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Energy Crisis and Economic Growth: Empirical Investigation from Pakistan

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Abstract
In globalizing world, energy plays the role as a basic need for life sustenance and sustainable progress of developed as well as of developing economies. This study has adopted multivariate model using real GDP per capita as indicator of economic growth and the gap between energy demand and supply as measure of energy crisis with employed labor force, real gross capital formation and inflation rate for empirical analysis using annual time series data from 1971-2015 of Pakistan. In order to avoid spurious results, the TYDL approach is employed for causality inspection and the ARDL approach to examine cointegration and estimate results. Bounds cointegration test confirms the existence of long run relation in model and estimated results of ARDL method ensure the significant impact of energy crisis on real GDP per capita. Causality findings suggest the unidirectional causal flow from energy crisis towards real GDP per capita in the study model.
Keywords: Economic Growth, Energy Crisis, ARDL Cointegration approach, Pakistan
JEL Classification: C10, E10, Q43, Y10

I. Introduction

Energy plays the role of oxygen for the survival of economies due to its widespread use in every field. The strategic input of energy is a prerequisite to keep rolling the ball of economic progress. Energy fluctuations obstruct the economy's drive towards progress.

Energy crisis can be defined as a gap between energy demand (use) and energy supply (production). Its fluctuations impede the smooth drive of economic and social life at both micro and macro level. This crisis is the impetus behind the extensively emerging literature and investigation on energy economics. The leading economies of the world damaged badly from this crisis (particularly oil crisis) in 1970's. The developing economies of the world also felt the cold chills of fever of 1970s crisis in the developed economies. The second half of the 20th century is entitled the decades of economies' viral infection of energy.

The energy importing economy of Pakistan is suffering from energy crisis since its inception due to lingering sector of energy in inherited weak economy. The degree of after effects of energy tremors remained diverse as these were endurable in starting but these became brutal with the passage of time. Reported by its government, Pakistan economy has entangled in the trap of energy catastrophe in current century. In the 21st century, energy crisis can be considered as a monster for Pakistan economy that is implying multidimensional side effects. UNDP describes the role of energy such as "*None of the Millennium Development Goals can be met without major improvement in the quality and quantity of energy services in developing countries*".

Energy as a third basic input improves the productivity level and also boosts the efficiency of other factor such as labor and capital. In this way, energy has direct and indirect channels to affect the production, income and employment, investment level. In Pakistan, energy crisis has played its role to downgrade the investment activities and also lowered the efficiency of basal sectors such as capital intensive industrial sector and mechanized agriculture sector. Pakistan has also caught the chills of fever of the recessionary phase of international economies mainly due to oil (a major component of total energy supply) fluctuations. Fluctuations in international energy (oil) prices have exaggerated the balance of payment deficit and debt issue of energy importing economy. So, energy crisis has intertwined with the prevailing economic crisis as well as global financial crisis with increasing trend of globalization.

The rationale to conduct this study is twofold; the first is to investigate the causality nexus between energy crisis and macroeconomic performance considering the case of Pakistan. Secondly, to inspect that is there any long term impact of energy crisis on macroeconomic performance where it is assessed by per capita real GDP? The rest of the paper is organized as follows: Section II provides the brief overview of energy sector performance in Pakistan. Section III sheds light on the previous studies on energy economics to build base for further analysis. Data and variables description are portrayed in section IV. Section V explains the econometric methodology and empirical results have been reported in section VI. Finally, section VII concludes the study with some options for future research.

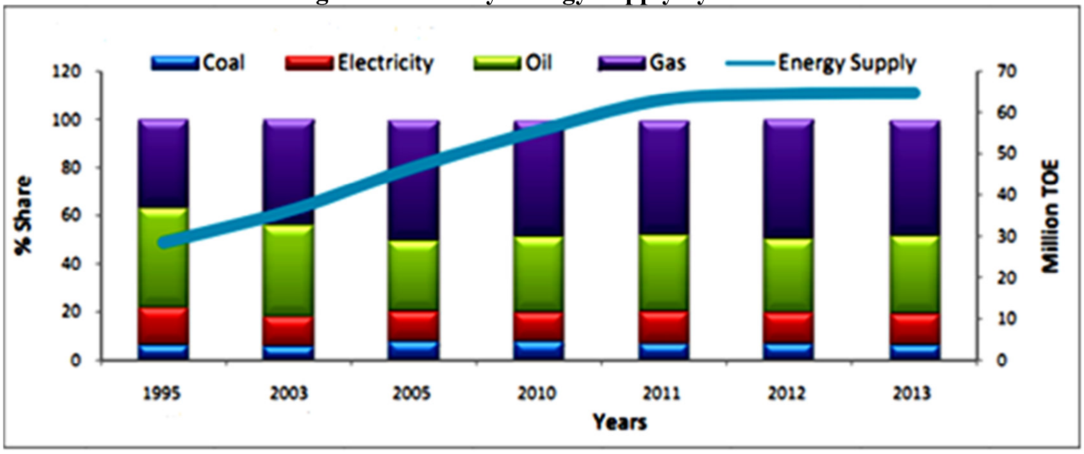
II. Overview of Energy Sector in Pakistan

The energy sector in Pakistan is governed by public sector and private sector (as Independent Power Producers in the power sector) in the operation of policies from generation to distribution policies. From 1995 to 2013, total energy supply increased by 4%. To check quality standards and tariff determination in energy sector OGRA and NEPRA act as monitoring authorities.

a. Energy Supply

Energy can be supplied through various sources. Sources of primary energy supply are mainly, coal, oil, gas and electricity. Figure 1 shows the trend of total energy supply and also the share of each source of energy in total supply of energy in Pakistan during 1995-2013.

