Current Issues in Time-Series Analysis for the Energy-Growth Nexus; Asymmetries and Nonlinearities Case Study: Pakistan

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Abstract: This paper investigates the asymmetric impact of energy consumption on economic growth by including oil prices, capital and labour as additional determinants in production function. In doing so, the non-linear ARDL bounds testing approach is applied for the period of $1985Q_I$-$2016Q_{IV}$. The empirical evidence confirms the presence of symmetric and asymmetric cointegration between energy consumption, oil prices, capital, labour and economic growth over the period of $1985Q_I$-$2016Q_{IV}$. Furthermore, rise in energy consumption (positive shock) adds to economic growth via stimulating economic activity and energy consumption negative shock retards economic growth insignificantly. Rise (positive shock) and fall (negative shock) in oil prices decline and stimulate economic growth. Capital and labor affect economic growth positively and negative by positive and negative shocks in capital and labor. The empirical findings open new insights for policy makers for long-run and sustainable economic development.

Keywords: Energy Consumption, Economic Growth, Oil Prices, Asymmetries

I. Introduction

The energy-growth nexus has come under intense scrutiny for the last four decades (Jumbe 2004, Chontanawat et al. 2008, Payne 2009, Ozturk 2010, Belke et al. 2011, Apergis and Tang 2013, Khan et al. 2014, Shahbaz et al. 2017a). The issue is important because energy drives the wheels of economic growth. A significant and sharp increase in the demand for energy can be attributed to; (a) promotion of economic growth in the emerging nations; and (b) maintenance of living standards in the developed nations. A considerable amount of empirical studies investigating the energy-growth nexus, shed light on four different hypotheses.

The growth hypothesis reveals that gross domestic product is significantly contributed by energy use (Ozturk, 2010). Empirically, the growth hypothesis is validated if a boost in real gross domestic product is caused by adding to energy demand. This suggests that energy conservation policies may impede economic growth. However, if economic growth is inversely affected by energy consumption then different arguments could justify for the adverse impacts of energy consumption on economic growth (Ozturk, 2010). For example, we could imagine a situation where a growing economy targets to reduce the level of energy consumption by the means of production shifts to lesser energy intensive sectors. Furthermore, the inefficient use of energy such as constraints in capacity use or an inefficient supply of energy may also have negative impact on economic growth or growth of real GDP (Chontanawat et al. 2008, Payne 2009, Ozturk 2010). *The conservation hypothesis* suggests that real GDP growth is not impeded by adopting energy conservation policies in an economy (Chontanawat et al. 2008, Payne 2009). The conservation hypothesis is validated if causality runs from real GDP growth to energy consumption. Yet, exogenous events or bad management of energy as well as political situation, quality of infrastructure, or bad management of natural resources can influence the level of energy consumption (Chontanawat et al. 2008, Ozturk 2010). In such situation, a boost in real GDP growth may have inverse effect on energy demand.

The neutrality hypothesis considers that energy use plays a minor role in the growth of real GDP or economic activity should not be significantly affected by energy use and hence economic growth (Chontanawat et al. 2008, Payne 2010, Ozturk 2010). In this case, approval of conservation policies would not harmful for real GDP growth. The main reason is that energy use does not Granger cause economic growth and in resulting, economic growth does not Granger cause energy use. Lastly, the f*eedback hypothesis* indicates the mutual alliance of energy use and real GDP growth. In such circumstances, a consistent (decrease) energy supply increases (decreases) real GDP, and similarly, a rise (decline) in real GDP leads to rise (decrease) in energy consumption (Chontanawat et al. 2008, Payne 2009, Ozturk 2010). If the energy-growth nexus is bidirectional then the feedback hypothesis is validated. This hypothesis suggests that for un-interrupted supply of energy and sustainable economic growth in an economy, we should adopt energy exploration policies. In such situation, adoption of efficient energy consumption policies may not be harmful for sustainable economic growth (Payne, 2009).

The presence of four competing hypotheses i.e. growth, conservative, feedback and neutrality indicates the ambiguity of empirical findings. This ambiguity in empirical results may be because of asymmetries exist in energy-growth nexus. This shows the complexity of relationship between energy consumption and economic growth. These asymmetries are outcome of complex economic system and system which generate macroeconomic variables under consideration for reliable empirical results to design comprehensive economic policies to main long-run economic growth. Pakistan implemented numerous economic reforms in fiscal, external and energy sectors over the period of time to maintain the macroeconomic performance. This has not only affected the macroeconomic performance but also created the possibility of asymmetries in the trend of the variables which may affect the association between energy consumption and economic growth. In such circumstances, linear empirical investigation provides inconclusive empirical results (Shahbaz et al. 2017a). This implies the importance of asymmetries while investigating relationship between energy consumption and economic growth. This chapter contributes to existing by three folds: (i), The augmented production function is employed to investigate the association between energy consumption and economic growth by considering oil prices, capital and labor using nonlinear framework. (ii) The unit root properties of energy consumption, economic growth, oil prices, capital and labor are investigated by applying linear and nonlinear unit root tests. Last but not least, (iii), The Nonlinear ARDL approach developed by Shin et al. (2014) is applied for examining nonlinear effect of energy consumption, oil prices, capital and labor on economic growth. Our empirical analysis reveals the asymmetric cointegration between economic growth and its determinants. Furthermore, economic growth positively and negative affects by positive and negative shocks stem in energy consumption. Oil prices affect economic growth negatively and positively by its positive and negative shocks. Positive shock in capital adds in economic growth but negative shock in capital declines it. The contribution of positive and negative shocks in labor to economic growth is positive and negative.

The rest of chapter is organized as following: Section-II reviews relevant literature. The modelling, data collection and methodology are described in Section-III. Section-IV deals with results interpretations. Finally, section-V provides conclusion with policy implications.

II. Literature Review

Kraft and Kraft (1978) applied the bivariate model to survey the energy-growth nexus over the period of 1947-1974 in the case of the USA. They stated that energy consumption causes real GNP in Granger sense. Later on, Abosedra and Baghestani (1991) reinvestigated the association between both variables by applying Granger (1969) causality approach. Their findings supported the view reported by Kraft and Kraft (1978). On the contrary, Zarnikau (1997) applied Granger (1969) causality test to re-examine the affiliation between energy demand (proxies by Divisia energy index) and real GDP growth for the US economy. The results showed the feedback effect i.e. bidirectional causality between both variables. Payne (2008) considered the energy-growth by Toda and Yamamoto (1995) causality approach and reported the neutral effect between both variables. The Markov-switching causality approach was applied by Fallahi (2011) to observe the energy-growth nexus in the case of USA. This model reports the causality results regime-wise such as 1971-75, 1977-82, 1989-95 and 2001-2005. The empirical exercise showed the feedback effect i.e. energy use causes growth and in resulting, growth causes energy use in 1971-75 and no causality is found between both variables for the rest of regimes.

