

Bounds Testing to Cointegration			Diagnostic tests			
Estimated Models	Optimal lag length	F-statistics	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}	χ^2_{SERIAL}
$F_Y(Y/R,NR,K,L)$	2, 1, 2, 1, 2	5.885***	0.3156	[1]: 1.2708	[1]: 2.4904	[1]: 0.0402; [2]: 2.0156
$F_R(R/Y,NR,K,L)$	2, 2, 1, 2, 2	8.318**	1.7180	[1]: 0.0228	[1]: 0.1456	[1]: 0.6259; [2]: 0.7227
$F_{NR}(NR/Y,R,K,L)$	2, 2, 2, 2, 2	28.868*	1.0836	[1]: 0.1894	[1]: 2.0130	[1]: 0.3029; [2]: 0.1399
$F_K(K/Y,R,NR,L)$	2, 1, 2, 2, 1	12.640**	0.2511	[1]: 0.5476	[1]: 0.1540	[1]: 1.1901; [2]: 1.3581
$F_L(L/Y,R,NR,K)$	2, 2, 2, 2, 2	3.370	1.3443	[1]: 0.6176	[1]: 5.5992	[2]: 3.6831; [3]: 4.1798
Significant level	Critical values (T= 40)					
	Lower bounds *I*(0)	Upper bounds *I*(1)				
1 per cent level	7.527	8.803				
5 per cent level	5.387	6.437				
10 per cent level	4.447	5.420				
Note: *, ** and *** show significance at 1%, 5% and 10% levels respectively.						

The empirical results of ARDL bounds testing are shown in Table-5. The results indicate that our computed F-statistics i.e. 28.868, 12.640, 8.813 and 5.885 are greater than upper critical bound at 1 per cent and 10 per cent level of significance once nonrenewable energy consumption, renewable energy consumption and economic growth are treated as predicted variables. This implies that there is cointegration between the series and confirms that renewable energy consumption, capital, nonrenewable energy consumption, capital, labour and economic growth are cointegrated for long run relationship over the period of 1972-2011 in case of Pakistan.

Reliability of the ARDL becomes doubtful due to the presence of structural break in a series. Therefore, we utilized Gregory-Hansen (1996) structural break cointegration approach to test the reliability and robustness of long run relationship between the variables (see Gregory-Hansen, 1996 for theoretical background). The results of Gregory-Hansen cointegration test i.e. a residual based cointegration test are shown in Table-6 which accommodates one structural break in the series. Our empirical evidence validates the presence of cointegration, allowing for structural breaks in 2000 and 1997 (following Zivot-Andrews unit root test) for nonrenewable energy consumption and capital which was investigated by applying FMOLS (fully modified OLS) approach. This procedure allows to use a dummy variable for structural break in nonrenewable energy consumption and capital series corresponding with to the impact of economic reforms and Asian crisis on Pakistan's economy.

Table-6: Gregory-Hansen Structural Break Cointegration Test

Model	$T_Y(Y/R,NR,K,L)$	$T_R(R/Y,NR,K,L)$	$T_{NR}(NR/Y,R,K,L)$	$T_K(K/Y,R,NR,L)$	$T_L(L/Y,R,NR,K)$
Structural Break	1997	1986	2000	1997	2001
ADF-Test	-3.4031	-3.2685	-4.9696	-6.0106	-2.9462
P-value	0.0013	0.0248	0.0000**	0.0000*	0.0043
Note: ** shows significance at the 5% level. The ADF statistics show the Gregory-Hansen tests of cointegration with an endogenous break in the intercept. Critical values for the ADF test at 1%, 5% and 10% are -5.13, -4.61 and -4.34 respectively.					