Figure 1: Primary Energy Supply by Source



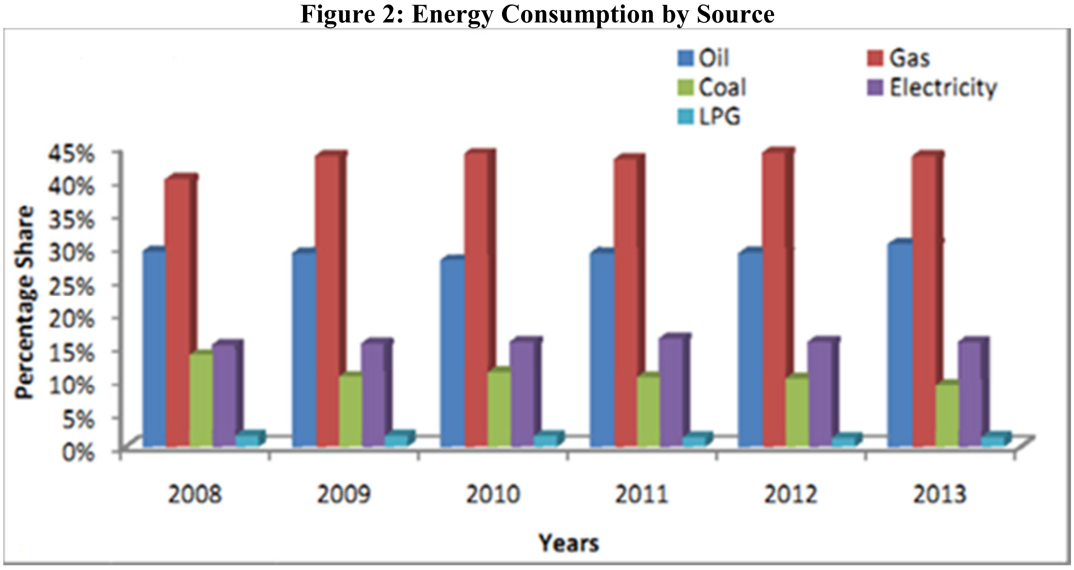
Source: Hydrocarbon Institute of Pakistan; (Pakistan Economic Survey 2013-14).

It can be seen that total energy supply increased from 28 million tonnes of oil equivalent (TOE) in 1995 to 64 million tonnes of oil equivalent (TOE) in 2013. The share of oil and gas in total energy supply underwent a large change as the share of oil declined from 41.6% in 1995 to 32.5% in 2013 while the share of gas increased from 36.8% in 1995 to 48.2% in 2013 due to high international oil prices.

b. Energy Consumption

In 2013 total energy consumption was 40185 million tonnes of oil equivalent (TOE). Consumption of gas stood at first and consumption of oil at second rank in total energy consumption in Pakistan. The share of gas remained around 43% to 45% in total energy consumption over time 1995 to 2013. Figure 2 breaks down the total energy consumption into different energy sources in Pakistan.

Figure 2: Energy Consumption by Source



Source: Hydrocarbon Development Institute of Pakistan, (Economic Survey of Pakistan 2013-2014).

It shows that the share of gas increased due to its increased use in power, transport sector and domestic sector. During last two decades, majority of domestic and commercial vehicles shifted to compressed natural gas (CNG) that resulted in the increased consumption of natural gas in transport sector. The shift from oil to gas consumption is mainly regarded to fluctuations in international and domestic prices of petroleum products.

c. Historical Background of Energy Sector in Pakistan

The performance of energy sector in Pakistan is depicted in table 1 that shows the ten year average values of all mentioned energy variables. The rate of increase in energy production in kilo TOE was greater during 1991-2000 due to openness of energy sector to private sector as IPPs in power sector. The rate of increase in energy consumption in kilo TOE was found greater in the last decade of 20th century and in the first decade of 21st century. One indicator of energy related to development is energy use per capita. This indicates that how much proportion of total energy (in terms of kilo gram of oil equivalent) is consumed by each person. This measure has gained a major shift in its rate from 1990 to 2000 due to more availability of energy by public and private sector as indicated by the figures in table 1.