Using Pakistani data, Riaz and Stern (1984) studied the energy-growth nexus by utilizing energy supply and demand functions. They reported that real GDP growth raises energy use and thus energy use enhances real GDP growth. Aqeel and Butt (2001) used the bivariate model to examine causality between energy sources (coal, petroleum, electricity consumption and consumption of natural gas and real GDP growth. They applied Granger (1969) cointegration and Hsiao Granger causality tests. Their results confirmed the existence of cointegration. The empirical exercise of causality test unveiled that total energy consumption Granger causes economic growth, petroleum consumption is cause of real GDP growth, neutral effect exists between natural gas consumption and economic growth (coal consumption and real GDP growth) and the short run causality between electricity consumption and economic growth is bidirectional. Yang (2000) used data on growth in energy use and real GDP growth to check the causality relation between the variables by applying Engle-Granger (1987) cointegration approach. He reported that variables are found to be cointegrated as well as the response effect exists between energy consumption and economic growth in Taiwan's economy. For Turkish economy, Altinay and Karagol (2004) examined causal association between growth in energy and real GDP growth by utilizing Hsiao's version of the Granger causality approach and Perron (1997) test with structural break points. They indicated the presence of structural breaks showing the impact of macroeconomic policies on growth in energy use and real GDP. Their analysis validated the neutral effect between the variables.

Lee and Chang (2005) used bivariate model to analyze the affiliation between use of energy and real GDP growth. They applied tests developed by Perron (1997) and Gregory and Hansen (1996) respectively. Their empirical outcome exposed that cointegration is present. Real GDP growth causes energy use and resultantly, energy use causes real GDP growth in Granger sense in Taiwan economy. Further, real GDP growth has positive and significant effect on energy demand. Lee and Chang (2007) applied linear and non-linear models to observe the outcome of energy use on domestic output growth in the case of Taiwan. Their results indicated the association between energy use and domestic output growth that is inverted U-shaped. It entails that at initial level of development, energy demand is increased with a boost in economic growth and starts to decline after a threshold level of real GDP per capita. Furthermore, the linear model confirms the existence of feedback effect between both variables. Dhungel (2008) examined the cointegration and causality relationships between both variables by using Johansen and Juselius (1990) cointegration and the VECM Granger causality approaches. The empirical evidence unveiled that both the series linked for long-run and causality is found running from energy causes growth in Nepal. For Tanzania, Odhiambo (2009) used the ARDL bounds testing to observe the long-run rapport between growth in energy use and income per capita growth. The cointegration between the variables is found once energy and electricity consumption were used as dependent variables. The causality analysis by Granger (1969) causality approach indicated that total energy demand is cause of income per capita growth in Granger sense. Paul and Uddin (2011) looked into the energy-growth nexus for Bangladesh by applying innovative accounting approach. Their results showed that growth in real GDP is not lead by growth in energy use, but shocks in growth in real GDP adversely affect growth in energy use. In the case of Indonesia, Arifin and Syahruddin (2011) inspected the causality between energy consumption measured by energy sources (renewable and non-renewable), and growth in income per capita by applying Toda and Yamamtoo (1995) Granger causality test. They documented that growth in income per capita is Granger caused by renewable energy.

Using the Pakistan economic data, Liew et al. (2012) examined whether sectoral economic growth leads energy consumption by applying the Johansen-Juselius (1990) and pair-wise Granger causality approaches. They articulated that the cointegration relation is valid for the long run relation. Moreover, their empirical exercise exposed the bidirectional causality between agriculture growth energy consumption. The neutral effect subsists between industrial growth and energy consumption and the similar inference is drawn for services growth and energy consumption. Zaman et al. (2012) explored the impact of total energy consumption on agriculture, industrial and services sectors using the bivariate models. They applied Johansen-Juselius (1990), error-correction model and innovative accounting approach for causality analysis. Their results suggest that total energy consumption has negative impact on industrial growth, population and agricultural growth negatively affect total energy use. They further found that the feedback effect is validated. Using data of the Croatian economy, Borozan (2013) explored the relationship between both variables. The results of VAR Granger causality test revealed that real GDP is Granger cause of total energy use confirmed by impulse response function test.

We find that these studies focused on applying the bivariate model to test the energy-growth nexus, but ignored the role of capitalization, labor and other potential variables. This implies that findings of these studies may be biased due to exclusion of pertinent variables. The mentioned variables such as capital and labor play important role in production function and both are determinants of economic growth and energy consumption. Other variables such as employment, government consumption expenditures, development spending, consumer prices, energy prices, oil consumption, exchange rate etc. may affect domestic production and energy consumption. For example, Yu et al. (1988) applied Granger (1969) and Sims (1972) causality techniques to probe the linkages between energy use, total employment and non-farm employment. Their empirical evidence showed that energy consumption Granger causes non-farm employment (neutral effect is present between both variables by Sims causality test) is reported by Granger (1969) causality test. Mahmud (2000) applied the partial equilibrium model to probe the effect of energy and non-energy inputs on manufacturing sector. The findings revealed that shocks in energy prices reduce capital investment and increase the cost of production in manufacturing sector, while energy and non-energy inputs are not possible substitutes. In the case of Greece, Hondroyiannis et al. (2002) explored the causality relation amid energy use, energy price and growth by employing Johansen and Juselius (1990) cointegration for the long-run. The VECM Granger causality test is employed for causal relationship among the series. They found the cointegration and growth causes energy and resultantly, energy causes growth.

Narayan and Smyth (2005) applied the trivariate model to test the causal relation amid energy use, income and employment using Australian time series data. They found cointegration and noted that employment and income cause energy use in Granger sense. For Pakistan, Mushtaq et al. (2007) studied the impact of agricultural growth and agricultural energy prices on agricultural energy consumption (oil, electricity and natural gas consumption). Their empirical exercise indicated the occurrence of the long-run affiliation and agricultural growth Granger causes oil and electricity consumption in agriculture sector. Salim et al. (2008) employed energy demand function by incorporating energy prices and real GDP growth in Bangladesh, China, India, Malaysia, Thailand and Pakistan. Their results showed the cointegration and energy use Granger causes real GDP growth and energy prices in the short-run in Pakistan. Yu et al. (2008) investigated energy demand by incorporating energy prices and per capita income growth in the trivariate framework for Chinese economy by applying the innovative accounting approach. They found the negative (positive) outcome of energy prices (per capita income growth) on energy consumption. Wesseh and Zoumara (2012) engaged energy, employment and growth to examine their relationship by applying non-parametric bootstrapped causality test in the case of Liberia. They confirmed the presence of cointegration by the ADRL bounds testing analysis.

They uncovered that energy use and employment boost growth process and enhance domestic production. The bootstrapped causality findings indicated that growth is cause of employment and the bidirectional relation is valid between energy and growth in Granger sense. Adom (2013) used energy demand function to test the energy-growth by applying time-varying approach in the case of Ghana. The results suggested that economic growth adds in energy demand and energy prices decline it, but impact varies with regime shifts.