Table-7: Long and Short Runs Results

Dependent variable = $\ln Y_t$				
Long Run Analysis				
Variables	Coefficient	Std. Error	T-Statistic	Prob. values
Constant	5.6541*	0.3073	18.395	0.0000
$\ln R_t$	0.0903*	0.0248	3.6380	0.0009
$\ln NR_t$	0.1428*	0.0180	7.9062	0.0000
$\ln K_t$	0.2318*	0.0497	4.6633	0.0000
$\ln L_t$	0.3638*	0.0455	7.9805	0.0000
Short Run Analysis				
Variables	Coefficient	Std. Error	T-Statistic	Prob. value
Constant	0.0094	0.0075	1.2460	0.2221

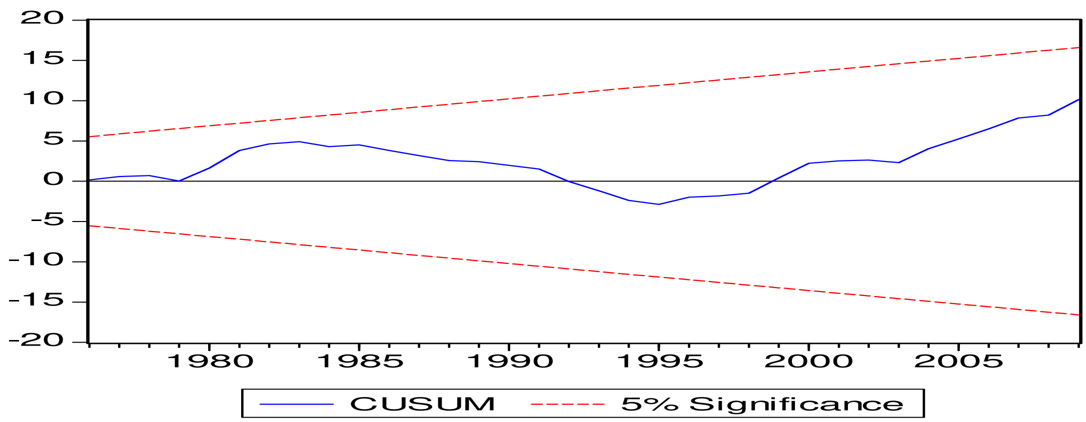
$\ln R_t$	0.0769*	0.0249	3.0813	0.0043
$\ln NR_t$	0.1172**	0.0478	2.4525	0.0200
$\ln K_t$	0.1734*	0.0402	4.3090	0.0002
$\ln L_t$	0.0794	0.1866	0.4259	0.6731
ECM_{t-1}	-0.3546*	0.1132	-3.1331	0.0038
R^2	0.4121			
F-statistic	4.3476*			
D. W	1.9252			
Short Run Diagnostic Tests				
Test	F-statistic	Prob. value		
χ^2 *NORMAL*	0.1190	0.9422		
χ^2 *SERIAL*	0.0579	0.8114		
χ^2 *ARCH*	0.1371	0.7134		
χ^2 *WHITE*	1.7298	0.1268		
χ^2 *REMSAY*	0.0720	0.7902		
Note: * and ** show significance at 1 and 5 per cent level of respectively.				

After confirming long run relationship between the variables, we investigated the long run and short run impacts of renewable energy consumption, nonrenewable energy consumption, capital and labour on economic growth in case of Pakistan. The results shown in Table-7 reveal a positive relationship between renewable energy consumption and economic growth which is statistically significant at 1 per cent. Same inference can be drawn for the relationship between non-renewable energy consumption and economic growth. Our empirical exercise implies that a 0.1428 per cent economic growth is linked with a 1 per cent increase in non-renewable energy consumption. This relationship is statistically significant at 1 per cent level. A positive and statistically significant effect of capital on economic growth is also supported by the estimated results. This shows that in the long run, capital plays a vital role to spur economic growth. Keeping the other things constant, a 1 per cent increase in capital use enhances domestic production and hence economic growth by 0.23 per cent in the country. The relationship between labour and economic growth is positive and is statistically significant at 1 per cent level implying that a 0.3638 per cent of economic growth is stimulated by 1 per cent increase in labour, everything else remaining same.