Table 1: Historical Background of Energy Sector Performance in Pakistan

Time Period	Energy production (kilo TOE)	Energy use (kilo TOE)	Energy use per capita (kg of oil equivalent)	Energy Import (% of total Energy Use)
1971-1980	17353.14	20553.11	294.11	15.56
1981-1990	27600.35	34057.90	350.49	18.87
1991-2000	41295.05	54460.26	421.76	23.80
2001-2010	58693.55	76180.54	476.01	22.93

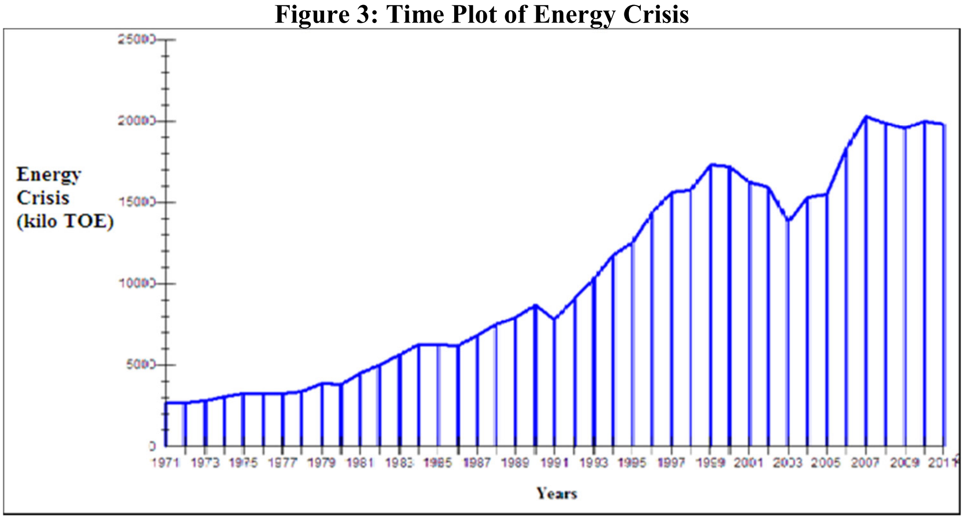
Source: Author's calculations based on the average of ten years' data from WDI.

d. Trend of Energy Crisis

Energy crisis can be defined as a gap between its demand and supply. In 1970s, developed economies suffered from energy crisis due to sky-rocketing prices of oil. Pakistan economy was infected by the energy crisis since inception but it survived the devastating effects of energy crisis of 70s. After 1970s, the Pakistani economy experienced rapid industrialization that resulted in increased consumption of energy. This increased demand was fulfilled through energy imports like oil. This increased the dependency of Pakistani economy on foreign economies.

Whereas, the energy reforms and introduction of IPPs increased the energy supply in 1990s. Energy supply and demand gap contracted in 2003-04 due to better performance of private sector in energy supply and contraction of energy use due to increasing oil prices.

Figure 3: Time Plot of Energy Crisis



Source: Author's plot using Microfit 4.1

Figure 3 shows that economy suffered from comparatively lesser shortfall of 13810.5 kilo TOE energy in 2003-04, but this crisis regained its position in 2007 and attained its peak level of 20308.6 kilo TOE. Circular debt remained a critical issue in recovery process of energy shortfall in 2009. Seeing this, energy sector received attention as a critical issue in political sphere. That's why measures were taken regarding energy conservation, its efficient use and energy availability (as gas pipelines from other economies) on political account and long term policy was introduced in 2013.

III. Literature Review

Since the late 1970s, extensive research has been conducted to investigate the energy-growth relation for single economies and for panel study of international economies. The analysis reveals the fact that there is no consensus on the energy-growth nexus due to sample country specific characteristics, sample time period for data, selected variables, econometric methodology etc. The plethora of previous studies can be categorized along three lines; the hypothesis criteria (Ozturk, 2010 and Apergis and Payne, 2009), the generation criteria (Guttormsen, 2004) and the modeling criteria (Esseghir and Khouni, 2014).

The hypothesis criteria follows the four lines of causal link between energy and growth; "feedback hypothesis", "conservation hypothesis", "energy-led growth hypothesis" and "neutrality hypothesis". Firstly, "feedback hypothesis" suggests the two way relation between energy consumption and economic growth which implies that economies are dependent on energy for growth and also great consumer of energy. Magazinno, 2014 found evidence of the "feedback hypothesis" between electricity demand and economic growth for Italy; Ahmad *et al*, 2014 for India; and Shahbaz, 2011 for Pakistan and Esseghir and Khouni, 2014; Shakeel *et al*., 2013 found the bidirectional relation by employing panel data. Secondly, evidence on the second strand of "energy-led growth hypothesis" is found in the studies of Adenuga and Ochu, 2013 for Nigeria; Bekhet and Othman, 2011 for Malaysia. In case of Pakisatn this hypothesis is supported by the work of Jebran, 2013; Afzal, 2012; Asghar and Rahat, 2011; Atif and Siddiqui, 2010; Siddiqui, 2004 and many other studies. Thirdly, under the "conservation hypothesis", the studies by He *et al*., 2012 in case of China (Shanghai city), Feridun and Shahbaz, 2011 in case of Pakistan; Udah 2011 in case of Nigeria supported the conservation policies due to one way causality from growth to energy. Finally, the "neutrality hypothesis" sets the logic of no causal link between energy and growth due to negligible role of energy in economic activity. Its evidence is found by Ozkan *et al*., 2012 between energy demand and growth in Turkey; Oderinde and Isola, 2011 between electricity consumption and output in Nigeria; Chiou-Wei *et al*., 2008 between energy consumption and GDP for USA and Thailand, Korea out of 8 Asian economies and Mushtaq *et al*., 2007 between gas consumption and growth in Pakistan.