The empirical findings reported by Granger (1969) and Sims (1972) may be biased due to low explanatory power. These standard approaches failed to detect causality from other channels and provided contradictory findings (Asafu-Adjaye, 2000). Given the limitation and discrepancies in traditional cointegration and causality tests, Iqbal (1986) applied the Zellner iterative method to examine the impact of energy consumption (all types of energy), capital and labor on small manufacturing sector in Pakistan. He noted that energy consumption, capital and labor are substitutes while the relationship between natural gas consumption and electricity consumption is complementary. Chishti and Mahmud (1990) re-investigated the relationship between energy, non-energy inputs and large manufacturing sector using an aggregate Divisia index. They reported that energy consumption, capital and labor are major determinants of large manufacturing sector. Their empirical evidence unveiled that energy and capital have complementary relationship while labor and energy are substitutes. Stern (1993) used the Divisia energy index as a measure of energy consumption to explore the energy-growth nexus. He used the multivariate framework by including capitalization and employment in the energy-growth nexus. The empirical evidence indicated that the unidirectional causal relation runs from energy consumption to economic growth. Stern (2000) incorporated capital and labor as contributing factors to energy consumption and economic growth. The production function is utilized to probe the energy-growth in the US economy. He applied Johansen (1991) for the long-run and the VECM Granger causality approaches for the causality linkages. The empirical evidence showed the positive effect of energy consumption, capital and labor on output growth i.e. shocks in energy consumption, capital and labor decline output growth and thus, economic growth. The empirical results revealed the neutral effect between energy use and output growth.

Using Pakistani data, Alam and Butt (2002) reinvestigated the direction of causality between both variables by incorporating capital and labor as supplementary determinants of energy use and output growth. They employed Johansen-Juselius (1990) test for cointegration and the VECM for causality relationship. They noted the validation of cointegration between the series. Their empirical exercise confirmed the feedback effect between both variables. Furthermore, capital causes energy consumption and economic growth and labor causes to economic growth in Granger sense for the short-run. Oh, and Lee (2004) applied energy demand (income and energy prices) and production (energy consumption, capital and labor) function in the multivariate framework to verify the energy-growth nexus in the case of Korea. Their findings indicated that energy use us lead by growth in income per capita. Soytas et al. (2007) applied the Toda-Yamamtoo (1995) and the variance decomposition approaches to re-assess the causal relation between energy consumption and economic growth by including capital, labor and carbon emissions in multivariate regression model for the USA. They exposed that the neutral effect is validated for energy consumption and economic growth. Similarly, Payne (2009) reinvestigated the causality between energy sources and income per capita growth by applying Toda-Yamamtoo (1995) causality approach. He found that energy sources do not contribute to income per capita growth. Kaplan et al. (2011) reinvestigated the causality between energy and growth using the multivariate versions of energy demand and neo-classical production functions by adding energy prices, capital and labor. They applied Johansen and Juselius (1990) for the long-run and the VECM Granger test for causality associations. Their findings validated the cointegration among the variables for both models. Further, they found the bidirectional affiliation between the series.

Similarly, Shahiduzzaman and Alam (2012) applied the supply-side production function to look into the energy-growth nexus by adding capital and labor for Australia. The Johansen-Juselius (1990) for cointegration as well as the Toda-Yamatoo (1995) Granger causality tests were applied. Their results supported for the occurrence of cointegration. They noted that energy use, capital and labor add in real GDP growth. The findings of Toda-Yamatoo (1995) Granger causality showed that real GDP growth is cause of energy use and energy use is cause of real GDP growth in Granger use. Using the US data, Gross (2012) reinvestigated the correlation between energy consumption and economic growth by including energy prices, trade, capitalization in the multivariate framework. The empirical evidence revealed that economic growth has positive impact on energy consumption. The feedback effect exists in the short run, but neutral effect is valid for the long-run between both variables is validated by the VECM Granger causality test. Using Swedish data, Stern and Enflo (2013) assessed the causality between energy (Divisia energy index) and output using the bivariate and multivariate production functions. They found that output Granger causes energy consumption, but the reverse is not true by using the bivariate model. In the multivariate model by incorporating capital and labor, their empirical evidence indicated that energy use is cause of economic growth in Granger sense. They have also used energy demand function and noted that energy prices and economic growth cause energy use in Granger sense. Shahbaz et al. (2012) investigated the impact of energy use measures by renewable and non-renewable energy sources on real GDP growth. They confirmed the long-run association and the feedback relation exists between consumption of energy sources and economic growth. Ahmed et al. (2013) used trivariate framework to examine the association between energy consumption and economic growth. Their empirical evidence provides that energy consumption plays important by stimulating economic growth. Yildirim et al. (2014) investigated the association between energy consumption and economic growth by using bivariate framework for N-11 countries. They found that neutral effect exists between energy consumption and economic growth in Pakistan. Ahmed et al. (2015) revisited the energy-growth nexus in Pakistan and found that economic growth leads energy consumption. In case of USA, Arora and Shi (2016) applied augmented production function for investigating linkages between energy consumption and economic growth by adding capital and labor as additional determinants of economic growth. Their empirical results indicate that energy consumption plays vital role in boosting economic growth like capital and labor. Shahbaz et al. (2016) augmented production function by adding financial development as additional determinant of economic growth and energy consumption. Their empirical evidence reported that financial development strengthens energy-growth nexus. For Turkish economy, Pata and Terzi (2017) noted that energy consumption is main stimulator of economic growth.

Considering important role plays by asymmetries in energy-growth nexus, Arac and Hasanov (2014) have applied linear and nonlinear empirical approaches to examine asymmetric relationship between energy consumption and economic growth. Their empirical evidence indicates that positive and negative shocks in energy consumption positive and negatively affect economic growth but impact of negative shocks stems in energy consumption has dominant effect that of positive shock. Shahbaz et al. (2017a) employed classical production function to examine asymmetric association between energy consumption and economic growth by applying nonlinear ARDL developed by Shin et al. (2014) for Indian economy. Their empirical results confirm the presence of asymmetries and cointegration as well. Economic growth positively and negatively affects by negative and positive shocks occur in energy consumption. Capital (positive and negative shocks) and labor (positive shock) also have positive effect on economic growth.

III. The Modelling, Data and Methodology

Inconclusiveness nature of production function always provides a motivation to researchers for investigating relationship between energy consumption and economic growth. In doing so, researchers applied different empirical approaches on production function by incorporating additional determinants of economic growth but empirical results on energy-growth are still ambiguous (Shahbaz et al. 2017a). Policy makers are handy-caped for designing a comprehensive economic and energy policies for sustainable long-run economic growth. Pakistan has been facing energy crisis for last two decades and satisfying domestic energy demand by importing oil[1]. This implies shows that oil prices shocks in international market not only affects energy-growth but also macroeconomic performance in Pakistan. In doing so, we have added oil prices as additional factor of domestic production affecting economic activity. Oil prices affect economic growth via supply-side and demand-side channels. The supply-side hypothesis entails that oil prices plays vital role in domestic production and rise in oil prices increases the cost of production. This rise in cost of production leads firms to lower output and increase production prices which hikes inflation (Tang et al. 2010, Shahbaz et al. 2017b). According to demand-side hypothesis, shocks in oil prices affect consumption and investment activities. Oil prices hikes slow economic activity by lowering demand for labor and in resulting, affect real wages. Oil prices shock affects inflation via cost of production and exchange and in resulting, economic activity is affected and hence, economic growth (Ftiti et al. 2016, Shahbaz et al. 2017b). The general form of the augmented production function is modeled as follows:

[1] Pakistan is basically an oil dependent country.

$$Y_t = f(E_t, OP_t, K_t, L_t) \quad (1)$$

The log-linear specification is used for empirical purpose following Shahbaz and Lean (2012). They argued that a log-linear specification is appropriate for attaining efficient and reliable empirical results compared to simple linear specification. We also transform variables into per capita units except oil prices. Following Shahbaz and Lean and later on Shahbaz et al. (2017a), we transform all the variables into natural-log. The empirical equation of augmented production function is modeled as follows:

$$\ln Y_t = \beta_0 + \beta_1 \ln E_t + \beta_2 \ln OP_t + \beta_3 \ln K_t + \beta_4 \ln L_t + \varepsilon_t \quad (2)$$

where, $\ln$ indicates natural-log, Y_t is economic growth measured by real GDP per capita, E_t shows energy consumption, O_t is oil prices, capital measures by gross fixed capital formation and labor are shown by K_t and L_t. ε_t is an error term with a normal distribution.