The lower segment of Table-7 reports the results of short run effects of renewable and non-renewable energy consumption, capita and labour on economic growth. In short span of time, renewable energy consumption, nonrenewable energy consumption and capital contribute to economic growth significantly. Again results confirm that capital is an important factor of production along with renewable and non-renewable energy consumption. Although, the impact of labour is positive but statistically insignificant implying that labor may take time to contribute to the process of domestic production and hence economic growth. The negative and statistically significant estimate of ECM_{t-1} corroborates the established long run relationship between renewable energy consumption, non-renewable energy consumption, capital, labour and economic growth in case of Pakistan. The results indicate that estimate of ECM_{t-1} i.e. -0.3546 is statistically significant at 1 per cent level of significance. This implies that a 0.3546 per cent changes in economic growth are corrected by deviations in short run towards long run equilibrium path. In this model, short run deviations in economic growth take 2 years and 6 month in converging to long run equilibrium path. The short run diagnostic tests show that error term of short run model is normally distributed. There is no serial correlation and same interpretation can be made for ARCH test. Our empirical exercise indicates that there is no problem of heterogeneity and error term has homogenous variance. The Ramsey reset test shows that functional form of the model is well specified.

Figure-1

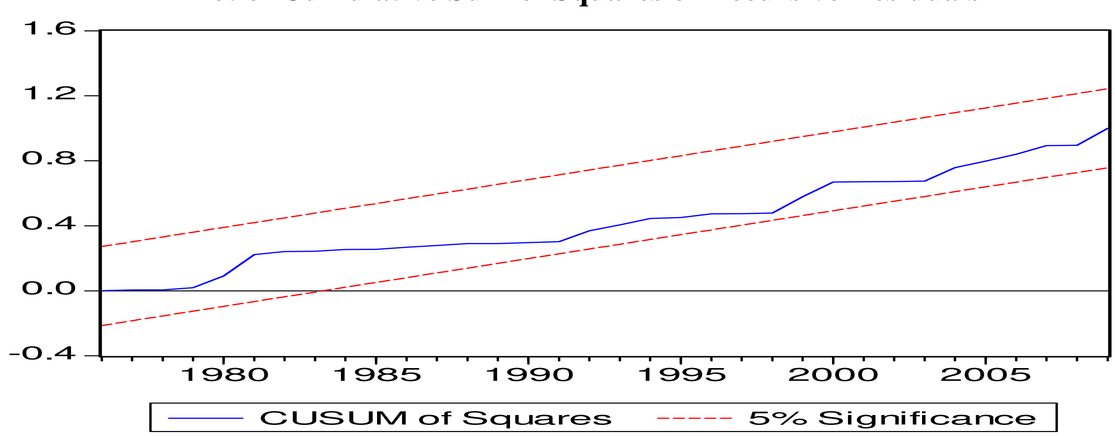
Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.

Figure-2

Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.

The stability analysis like the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) tests reveal the supremacy of long run as well as of short run parameters. The results of CUSUM and CUSUMsq are shown in Figure 1 and 2. Based on the empirical evidence provided in Figure 1 and 2, we may reject the hypothesis of "misspecification of empirical model" if graphs of both CUSUM and CUSUMsq test cross critical bounds i.e. red lines. Figure 1 and 2 show that the graphs do not seem cross critical bounds at 5 per cent level of significance (Bahmani-Oskooee and Nasir, 2004). This suggests that long run and short run models are correctly specified and estimates are stable.

After finding long-and-short runs affect of renewable energy consumption, non-renewable energy consumption, capital and labour on economic growth in case of Pakistan over the period of 1972-2011. The direction of causal relationship between these variables is investigated by applying VECM Granger causality approach. The appropriate environmental and energy policies to sustain economic growth are dependent upon the nature of causal relationship between the series. In doing so, we applied VECM granger causality approach to detect the causality between renewable energy consumption, non-renewable energy consumption, capital, labour and economic growth to help policy makers in formulating comprehensive energy policy to accelerate economic growth in the long run.