The second strand, "the generation criteria", assorts the literature based on econometric methodology and it follows the four generations. The first generation undertakes the studies that assume data series to be stationarity and thus apply the standard granger causality test and the traditional VAR model (Sims, 1972). The studies that come under the second and the third generation line do not assume stationarity of data series and thus apply the cointegration approaches. The second generation studies verify the cointegration in bi-variate model and then estimate the error correction model by Engle and Granger (1987) to determine causality. The third generation studies overcome the flaws of second generation by conducting multivariate analysis where Johansen and Juselius (1989) is applied for cointegration and causality is determined by granger test proposed by Toda and Yamamoto. But the bounds test approach (Pesaran *et al*., 2001). Third generation also has serious flaws as it requires the all variables to be integrated of same order and does not allow any variable to be integrated of zero order. To overcome these limitations, the fourth generation criterion is proposed by Adom (2011). This generation line adopts the ARDL bounds to cointegration approach that is equally well applicable for small sample and data series that are integrated of different order. The 1st generation studies are Omojolaibi (2013) for Nigeria economy, Kraft and Kraft (1978) for USA. The 2nd generation methodology is employed by Ozkan *et al*. (2012), Nwosa and Akinbobola (2012), Bekhet and Othman (2011) for empirical investigation. While, Magazinno (2014), Jebran (2013), Adenuga and Ochu (2013), Razzaqi and Sherbaz (2011), Belke *et al*. (2010) and Adjaye (2000) adopted the 3rd generation multivariate cointegration approach. In the last, the 4th generation ARDL bounds test for cointegration is employed by Ahmad *et al*. (2014), Solarin and Shahabaz (2013), Mehrara and Musai (2012), Feridun and Shahbaz (2011) and Oderinde and Isola (2011).

The third strand, "the modeling criteria", categorizes the earlier studies into two groups on basis of functional form. The first group assents on the adoption of energy demand function such as the work of Adjaye (2000) and Javid and Qayyum (2014). In contrast, the second group assumes the augmented form of neo-classical production function where energy is treated as an input factor. The studies by Soytas and Sari (2003) and Paul and Bhattacharya (2004), Siddiqui (2004) and Shahbaz *et al*. (2012) undertake the production function form of second strand.

To support the brief literature review on energy economics, literature survey based studies are conducted by Ozturk (2010) and Omri (2014).

The review of prior studies elucidates the inconclusive nature of findings. These mixed outcomes arise from a lot of factors such as sample country specific characteristics, sample time period, selected variables, econometric methodology, aggregate and disaggregate analysis of energy and assumed different functional form of model. For Pakistan economy the review of prior empirical studies go in favor of accepting the energy-led growth hypothesis. Moreover, this review suggests for conducting research work for this economy with adoption of the latest econometric methodology of ARDL approach for cointegration and TYDL granger causality approach.

IV. Data and Construction of Variables

This study employed the augmented neo-classical production function by including variable of energy in its framework. It becomes as follows:

$$Y_t = A\, f(ELF_t, K_t, ENC_t, INF_t)$$

Where, (Y_t) denotes real gross domestic product per capita (GDP) that is used to assess economic growth. Here, employed labor force (ELF_t), real gross capital formation (K_t), energy crisis (ENC_t) and inflation rate (INF_t) is treated as explanatory variable. Core variable of study, the energy crisis has been calculated by taking the difference between energy demand (use) and its supply (production). Annual time series data is taken over time period from 1971 to 2015 according to its availability from World Bank Database (WDI) and Pakistan Economic Survey.

Detailed explanation and data sources of all variables of model are portrayed in table 2.