The study covers the period of 1985_{QI}-2016_{QIV}. The World Development Indicators (CD-ROM, 2017) is used to collect data on real GDP (in local currency, constant 2010), energy consumption (kg of oil equivalent), gross fixed capital formation (in local currency, constant 2010) and labor force. The data on oil prices is obtained from Pakistan Energy Year Book (2017)[2]. Total population is used to convert all the variables into per capita unit except oil prices.

III.I The NARDL Bounds Testing Approach for Asymmetric Cointegration

The presence of asymmetries in energy consumption, oil prices, capital, labour and economic growth intends us to apply nonlinear cointegration approach to examine asymmetric cointegration long run between the variables. In doing so, we choose multivariate nonlinear ARDL (NARDL) cointegration test originated by Shin et al. (2014) in order to examine long run relationship between the variables. This approach captures asymmetries and nonlinearities stem in time series data. The NARDL approach differentiates the long run and short run asymmetric impact of energy consumption, oil prices, capital and labour on economic growth. The vector

[2] Oil prices transform into real terms by deflating inflation.

error correction model (VECM) or smooth transition model (STM) suffer from convergence problem if proliferation of estimates exists. The NARDL provides efficient empirical analysis by solving issue of proliferation of estimates related problem. This test does not required that all the variables should be integrated at same order of integration. The NARDL test is applicable if all the variables are integrated at I(1) or variables have flexible order of integration. In the presence of asymmetries and nonlinearities, flexibility of integrating order is important (see for more details Hoang et al. 2016). This approach solves the problem of multicollinearity with the help of appropriate lag length selection of the variables (Shin et al. 2014). The empirical equation of production function is modelled in equation-3 following NARDL framework introduced by Shin et al. (2014):

$$\begin{aligned}\Delta Y_t &= \alpha_0 + \rho Y_{t-1} + \theta_1^{+} E_{t-1}^{+} + \theta_2^{-} E_{t-1}^{-} + \theta_3^{+} O_{t-1}^{+} + \theta_4^{-} O_{t-1}^{-} + \theta_5^{+} K_{t-1}^{+} + \theta_6^{-} K_{t-1}^{-} + +\theta_7^{+} L_{t-1}^{+} + \theta_8^{-} L_{t-1}^{-} \\ &+ \sum_{i=1}^{p} \alpha_1 \Delta Y_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta E_{t-i}^{+} + \sum_{i=0}^{q} \alpha_3 \Delta E_{t-i}^{-} + \sum_{i=0}^{q} \alpha_4 \Delta O_{t-i}^{+} + \sum_{i=0}^{q} \alpha_5 \Delta O_{t-i}^{-} + \sum_{i=0}^{q} \alpha_6 \Delta K_{t-i}^{+} + \sum_{i=0}^{q} \alpha_7 \Delta K_{t-i}^{-} \\ &+ \sum_{i=0}^{q} \alpha_7 \Delta L_{t-i}^{+} + \sum_{i=0}^{q} \alpha_8 \Delta L_{t-i}^{-} + D_t + \mu_t\end{aligned} \tag{3}$$

where, α_i indicates the short-run estimates in equation-3 and long-run estimates are shown by θ_i with $i = 1...8$. This shows that short-run analysis intends to examine the immediate impacts of exogenous variables changes i.e. energy consumption, oil prices, capital and labour on dependent variable i.e. economic growth. On contrary, time reaction and speed of adjustment towards long-run equilibrium level is measured by long run analysis. The Wald test is applied in order to test the presence of asymmetries in long-run ($\theta = \theta^{+} = \theta^{-}$) and short-run ($\alpha = \alpha^{+} = \alpha^{-}$) as well for all the variables i.e. energy consumption, oil prices, capital and labour. Y_t is economic growth, E_t indicates energy consumption, O_t is oil prices, K_t shows capital and L_t is labour. We also incorporate D_t is a dummy variable, captures the effect of structural break is determined by Kim and Perron (2009) unit root test. p and q is used to show the optimal lag length not only for dependent variable (Y_t) but also for independent variables (E_t, O_t, K_t, L_t) employing the Akaike information criterion (AIC) due to its superior explanatory properties. The explanatory variables are decomposed into positive and negative partial sums as follows:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max\left(\Delta x_j, 0\right) \quad x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min\left(\Delta x_j, 0\right),$$

with x_t indicates E_t, O_t, K_t and L_t.

We follow bounds test i.e. joint test of all the lagged levels of regressor proposed by Shin et al. (2014) in order to examine the presence of long run cointegration while accommodating asymmetries. We use two test(s): t-statistic developed by Banerjee et al. (1998) and F-statistic originated by Pesaran et al. (2001). Using t-statistic, we follow the null hypothesis: $\theta = 0$ against alternate hypothesis: $\theta < 0$. F-statistic follows the null hypothesis: $\theta^+ = \theta^- = \theta = 0$. The rejection of null hypothesis of no cointegration indicates the presence of long-run relationship between economic growth and its determinants, and vice versa. Asymmetric estimates for long run are estimated following $L_{mi^+} = \theta^+ / \rho$ and $L_{mi^-} = \theta^- / \rho$. These estimates for long run, with respect to positive and negative shocks in energy consumption, oil prices, capital and labour, quantifies the association between the variables for long run equilibrium. The asymmetric dynamic multiplier effects are measured by following equations as given below:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial E_t^+}, m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial E_t^-}, \; m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial O_t^+}, \; m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial O_t^-}, \; m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial K_t^+}, \; m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial K_t^-}$$

$$m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial L_t^+}, \; m_h^- = \sum_{j=0}^{h} \frac{\partial Y_{t+j}}{\partial L_t^-} \text{ for } h = 0, 1, 2 \ldots..$$

where, if $h \to \infty$, then $m_h^+ \to L_{mi^+}$ and $m_h^- \to L_{mi^-}$.

The asymmetric response of economic growth to positive and negative shocks in energy consumption, oil prices, capital and labour are shown by dynamic multipliers. These multipliers estimates show the dynamic adjustments from the initial to new equilibrium between the variables in system following a variation affecting the system.

IV. Results Interpretations

Table-2 reports descriptive statistics and pair-wise correlation. The empirical evidence indicates that volatility in oil prices is more than economic growth volatility. Energy consumption is less volatile than volatility in capitalization and labor has less volatility compared to oil prices, economic growth, energy consumption and capitalization. The Jarque-Bera test is also applied to test whether the variables have normal distribution or not. The results are reported in Table-2 and we find that null hypothesis of normal distribution is rejected. This implies that distribution of all the variables is not independent and identical. We consider the distribution symmetric if distribution of data provides a bell shaped curve. The results provided by Skewness and Kurtosis show the presence of potential asymmetry in the distribution of time series data. This leads us for apply the asymmetric autoregressive distributive lag-modelling (NARDL) for empirical analysis rather than symmetric autoregressive distributive lag-modelling (ARDL). The NARDL approach to cointegration is helpful in solving the issue of non-normality by capturing the presence of asymmetries stemming in time series data (Shin et al. 2014). The pair-wise correlation analysis reveals the positive correlation between energy consumption and economic growth. Oil prices are inversely correlation with economic growth. A positive correlation exists between capital (labor) and economic growth. Oil prices, capital and labor are positive correlated with energy consumption. A positive correlation occurs of capital and labor with oil prices but labor is negatively correlated with capital.