Table-8 presents the empirical evidence of long run and short run causality relationships. The results validate the feedback hypothesis between renewable energy consumption and economic growth, non-renewable energy consumption and economic growth, renewable energy consumption and non-renewable energy consumption, capital and economic growth, renewable energy consumption and capital and, between nonrenewable energy consumption and capital in case of Pakistan for the long run. The results indicate that causality running from renewable energy consumption to economic growth is stronger compared to causal relationship from nonrenewable energy consumption to economic growth. This shows that government must pay attention to launch comprehensive energy policy (renewable energy sources) in the long-run. Given the fact that Pakistan is producing less than one percent of its energy consumption from renewable energy consumption (Sheikh, 2010), the marginal productivity of the renewable energy is expected to be higher. Conventional sources of energy such as the extensive use of fossil fuels are no more sustainable since we have to import them and they emit high CO_2 emissions. It is much costly and most of our foreign resources are consumed to import these expensive fossil fuels. Just coastal areas of Sindh and Balochistan provinces have the potential of producing 50,000 MW of energy through wind turbines. Northern areas can generate up to 300 MW of electricity which would be more than the needs of that region. There are many more options available in the country, since Pakistan is blessed with plenty of natural resources. It just lacks the concentrated and consistent efforts towards the appropriate policy planning and implementation.

Table-8: The VECM Granger Causality Analysis

Dependent Variable	Direction of Causality										
	Short Run					Long Run	Joint Long-and-Short Run Causality				
	$\Delta \ln Y_{t-1}$	$\Delta \ln R_{t-1}$	$\Delta \ln NR_{t-1}$	$\Delta \ln K_{t-1}$	$\Delta \ln L_{t-1}$	ECT_{t-1}	$\Delta \ln Y_{t-1}, ECT_{t-1}$	$\Delta \ln R_{t-1}, ECT_{t-1}$	$\Delta \ln NR_{t-1}, ECT_{t-1}$	$\Delta \ln K_{t-1}, ECT_{t-1}$	$\Delta \ln L_{t-1}, ECT_{t-1}$
$\Delta \ln Y_t$	….	4.8030** [0.0172]	3.9709** [0.0318]	4.1559** [0.0227]	1.1307 [0.3378]	-0.3611** [-2.3099]	….	9.0810* [0.0003]	3.4882** [0.0305]	5.8943* [0.0035]	3.4434** [0.0319]
$\Delta \ln R_t$	4.2863** [0.0251]	….	8.3899* [0.0016]	1.2452 [0.3051]	1.4351 [0.2570]	-0.5116** [-2.7469]	3.6967** [0.0249]	….	7.8412* [0.0007]	2.7885*** [0.0614]	3.5460** [0.0289]
$\Delta \ln NR_t$	5.2451** [0.0125]	15.1161* [0.0000]	….	4.3784** [0.0234]	2.0560 [0.1490]	-0.2276** [-2.1287]	4.6055** [0.0015]	10.3854* [0.0001]	….	3.9649** [0.0193]	2.4911*** [0.0834]
$\Delta \ln K_t$	0.6869 [0.5123]	0.5771 [0.5685]	0.6852 [0.5132]	….	1.8140 [0.1838]	-0.6743* [-4.2756]	15.0685* [0.0000]	7.1412* [0.0012]	6.9683* [0.0015]	….	14.3940* [0.0000]
$\Delta \ln L_t$	0.7043 [0.5036]	1.7474 [0.1941]	5.1641** [0.0129]	1.3630 [0.2736]	….	….	….	….	….	….	….
Note: *, ** and *** show significance at 1, 5 and 10 per cent levels respectively.											