Table 2: Construction of Variables

Variables	Measurement Description and Data Source of Variables
Explained Variable	
Economic Growth (GDP)	Real GDP is the proportion of total output produced in economy by using domestic resources over a given time period evaluated at base year prices. Real GDP per capita, a measure of economic growth that is closely related to welfare, is obtained by dividing this total real GDP on total population. This is measured in Pakistani rupee. World Bank Database (WDI) is used to obtain data on this variable.
Explanatory Variables	
Employed Labor Force (ELF)	Employed labor force is the part of total labor force that is enjoying monetary benefits. It is measured in million individuals that are employed. Its data is obtained from various issues of Pakistan economic survey.
Real Gross Capital Formation (K)	Real gross capital formation is used as proxy of capital. It has been measured in million Pakistan rupees. Data for this measure is taken from World Bank Database (WDI).
Energy Crisis (ENC)	Energy crisis has been measured by the difference between energy demand (energy use) and supply (energy production). To get overall measure of energy it has been taken in terms of kilo tonnes of oil equivalent as its unit of measurement. The data on components of energy crisis like energy production and energy use has been taken from International Energy Agency (IEA).
Inflation Rate (INF)	The tariff and rate structure of energy is a major contributor to overall inflation (especially energy inflation). The annual rate of change in consumer price index (2005 as base year) has been used as measure of inflation. The data for inflation rate is taken from IMF (International Financial Statistics).

V. Econometric Methodology

Various econometric techniques have been presented in literature on causality such as standard Granger causality test, Graph theoretic approach and TYDL causality approach. Regarding cointegration and model estimation to find the significance and insignificance of the impact of regressors on regressand, Engle-Granger (1987), Johansen (1988), Johansen-Juselius (1989) and ARDL approach by Pesaran *et al.* (2001) have been adopted. Keeping in view the merits of TYDL causality approach and ARDL approach to cointegration, the present study has undertaken the empirical analysis using these modern approaches. Both selected approaches do not give too much weightage to the order of integration for all variables to be the same. These are equally well applicable to the model where all variables are integrated of mix order (as I (0) or I (1)) and provide unbiased and consistent estimates in small samples as well.

a.TYDL Approach

Under TYDL causality test (WALD statistic) VAR specification for multivariate model of the study is following

$$GDP_t = \alpha_1 + \sum_{i=1}^{k+d} \beta_1 \mathrm{GDP}_{t-i} + \sum_{i=1}^{k+d} \gamma_1 \mathrm{ENC}_{t-i} + \sum_{i=1}^{k+d} \theta_1 \mathrm{ELF}_{t-i} + \sum_{i=1}^{k+d} \delta_1 \mathrm{K}_{t-i} + \sum_{i=1}^{k+d} \varphi_1 \mathrm{INF}_{t-i} + \epsilon_t \qquad (1)$$

$$ENC_t = \alpha_2 + \sum_{i=1}^{k+d} \gamma_2 \mathrm{ENC}_{t-i} + \sum_{i=1}^{k+d} \beta_2 \mathrm{GDP}_{t-i} + \sum_{i=1}^{k+d} \theta_2 \mathrm{ELF}_{t-i} + \sum_{i=1}^{k+d} \delta_2 \mathrm{K}_{t-i} + \sum_{i=1}^{k+d} \varphi_2 \mathrm{INF}_{t-i} + \epsilon_t \qquad (2)$$

$$ELF_t = \alpha_3 + \sum_{i=1}^{k+d} \theta_3 ELF_{t-i} + \sum_{i=1}^{k+d} \beta_3 GDP_{t-i} + \sum_{i=1}^{k+d} \gamma_3 ENC_{t-i} + \sum_{i=1}^{k+d} \delta_3 K_{t-i} + \sum_{i=1}^{k+d} \varphi_3 INF_{t-i} + \epsilon_t \quad (3)$$

$$K_t = \alpha_4 + \sum_{i=1}^{k+d} \delta_4 K_{t-i} + \sum_{i=1}^{k+d} \beta_4 GDP_{t-i} + \sum_{i=1}^{k+d} \gamma_4 ENC_{t-i} + \sum_{i=1}^{k+d} \theta_4 ELF_{t-i} + \sum_{i=1}^{k+d} \varphi_4 INF_{t-i} + \epsilon_t \quad (4)$$

$$INF_t = \alpha_5 + \sum_{i=1}^{k+d} \varphi_5 INF_{t-i} + \sum_{i=1}^{k+d} \beta_5 GDP_{t-i} + \sum_{i=1}^{k+d} \gamma_5 ENC_{t-i} + \sum_{i=1}^{k+d} \theta_5 ELF_{t-i} + \sum_{i=1}^{k+d} \delta_5 K_{t-i} + \epsilon_t \quad (5)$$

Here, d_{max} is the maximum integration order of variables and k is the order of lagged coefficient. This $(k + d_{max})th$ VAR model is estimated to find out the WALD statistic value that follows chi-square distribution. The decision of causality is made with help of probability value of the computed statistic.

b.ARDL Model Specification

The general from of ECM considering the case of two variables X and Y is specified as

$$\Delta Y_t = \alpha + \sum_{i=1}^{n-1} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{m-1} \gamma_i \Delta X_{t-i} + \Omega Y_{t-1} + \delta X_{t-1} + u_t \quad (6)$$

Where Δ is difference operator, t shows the time, n lags for Y variable and m lags for X variable are used, β_i and γ_i are short term parameters and Ω and δ are long term parameters, u_t is white noise error term.