Table-1: Descriptive Statistics and Pair-wise Correlation

Variable	$\ln Y_t$	$\ln E_t$	$\ln O_t$	$\ln K_t$	$\ln L_t$
Mean	9.3133	4.6898	2.4793	7.4505	2.6414
Median	9.2623	4.7083	2.2656	7.4203	2.6186
Maximum	9.6063	4.8496	3.3973	7.7528	2.7657
Minimum	9.0066	4.4389	1.4755	7.1917	2.5751
Std. Dev.	0.1734	0.1098	0.5619	0.1378	0.0642
Skewness	0.1042	-0.6773	0.2888	0.5815	0.5065
Kurtosis	1.8072	2.4611	1.6564	2.7340	1.7390
Jarque-Bera	7.8186	11.3371	11.4077	7.5935	13.9529
Probability	0.0200	0.0034	0.0033	0.0224	0.0009
$\ln Y_t$	1.0000				
$\ln E_t$	0.4492	1.0000			
$\ln O_t$	-0.1244	0.2588	1.0000		
$\ln K_t$	0.4863	0.2106	0.2729	1.0000	

$\ln L_t$	0.0069	0.2307	0.2609	-0.1085	1.0000

Traditional unit root test such as DF (Dickey and Fuller, 1979), ADF (Dickey and Fuller, 1981), PP (Philips and Perron, 1988), KPSS (Kwiatkowski et al. 1992), ADF-GLS (Elliott et al. 1996) and N-P (Ng-Perron, 2001) may provide ambiguous empirical results. These unit root tests may accept null hypothesis when it is false and vice versa due to their weak explanatory properties. Furthermore, these unit root test ignore the importance of structural breaks occurring in time series data. The presence of structural breaks in the series may intend traditional unit root tests to provide vague empirical results and may cause a problem of unit root in the time series. This issue is solved by applying ZA unit root test (Zivot-Andrews, 1992). This test provides superior empirical results containing information about unknown single structural break occurring in the series. The results are reported in Table-3. We find that economic growth, energy consumption, oil prices, capital and labor have unit root problem in the presence of structural breaks. These breaks are related to economic policies implemented into energy market to sustain long-run economic growth. For example, in 1991, government of Pakistan, initiated economic reforms by introducing a reaching package for expediting economic growth by using free market mechanism. The central point of these reforms was disinvestment in public enterprises, deregulations as well as denationalization. These reforms encouraged private sector which affected total factor productivity and hence economic growth (Looney, 1992). After 1st differencing, all the variables have found stationary. This leads us to conclude that economic growth, electricity consumption, oil prices, capital and labor are integrated at I(1).

Table-3: Unit Root Analysis

Variable	Z-A Unit Root Test		K-P Unit Root Test		
	T-statistic	Time Break	T-statistic	Prob.	Time Break
$\ln Y_t$	-3.247 (1)	$1991Q_{IV}$	-3.4779 (1)	0.3993	$2003Q_{I}$
$\ln E_t$	-4.025 (2)	$2007Q_{II}$	-3.0811 (3)	0.6391	$1991Q_{I}$
$\ln O_t$	-4.283 (1)	$1998Q_{I}$	-3.5585 (1)	0.3546	$2003Q_{I}$
$\ln K_t$	-3.368 (2)	$2008Q_{III}$	-2.6083 (2)	0.8660	$1991Q_{I}$
$\ln L_t$	-2.373 (1)	$2006Q_{II}$	-2.1683 (2)	0.8686	$2013Q_{I}$
$\Delta \ln Y_t$	-5.430 (2) **	$1993Q_{III}$	-5.7470 (2) *	0.0001	$1992Q_{II}$
$\Delta \ln E_t$	-7.041 (2) *	$2007Q_{IV}$	-6.9013 (3) *	0.0000	$2008Q_{I}$
$\Delta \ln O_t$	-7.963 (1)*	$2005Q_{III}$	-6.8085 (1) *	0.0000	$1998Q_{I}$

$\Delta \ln K_t$	-6.093 (2)*	2006Q_I	-6.4395 (2) *	0.0000	2005Q_I
$\Delta \ln L_t$	-4.568 (2) **	2001Q_{II}	-6.9575 (2) *	0.0000	2005Q_{II}
Note: * and ** show significance at 1% and 5% levels of significance respectively.					

For testing whether non-linearity is present in the variables or not, we apply BDS test developed by Brock et al. (1988). Table-4 shows the results of the BDS test and we fine that the null hypothesis of i.i.d (independently and identically distributed) has been rejected. It implies the non-normal distribution of data which shows the presence of nonlinearity. We may note that all the variables have nonlinear behavior. The presence of nonlinearity in the variables makes unit root analysis ambiguous. This issue is solved by applying non-linear unit root tests developed by Bierens, (1997) and Breitung (2000) unit root tests. The results are reported in Table-5 and we find that all the variables are found non-stationary in the presence of non-linearity confirmed by Bierens, (1997). Similarly, the results of Breitung (2000) unit root test corroborated that all the variables have unit root problem at level in the presence of nonlinearity. This confirms that all the variables are integrated at I(1) in the absence and presence of nonlinearity.

Table-4: BDS Test for Non-Linearity

Dimension	BDS Statistic	Std. Error	Z-Statistic	Prob.
$\ln Y_t$				
2	0.2003	0.0039	51.2741	0.0000
3	0.3379	0.0062	54.4014	0.0000
4	0.4332	0.0073	58.5949	0.0000
5	0.5002	0.0077	64.9521	0.0000
6	0.5477	0.0074	73.812	0.0000
$\ln E_t$				
2	0.2048	0.0055	37.1813	0.0000
3	0.3482	0.0087	39.6414	0.0000
4	0.4482	0.0104	42.7088	0.0000
5	0.5173	0.0109	47.1505	0.0000
6	0.5647	0.0106	53.2128	0.0000
$\ln O_t$				
2	0.1829	0.0042	42.6033	0.0000
3	0.3025	0.0067	44.6288	0.0000
4	0.3800	0.0080	47.4339	0.0000
5	0.4295	0.0082	51.8140	0.0000
6	0.4655	0.0079	58.6840	0.0000

$\ln K_t$				
2	0.1817	0.0067	26.8869	0.0000
3	0.3026	0.0107	28.0414	0.0000
4	0.3812	0.0129	29.5359	0.0000
5	0.4302	0.0135	31.8459	0.0000
6	0.4574	0.0130	34.9531	0.0000
$\ln L_t$				
2	0.2020	0.0047	42.8200	0.0000
3	0.3400	0.0074	45.4885	0.0000
4	0.4353	0.0088	49.0898	0.0000
5	0.5018	0.0092	54.5111	0.0000
6	0.5487	0.0088	62.0642	0.0000