The results reported in Table-8 indicate that in the short run, bidirectional causal relationship is found between renewable energy consumption and economic growth. Nonrenewable energy consumption and economic growth Granger cause each other. The feedback hypothesis also exists between renewable and nonrenewable energy consumption. The unidirectional causal relation is running from capital to economic growth and nonrenewable energy consumption. Nonrenewable energy consumption Granger causes labor. The statistically significance of joint long-and-short run causality corroborates our long run and short run causal relationships between the series over the study period of 1972-2011.

V. Conclusion and Future Research

The present study investigated the relationship between energy (renewable and nonrenewable) consumption and economic growth using Cobb-Douglas production function in case of Pakistan. The autoregressive distributed lag model or ARDL bounds testing and Gregory and Hansen (1990) structural break approaches to cointegration are applied to test the existence of long run relationship between renewable energy consumption, nonrenewable energy consumption, capital, labour and economic growth. The VECM Granger causality approach is used to examine the direction of causal relationship between these series.

Our empirical exercise confirmed that the variables are cointegrated for long run relationship over the study period of 1972-2011. The results indicated that renewable and nonrenewable energy consumption enhances economic growth. Capital and labor are also important factors of economic growth contributing to domestic production in the country. The causality analysis confirms the existence of feedback hypothesis between renewable energy consumption and economic growth as well as in the case for nonrenewable energy consumption.

The use of renewable energy consumption produces less CO_2 emissions as compared to the use of nonrenewable energy consumption. Therefore, the current study can be augmented in future by investigating the relationship between energy consumption (renewable energy consumption and nonrenewable energy consumption), CO_2 emissions and economic growth following on *supply-side* and *demand-side* in case of Pakistan as well as in SAARC region (South Asian and Regional countries) following Bloch et al. (2011).

Furthermore, the findings of the present study may be biased due to the assumption of constant technology and use of aggregate measure of renewable energy consumption. The inclusion of technology in the model with the sources of renewable energy such as nuclear energy, hydropower, wind power, biomass etc. would make the analysis more comprehensive to test as to which source of renewable energy should be focused more to enhance domestic production and hence economic growth. The disaggregated renewable energy consumption can be added in CO_2 emissions model to investigate the existence of environmental Kuznets curve (EKC) which would help policy makers in formulating comprehensive energy policy to spur economic growth by improving environmental quality in case of Pakistan.

Footnotes

1. The information regarding the renewable energy potential has been borrowed from various reports, available on the official website of Alternative Energy Development Board, Ministry of Water and Power, Government of Pakistan.
2. Austria, Belgium & Luxembourg, Bulgaria, Finland, France, Germany, Greece, Republic of Ireland, Italy, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and United Kingdom
3. Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Indonesia, Korea, Mexico, Peru, Philippines, Poland, Portugal, Russia, Thailand, Turkey.
4. Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.
5. Australia, Austria, Belgium, Canada, Denmark, France, Germany, Iceland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.
6. Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Moldova, Russia, Tajikistan, Ukraine, Uzbekistan.
7. Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama.
8. Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Canada, Cameron, Chile, China, Comoros, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Guinea, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland,

Italy, Japan, Jordan, Kenya, Korea, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Mauritius, Mexico, Morocco, Mozambique, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Senegal, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syria, Thailand, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela, Zambia.

9. Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama
10. Belgium, Bulgaria, Czech Rep., Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxemburg, Hungary, Netherland, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, UK, Norway.
11. Akkemike and Göksal (2012) probed energy-growth nexus and reported that feedback hypothesis exists in seven-tenths of the countries, neutral hypothesis in two-tenths.
12. See Shahbaz (2010) for more details
13. See Shahbaz and Lean (2012) for more details
14. For details see Shahbaz et al. (2011)
15. If the variables are integrated at I(0) then F-statistic should be greater than lower critical bound for the existence of cointegration between the series.

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