Thus on the basis of general form of ARDL estimation as in equation (1), UECM relating to the study model is specified as follows

$$\Delta(GDP)_t = \alpha + \beta_1 (GDP)_{t-1} + \beta_2 (ELF)_{t-1} + \beta_3 (K)_{t-1} + \beta_4 (ENC)_{t-1} + \beta_5 (INF)_{t-1} + \sum_{i=0}^{m} \delta_1 \Delta(GDP)_{t-1} + \sum_{i=0}^{n} \delta_2 \Delta(ELF)_{t-1} + \sum_{i=0}^{p} \delta_3 \Delta(K)_{t-1} + \sum_{i=0}^{q} \delta_4 \Delta(ENC)_{t-1} + \sum_{i=0}^{r} \delta_5 \Delta(INF)_{t-1} + u_t \quad (7)$$

Bounds Testing Procedure

Prior to the estimation of long run coefficients and error correction model, the checking of the existence of long run relation is mandatory. For this ordinary least square method is adopted to find out the WALD statistic under F distribution. The null and alternative hypotheses to inspect the joint significance of the parameters of lagged variables are as follows:

Ho: β1= β2= β3= β4= β5=0 (Cointegration does not exist.)
Ha: β1 ≠ β2 ≠ β3 ≠ β4 ≠ β5 ≠ 0 (Cointegration exists.)

The computed F-statistic value is compared with two critical values as lower bound and upper bound given by Pesaran *et al*. 2001. If the F-statistic is less than the lower bound critical value then we do not reject the null hypothesis. If the F-statistic lies between the limits of lower and upper bound then result remains inconclusive. If the F-statistic value is greater than the upper bound critical value then null hypothesis is rejected and it is concluded that cointegration exists.

Once cointegration (long run relation) is found then long run parameters are estimated by the following equation

$$GDP_t = \alpha + \sum_{i=0}^{m} \lambda_1 GDP_{t-i} + \sum_{i=0}^{n} \lambda_2 ELF_{t-i} + \sum_{i=0}^{p} \lambda_3 K_{t-i} + \sum_{i=0}^{q} \lambda_4 ENC_{t-i} + \sum_{i=0}^{r} \lambda_5 INF_{t-i} + u_t \quad (8)$$

The short run dynamic results are estimated by using the following equation

$$\Delta GDP_t = \alpha + \sum_{i=1}^{m} \theta_1 \Delta(\mathrm{GDP})_{t-i} + \sum_{i=0}^{n} \theta_2 \Delta(\mathrm{ELF})_{t-i} + \sum_{i=0}^{p} \theta_3 \Delta(\mathrm{K})_{t-i} + \sum_{i=0}^{q} \theta_4 \Delta(\mathrm{ENC})_{t-i} + \sum_{i=0}^{r} \theta_5 \Delta(\mathrm{INF})_{t-i} + \omega \mathrm{ECM}_{t-1} + u_t \quad (9)$$

Where (θ_i) represents the short run parameters of differenced terms and (ω) is the coefficient of error correction term that explains the adjustment speed from short run disequilibrium to long run equilibrium each year. The negative sign of (ω) with statistically significant probability assures the convergence in long run.

VI. Empirical Results

This section discusses the empirical outcomes of causality and cointegration approaches.

a. Unit Root Results

Phillips-Perron test has been employed to avoid spurious results in time series analysis. Table 3 reports the probability values under level and first difference and its last column concludes about the stationary behavior of series. It shows that per capita real GDP, employed labor force (ELF), energy crisis (ENC) and real gross capital formation (K) become stationary after taking first difference of series at 1% level of significance. That's why these are found to be integrated of order one. While inflation rate (INF) is found to be integrated of order zero due to significant probability at level.

Table 3: Unit Root Results

Variables	Phillips-Perron test				Decision
	Level		1st Difference		
	C	C & T	C	C & T	
Per Capita Real GDP (GDP)	0.99	-2.22	-4.52**	-4.56**	**I(1)**
Employed Labor Force (ELF)	1.50	-1.01	-4.72**	-5.04**	**I(1)**
Real Gross Capital Formation (K)	-0.33	-2.77	-4.72**	-4.62**	**I(1)**
Inflation rate (INF)	-3.39*	-3.48*	-7.86**	-6.83	**I(0)**
Energy Crisis (ENC)	0.27	-2.51	-5.59**	-5.59**	**I(1)**

Note: C indicates only intercept case and C & T denotes intercept and trend case. ** represents 01% significance level, * indicates 05% significance level.

Source: Author's Calculations using EViews 7.0

These findings suggest that the application of TYDL approach and ARDL approach would be appropriate for empirical analysis using above mentioned series due to mix order of integration.

b. Causality Results

We have observed the direction of causality by adopting Toda Yamamoto and Dolado Lütkepohl (TYDL) granger causality approach. In multivariate framework the causality is determined by employing WALD test based on VAR model / Block exogeneity. Table 4 reports the probability values of WALD test under chi-square distribution. The causality results suggest that there is one way causal link from energy crisis to per capita real GDP. This unidirectional causality is significant at both 5% and 10% levels of significance. This shows that deficiency in energy availability decelerate the pace of economic growth. This one way relation from energy variable towards per capita real GDP is also observed by Javid *et al.* (2013) using bivariate traditional granger causality test and by Asghar and Rahat (2011) through Graph Theoretic Approach.