Table-5: Nonlinear Unit Root Analysis

Variables	Bierens Unit Root Test		Breitung Unit Root Test	
	T-Statistic	Prob. Value	T-Statistic	Prob. Value
$\ln Y_t$	-2.2508	0.4940	0.0081	0.9684
$\ln E_t$	-1.4527	0.9080	0.0175	0.9970
$\ln O_t$	-3.6630	0.1290	0.0165	0.9429
$\ln K_t$	-2.0808	0.6120	0.0073	0.1920
$\ln L_t$	-3.4330	0.2260	0.0076	0.1911

The presence of nonlinearity intends us for applying the nonlinear (asymmetric) ARDL approach developed by Shin et al. (2014) as all the variables have nonlinear behavior. In doing so, the general to specific approach is applied following Greenwood-Nimmo et al. (2013). The lag length for appropriate model is chosen based on Akiake Information Criterion (AIC). The appropriate lag length helps in providing accurate estimation and dynamic multipliers (Katrakilidis and Trachanas, 2012). The results of NARDL approach are reported in Table-6. We find that energy consumption, oil prices, capital and labor elucidate economic growth by 76.58% (R^2 = 0.7658). This shows that contribution of energy consumption, oil prices, capital and labor is by 76.58% and rest (23.42%) is explained by error term in production function. The absence of autocorrelation in empirical model is confirmed by The Durbin Watson (DW) test statistic which is 2.2000. This implies that considered variables i.e. energy consumption, oil prices, capital and labor in production function explain economic growth without autocorrelation. Additionally, we find that empirical model has normal distribution. There is no problem of serial correlation and white heteroscedasticity. There is absence of auto-regressive conditional and functional form of empirical is well constructed. This shows the reliability and consistency of empirical model in NARDL framework.

In ARDL framework, empirical results confirm that calculated F_{PSS} statistic is statistically significant at 1% level of significance which indicates that upper critical bounds is less calculated F_{PSS} statistic. This confirms the existence of cointegration between energy consumption, oil prices, capital, labour and economic growth for the period of $1985Q_1$–$2015Q_4$. The presence of asymmetry in long-run and short-run is investigated by applying Wald test. The account of nonlinearity and asymmetry is very important to be considered while estimating production function while studying association between energy consumption, oil prices, capital, labour and economic growth. The t-statistic of T_{BDM} originated by Banerjee et al. (1998) also corroborates the presence of cointegration between the variables at 1% level of significance. We apply NARDL F-statistic (F_{PSS}) developed by Shin et al. (2014) and find that energy consumption, oil prices, capital, labour and economic growth have long-run asymmetric cointegration in case of Pakistan. It implies that how much asymmetries and nonlinearities are important while investigating the production function by considering energy consumption and oil prices are additional determinants.

Long-run and short-run asymmetric impact of energy consumption, oil prices, capital and labour on economic growth is reported in Table-6. We find that positive shock exist in energy consumption has positive and significant impact on economic growth. A negative shock in energy consumption declines economic growth insignificantly. It implies that an increase in energy consumption is playing its role in stimulating economic growth. We may conclude that energy consumption has positive effect on economic growth. This empirical evidence is consistent with existing studies such as Zaman et al. (2011), Ahmed et al. (2013), Ahmed et al. (2015), Shahbaz et al. (2016) who also report that energy consumption enhances domestic production and hence stimulates economic growth. Positive shock in oil prices declines economic growth but negative shock in oil prices increase economic growth. This shows that rise in oil prices decreases economic growth and the impact of positive and negative shock on economic shocks is according to our expectations. Rise in oil prices affects economic growth directly and indirectly. Directly, oil prices rise transmits to cost of production which decreases firms' investment activities and hence domestic production is declined. Indirectly, oil prices rise affects exchange rate and inflation as well which in resulting, affects economic activity and hence economic growth (Shahbaz et al. 2017a). This empirical evidence is consistent with existing studies in energy economics literature such as Jimnez-Rodrguez and Snchez (2005) and Ali (2016) for OECD countries, Farzanegan and Markwardt (2009), Behmiri and Mnaso (2013) for Sub-Saharan countries, Ftiti et al. (2016) who conclude that oil prices rise adversely affects economic growth.

Economic growth is positively affected by positive shock stems in capital and negative shock in capital has negative effect on economic growth. This shows that positive shock stems in capital stimulates fiscal investment in infrastructure development for long-run. This increases domestic production and hence, long-run sustainable economic growth. On contrary, negative shock occurring in capital declines economic growth by lowering domestic production. Overall, capital is positively linked with economic growth. Similarly, existing studies in literature such as Mehta (2009), Sahoo and Dash (2009) for India and Sahoo et al. (2010) for China and Shahbaz et al. (2017b) for India also report that capital plays its significant role in stimulating economic activity which speeds up economic growth. The asymmetric relationship between labour and economic growth is interesting and statistically significant. Economic growth is positively and negatively affected by positive and negative shocks stem in labour. The estimates of labour for positive and negative on economic growth are 0.3128 and -1.8712 respectively. It implies that rise in labour force contributes to economic growth significantly by increasing consumption and investment activities. Pakistan's young population is almost 60% which shows the economic dependence of Pakistan's economy on young population. In such circumstances, any adverse shock in labour force will not only decrease domestic production but also dismantle economic growth. These empirical findings are consistent with Shahbaz et al. (2017) but contrary with Ismail et al. (2015) for India and Malaysia respectively.

In short run analysis (Table-6), we find that positive shock stems in energy consumption has positive and significant impact on economic growth (coefficient is 0.4925). A lagged differenced positive shock stems in energy consumption harms economic growth by 0.2554 and it is statistically significant at 1% level. Differenced positive shock in oil prices has negative impact on economic growth but statistically significant at 1% level. Economic growth is positive affected by lagged differenced positive shock in oil prices at 1% level of significance. Economic growth is positively stimulated by differenced positive shock in capital. A positive shock in capital contributes to economic growth by 0.1455% but lagged differenced positive shock in capital declines economic growth by 0.0916. These results are statistically significant at 1% level respectively. Differenced and lagged differenced positive shock stem in labour have negative and statistically significant effect on economic growth. This shows that in short run, rise in labour force will not contribute in economic growth due to mismatch between supply and demand for labour but it adjusts in long run. The reliability of empirical findings is confirmed by applying CUSUM and CUSUMsq. The CUSUM and CUSUMsq are lying between critical bounds at 5% level which shows that empirical results are reliable and consistent (see Figure-1).