Table 4: TYDL Causality Results

		Dependent Variable				
		GDP	**ENC**	**K**	**ELF**	**INF**
Independent Variable	**GDP**	-	0.03**	0.02**	0.157	0.749
	ENC	0.023**	-	0.01**	0.107	0.66
	K	0.06*	0.377	-	0.384	0.195
	ELF	0.146	0.269	0.023**	-	0.325
	INF	0.08*	0.516	0.957	0.26	-

Note:**, * indicates the significance at 5%, 10% level.

Source: Author's calculations using EViews 7.0

c. Bounds Test for Cointegration Results

We have used the Akaike Info Criterion (AIC) to find the optimal lags for variables in model. AIC has suggested maximum lag length 2 in the specified model. By running OLS on equation (7), we have found the F-statistic under WALD test to decide about the cointegration. Table 4 reports the results of WALD test F-statistic for specified model.

Table 5: F-statistic for Cointegration

F-Statistic (Probability)	Lag	Significance Level	Bounds Test Critical Values I(0)	I(1)	Decision
7.276 (0.000)	2	1%	4.40	5.72	Cointegration exists.
		5%	3.47	4.57	
		10%	3.03	4.06	

Note: k=4, (Pesaran *et al*., 2001, page: 301)

The calculated value of F-statistic 7.276 is found to be greater than the upper bound critical value at both 1% and 5% level of significance. So the null hypothesis of no cointegration is rejected and it is concluded that there exists a long run relation among variables of model.

d. Results of ARDL Estimated Model

After confirming the existence of cointegration, next step is to estimate the long run coefficients of the study model. Table 5 reports the long run estimated results of augmented neo-classical production function where per capita real GDP is dependent variable.

Table 6: Estimated Long Run Coefficients Using the ARDL Approach

ARDL (2, 1, 2, 1, 2) selected based on Akaike Information Criterion			
Dependent Variable is **GDP**			
Regressor	**Coefficient**	**Standard Error**	**T-Ratio [Probability]**
ELF	469.035	84.201	5.570 [0.000]
K	0.008	0.002	3.412 [0.002]
ENC	-0.672	0.185	-3.634 [0.001]
INF	-61.425	57.274	-1.073 [0.292]
C	11685.8	1247.2	9.369 [0.000]
T	513.514	142.918	3.593 [0.001]

Source: Author's calculations using Microfit 4.1

ELF, the first explanatory variable, has positive impact on per capita real GDP. It implies that increase in ELF is directly associated with (GDP). Increase in the employed workforce of Pakistan promotes its economic growth. The coefficient of the second variable real gross capital formation (K) is also positive and significant. Increase in the capital formation leads to economic growth through both direct and indirect channels. Enhancing the capital level opens the new investment opportunities and also makes employed labor more efficient. These channels of investment opportunities and efficient labor increase the income level of people and improve their living standard. So the significant impact of labor and capital is consistent with the outcomes of the standard neo-classical model about the role of labor and capital on GDP.

The core variable, energy crisis (ENC) implies negative effect on GDP. As suggested by the t-statistic and its probability value, this adverse impact of ENC on GDP is also highly significant. Due to its contribution as third basic input factor in production process, fluctuations in energy availability damage the smooth progress of economy. Its fluctuations render the physical capital less efficient and also lower the efficiency of labor as being an essential part of today's living standard. Inflation rate also affects GDP negatively but its insignificance suggests that its contribution to decline in GDP does not carry importance.

Table 6 reports the error correction term and the short run dynamic results using the unrestricted error correction model (UECM). The error correction term shows the speed of adjustment of variables towards long term equilibrium. Its sign is not only negative but also highly significant. Its significance validates the existence of long run relation as suggested by bounds test. The coefficient value -0.37 shows that approximately 37% of deviations from the long term equilibrium is corrected after each year.

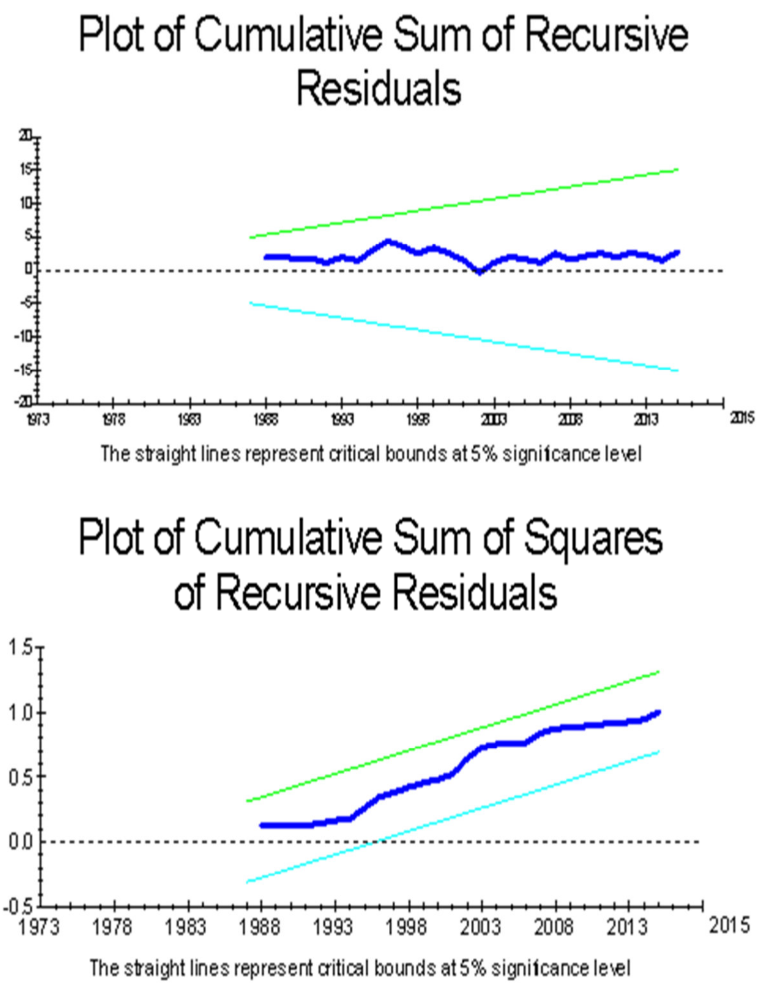
Table 7: Error Correction Representation of Model

ARDL (2, 1, 2, 1, 2) selected based on Akaike Information Criterion			
Dependent Variable is **dGDP**			
Regressor	**Coefficient**	**Standard Error**	**T-Ratio [Probability]**
dGDP1	-0.336	0.123	-2.725 [0.010]
dELF	-7.598	92.574	-0.820 [0.935]
dK	0.005	0.001	4.607 [0.000]
dK1	0.004	0.001	3.423 [0.002]
dENC	0.200	0.081	2.462 [0.019]
dINF	7.967	15.941	0.500 [0.621]
dINF1	45.714	14.925	3.062 [0.004]
dC	4362.3	1112.9	3.920 [0.000]
dT	191.693	57.103	3.357 [0.002]
ecm (-1)	-0.373	0.084	-4.437 [0.000]

Source: Author's estimations using Microfit 4.1

Finally, to check the model stability cumulative sum and cumulative sum of squares tests have been used. Figure 4 displays the CUSUM and CUSUMSQ plots within 95% confidence interval of the estimated model. As these plots lie within the bounds, so, this confirmed that the estimated coefficients of model are stable over time.

Figure 4: CUSUM and CUSUMSQ Plots



Source: Author's plot using Microfit 4.1

VII. Conclusion

The intent to conduct this study was to inquire that either energy crisis is a significant contributor to slow the economic progress in long term or not. For this purpose, multivariate augmented production function framework was used to determine the impact on macroeconomic performance. Multivariate model was used to explore the impact of energy crisis on macroeconomic performance by adopting augmented production function framework. The empirical analysis is conducted by employing the most efficient approaches such as ARDL cointegration approach and TYDL causality approach. The study undertakes the case of Pakistan economy covering time period from 1971 to 2015 according to data availability.

Toda Yamamoto and Dolado Lütkepohl (TYDL) causality test suggested the unidirectional causal link that flows from energy crisis towards per capita real GDP. The application of ARDL approach explored the fact that energy crisis renders significant adverse influence on real GDP per capita. Labor and capital exert significant positive influence but inflation rate implies insignificant negative influence on real GDP per capita. Moreover, any short term fluctuations move toward the long term equilibrium by 37% each year as suggested by the error correction term.

Therefore, from this empirical analysis, it is concluded that Pakistan economy suffered badly from the energy crisis. So, there is an ardent need to reform energy sector and introduce short term as well as long term policies on both aspects of energy demand and supply. It is because a sustainable energy future would lead to sustainable development path due to intertwined nature of energy in each sector of economy's life.

To the best of my knowledge, the present work is the first study that has analyzed empirically the impact of energy crisis (by aggregating all major sources of energy in terms of kilo tonnes of oil equivalent) on economic growth of Pakistan. This study has taken the gap between energy demand and supply as a measure of energy crisis. Although copious research has undertaken on energy economics nexus but mostly previous studies have focused on the examination of nexus of economic growth with just energy consumption or just its supply (in both aggregate and disaggregate aspects). So, this study pinpoints some areas to conduct further research for in-depth analysis. It is suggested that the sensitivity analysis of energy crisis with other indicators of macroeconomic performance can be undertaken. Empirical investigation can be conducted by disaggregating the energy like electricity crisis, oil crisis and gas crisis on economic growth and investment opportunities.

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