Table-6: NARDL Empirical Analysis

Variables	**Coefficient**	**Std. Error**	**T-Statistic**
Constant	2.3482*	(0.4112)	[5.7104]
$\ln Y_{t-1}$	-0.2603*	(0.0456)	[-5.7119]
$\ln E^{+}_{t-1}$	0.1675*	(0.0354)	[4.7314]
$\ln E^{-}_{t-1}$	-0.0643	(0.0552)	[-1.1654]
$\ln O^{+}_{t-1}$	-0.0167*	(0.0041)	[-4.1095]
$\ln O^{-}_{t-1}$	0.0097**	(0.0038)	[2.5275]
$\ln K^{+}_{t-1}$	0.0559*	(0.0150)	[3.7362]
$\ln K^{-}_{t-1}$	-0.0301*	(0.0086)	[-3.5250]
$\ln L^{+}_{t-1}$	0.3128*	(0.0834)	[3.7519]
$\ln L^{-}_{t-1}$	-1.8712*	(0.4717)	[-3.9672]
$\Delta \ln Y_{t-1}$	0.5481*	(0.0770)	[7.1185]
$\Delta \ln E^{+}_{t-1}$	0.4925*	(0.0866)	[5.6859]
$\Delta \ln K^{+}_{t}$	0.1445*	(0.0230)	[6.2888]
$\Delta \ln O^{+}_{t}$	-0.0404*	(0.0079)	[-5.1069]
$\Delta \ln L^{+}_{t-1}$	-18.4892*	(3.6589)	[-5.0532]
$\Delta \ln Y_{t-1}$	0.2120*	(0.0753)	[2.8141]
$\Delta \ln L^{+}_{t-1}$	12.5604*	(3.9859)	[3.1512]
$\Delta \ln K^{+}_{t-1}$	-0.0916*	(0.0262)	[-3.4999]
$\Delta \ln E^{+}_{t-1}$	-0.2554*	(0.0875)	[-2.9190]
$\Delta \ln O^{+}_{t-1}$	0.0240*	(0.0085)	[2.8241]

Long-run Results and Diagnostic Analysis			
$L^{+}_{\ln E}$	0.6436*	(0.0753)	
$L^{-}_{\ln E}$	-0.2470	(0.2104)	
$W_{L_{\ln E}}$	15.8205*	(0.2239)	
$L^{+}_{\ln O}$	-0.0642*	(0.0100)	
$L^{-}_{\ln O}$	0.0373*	(0.0124)	
$W_{L_{\ln O}}$	39.7908*	(0.0161)	
$L^{+}_{\ln K}$	0.2147*	(0.0385)	
$L^{-}_{\ln K}$	-0.1158*	(0.0251)	
$W_{L_{\ln K}}$	45.0498*	(0.0493)	
$L^{+}_{\ln L}$	1.2015*	(0.2321)	
$L^{-}_{\ln L}$	-7.1881*	(1.2515)	
$W_{L_{\ln L}}$	36.3336*	(1.3919)	
R^2	0.7658		
χ^2_{Norm}	2.5179		
χ^2_{SC}	1.2914		
χ^2_{HET}	0.3758		
χ^2_{ARCH}	0.3760		
χ^2_{FF}	1.9139		
$\boldsymbol{t_{BDM}}$ T_{BDM}	-5.7119*		
$F_{PSS-Nonlinear}$	4.2956*		
AIC	-8.7310		
SIC	-8.2785		
Hannan-Quinn	-8.5472		

Note: 99% upper (lower) bound with k = 4 is 5.06 (3.74). 95% upper (lower) bound with k = 6 is 4.43 (3.15). The superscript "+" and "-" denote positive and negative cumulative sums, respectively. L^{+} and L^{-} are the estimated long-run coefficients associated with positive and negative changes, respectively, defined by $\hat{\beta} = -\hat{\theta}/\hat{\rho}$. W_{LR} represents the Wald test for the null of long-run symmetry for respective variable. χ^2_{SC}, χ^2_{FF}, χ^2_{HET}, and χ^2_{NORM} denote LM tests for serial correlation, normality, functional form and Heteroscedasticity, respectively. S.E stands for standard errors. * and ** indicate significance at 1% and 5% levels, respectively.

Figure-1: Stability Diagnostics

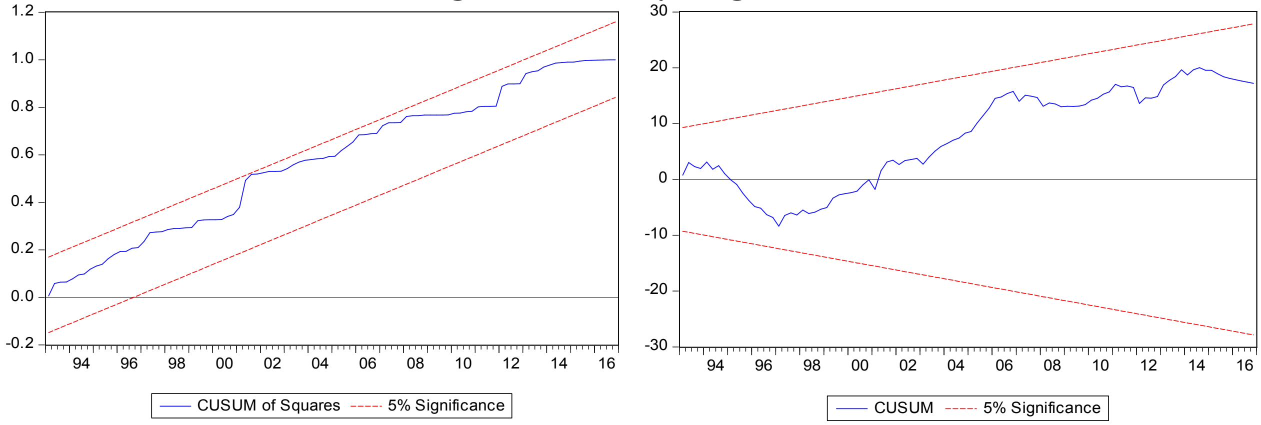
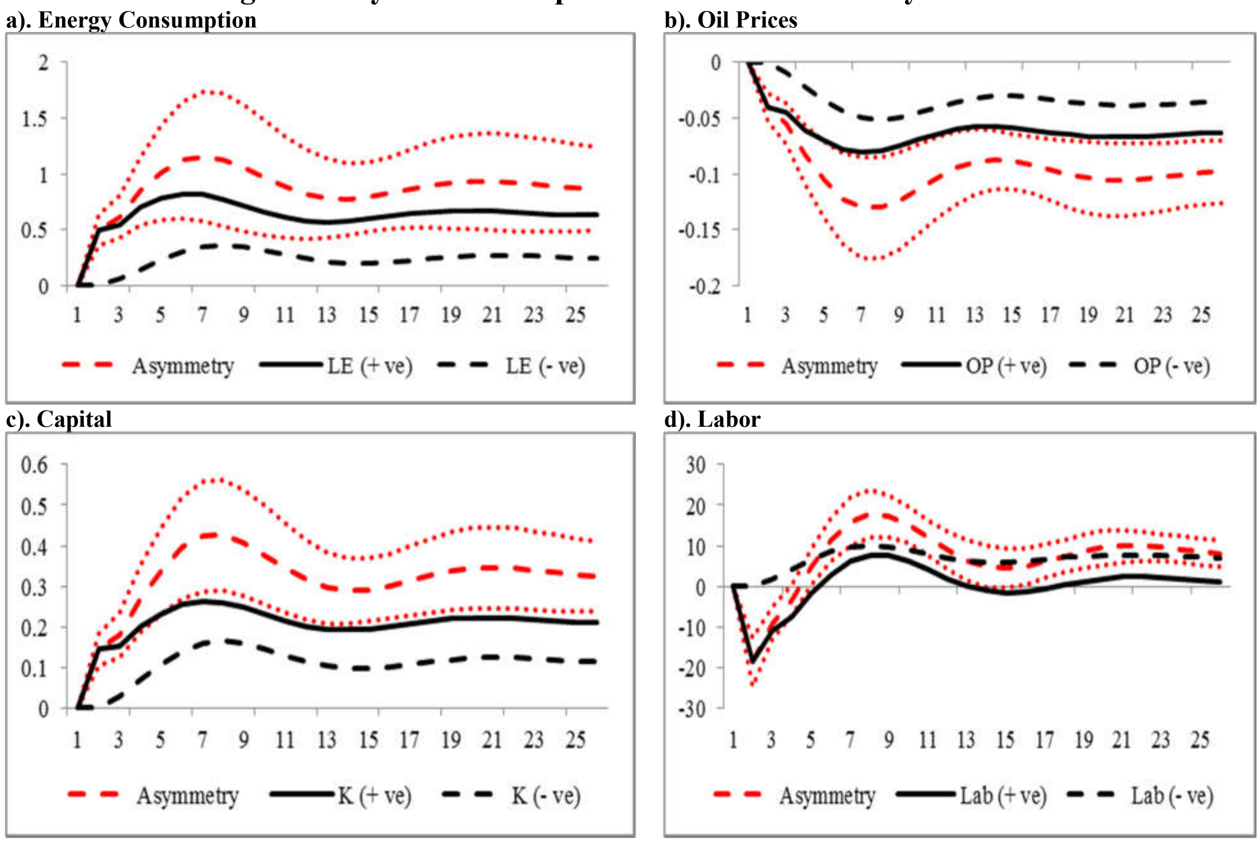


Figure-2: Dynamic Multipliers with LR and SR Asymmetries



Note: Black (dotted) line show positive (negative) impact while red lines show asymmetry and confidence (upper and lower) bands.

We apply multiple dynamic adjustments and results are shown in the plots the cumulative dynamic multipliers (see Figure-2). We find that these results indicate the pattern of adjustment in production function in its new long-run equilibrium due positive and negative shocks stem in energy consumption, oil prices, capital and labour force respectively. The basis of dynamic multipliers for empirical estimation is the best fitted NARDL fooling Akiake information criterion (AIC). The continuous black line and dashed black line shows positive and negative capturing the adjustments of production function to positive and negative shocks in independent variables at given forecast horizons. The continuous red line (asymmetric curve) indicates the difference between the dynamic multipliers linked with positive and negative shocks i.e. $m_h^+ - m_h^-$. The dotted red lines (lower and upper bands) at a 95% confidence interval indicates the statistical significance at 95% confidence interval of asymmetry at any horizon *h*. The results are reported in Figure-2. We find that energy consumption (overall) contributes to economic growth via stimulating economic activity and increasing domestic production. From initial point, impact of positive shock stems in energy consumption has dominant effect on economic growth compared to negative shock in energy consumption. On similar lines, asymmetric response to shocks in energy consumption is statistically significant. The linkages between oil prices and economic growth is negative. This indicates that positive shock in oil prices dominantly dismantle economic growth by lowering economic activity although, negative shocks in oil prices increases economic growth but in less magnitude. Oil prices rise retards economic growth as role of positive stems in oil prices dominates that of negative shocks in oil prices on economic growth for long-run (-0.0167 vs 0.0097, Table-6). Capital contributes economic growth significantly. It shows that positive shock in capital has dominating positive effect on economic growth compared to decline in economic growth due to negative shock in capital (0.0559 vs -0.0301, Table-6). Lastly, economic growth is positively and negatively affected by positive and negative shocks in labour but negative shock in labour has negative and dominant effect on economic growth that of positive shock in labour. This shows that due to decline in economic activity firms are ready to fire people which adversely affects domestic production and hence economic growth. In recovery period, firms are reluctant to hire people due to uncertain future. That's why positive shock in labour even contributes to economic growth but in less magnitude.

V. Conclusion and Policy Implications

The presence of four competing hypotheses on energy-growth nexus is always a key of interest and research for academician, practitioners and policy makers. These empirical findings are diverse due to use of different data for different countries, data sample and econometrical approaches. The issue is still under consideration for efficient empirical analysis to provide comprehensive policy implication to attain sustainable economic development by implementing appropriate energy policy. In doing so, we employed production function to examine relationship between energy consumption and economic growth by adding oil prices as additional factor affecting economic growth and energy consumption as well. The nonlinear unit root test is applied to confirm whether variables are integrated at I(0) or I(1). Considering the importance of asymmetries in time series data, we apply the nonlinear ARDL testing approach to test the asymmetric effect of energy consumption along with oil prices, capital and labour on economic growth in Pakistan. The empirical evidence confirms the presence of symmetric and asymmetric cointegration between energy consumption, oil prices, capital, labour and economic growth over the period of 1985Q_I-2016Q_{IV}. Furthermore, rise in energy consumption (positive shock) adds to economic growth via stimulating economic activity and energy consumption negative shock retards economic growth insignificantly. Rise (positive shock) and fall (negative shock) in oil prices decline and stimulate economic growth.

The positive shocks in energy consumption has substantial effect on domestic production and hence, on economic growth. This entails the importance of efficient use of existing energy sources for sustainable long-run economic growth. In such situation, exploring new energy sources is also an appropriate solution to stimulate economic activity. Any reduction in energy supply will decline domestic output confirmed by negative shock in energy consumption. This suggests government for maintaining a stable energy consumption rather to reduce energy supply. In doing so, government should encourage for the use of energy efficient and savings technologies not only in production activities but also in consumption activities by using proper electronic and print media campaigns. A negative relationship between oil prices and economic growth reveals the importance of using alternative sources of energy. Pakistan oil market is direly linked with international market which hits domestic oil prices if any shock in oil prices at international level. Pakistan is an oil dependent country and huge amount of foreign reserves is consumed to import oil for meeting domes energy demand. This directly hits to exchange rate and weaken local currency which increases local inflation. This entails the dire need to explore new energy sources such as oil which not only will save foreign reserves but also reduce dependence on imported oil. This amount of foreign reserves can be used to import energy-efficient and environment friendly technology to stimulate domestic production.

The positive and negative effect of positive and negative shock of capital on economic growth reveals the importance of capital for domestic production. This entails that capital plays a vital role in stimulating economic activity. This shows that government should pay more focus in establishing infrastructure development for achieving long-run sustainable economic growth. There is a dire need of understanding capital-growth nexus for policy makers and practitioners. A consistent improvement in capital will speed-up economy by raising economic growth and decline in capital improvement will retard economic growth confirmed by negative shock in capital. In such circumstances, government should focus to increase R & D expenditures improving quality of capital via conducting research for introducing energy efficient capital which not only enhances domestic production but also saves energy for future generations and of course, for sustainable economic growth. Finally, positive shock stems in labour leads economic growth. This shows that without labour sustainable economic growth in long run is impossible as negative shock in labour declines economic growth. Therefore, government should investment in labour force to attain long run economic growth by improving their technical efficiency via technical education. Agriculture sector absorbs major portion of labour force and adoption of technology in agriculture enhances its production much easier. In such situation, government should open technical level at town level to educate farmers i.e. related labour force for using energy-saving and growth-stimulating technology for agriculture production. This model can also be implemented in industrial sector after careful and comprehensive policy design. Improvements in technical education not only helps labour force to increase their productivity but also saves energy wastage and environment from degradation.

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