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# Energy consumption: The importance of institutional quality in Pakistan

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**Abstract**

*The energy sector of Pakistan has undergone several changes over the previous several years, due to the ever-increasing energy consumption. The objective of this study is to determine the extent to which the consumption of energy sources can be attributed to Pakistan's institutional quality, based on the perception of positive impact of institutional quality on facilitation of public goods. In this context, the demand functions of energy sources (electricity, natural gas and petroleum products) for four main economic sectors(i.e., residential, industry, commercial and agricultural sectors), have been examined by employing bound testing to cointegration (ARDL approach), over a period of 35 years (1984-2019). The analysis reveals that institutional quality has significant positive impact on energy consumption. The results of the study provide implications for energy sector reforms by illustrating the importance of institution-building policy efforts.*

**Keywords**
Energy demand; Energy prices; Demand elasticities
**JEL Classification**
C02, C31, C63

## 1 Introduction

Pakistan has experienced a rapid growth in consumption of primary energy over the last few decades. According to Pakistan Country Statistics (2018), the primary energy consumption has grown by 150% in the last twenty years. However, the supply has not increased in accordance to the rise in demand due to several constraints such as circular debt, increased reliance on oil/gas, decline in gas reserves, inadequate exploitation of coal reserves, underutilization of power generating units, hydel etc. The energy crisis has become an inevitable challenge due to inefficient resource management, lack of

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investment in the infrastructure and absence of a well-planned policy (Alahdad, Z., 2012). Successive energy policies have focused on the expansion and diversification of energy system through installation of new energy projects, yet the production capacity fails to fulfill the energy needs. The country still faces serious challenges to meet its energy needs (Siddiqui, 2004; Hye and Raiz, 2008). In order to ensure efficient use of energy the pricing policy has also undergone a number of changes. OGRA which conduct publics hearings and set prices for natural gas and petroleum products have capped the petroleum products prices in different periods (Afia Malik, 2008).

On the other hand, several reforms have been made in the power sector for improving bill collection and reducing the shortfall in the generation capacity. In the past decade, Pakistan spent more than 2 percent of its GDP on electricity subsidies, which not only increased national debt but also weakened the country's external position. In 2015-16 the electricity subsidies were 0.8% of the GDP (World Bank, 2017), which was the same as total expenditure on public health. In order to cover the cost of electricity production at least Rs.3 is paid by the government on every Kwh consumed by the domestic user (Awan, et. al, 2019). However, the government has increased electricity tariffs for the residential consumers and eliminated subsidies for commercial and industrial consumers in October 2013 (World Bank, 2016). Despite the pricing policy reforms the demand and supply gap has further widened due to the inefficient use and wastage of energy resources (Annual report of the State Bank, 2018).

In view of the current challenges, two important issues have been addressed in this study. Firstly, it analyzes why the energy pricing policy reforms have not been successful in increasing the efficient use of energy? In order to address this question, this study extends the existing literature by analyzing the demand functions of energy sources[1] of the four main economic groups (i.e., residential, industry, commercial and agricultural sectors). In this context, this study incorporates other potential variables (degree of industrialization, urbanization and institutional quality) in addition to the traditional economic variable (income and price). Pakistan was ranked among the most urbanized countries of South Asia with a rise of 47% in urban population growth in 2010 (ADB). This rise in urbanization has increased the transportation usage by 300% (Economic survey of Pakistan, 2012), which leads to more energy consumption. In addition to urbanization, institutional quality has also been analyzed as a key determinant of energy specifically electricity consumption. Previous studies suggest that institutional quality increase the consumption of energy, as they increase the provision of public goods (Pierre and Rothstein, 2011; Acemoglu and Robinson, 2006; Deacon et al., 2003 and Boix et al., 2003). Provision of public goods such as access to electricity and natural gas requires large scale transmission and distribution infrastructure and long term investment which is highly expensive (Abbott, 2001).

[1] Electricity, petroleum products and natural gas

In most countries electrification programs specifically rural electrification have been conducted through government funding and special national programmes (Zomers, 2003). Therefore, provision of energy goods (i.e. electricity and natural gas) to the population is completely politically driven and depends on the political and administrative system of a country. The government of Pakistan has also conducted several rural electrification and gas provision programs since 2007, under the power sector development programs to raise the socioeconomic standards of rural population. The village electrification and gas provision programs have always been an integral part of the government agenda in Pakistan (Economic Survey of Pakistan, 2020). Hence, including institutional quality as a determinant of energy consumption will provide useful insights to analyze the extent to which Pakistan's energy consumption is affected by its institutional quality. It will also assess whether the extensions of national grid system ensure the availability of electricity to the targeted population. However, previous studies on Pakistan's energy consumption have ignored this variable. In order to overcome this gap, the institutional quality index has been analyzed as a determinant of energy consumption which has been constructed by using data from International Country Risk Guide (ICRG). The index has been constructed by taking an average of Pakistan's government stability, investment profile, law and order, corruption, democratic accountability and Bureaucratic Quality.

However, in case of Pakistan very little analytical work has been done in this regard. Iqbal M. (1983) analyzed the residential price and income elasticities for electricity and gas for the period 1960 to 1981 using OLS. The income elasticity was positive for both the energy goods; however, the own price elasticity was found to be negative in case of gas. Later Siddiqui and Haq (1999) examined the demand function for gas, electricity and petroleum products for aggregate and disaggregate levels using OLS estimation technique. They concluded that in general energy consumption is income and price elastic. There are other studies which focus on only one energy item i.e. electricity which use causality test and co integration in order to analyze the relation of electricity consumption and growth of the economy. For example, according to Aqeel and Butt (2001), Siddique (2004) and Lee (2005), there is uni-directional causality from energy demand to GDP while, Jamil and Ahmed (2010) predicted the causality to be unidirectional from economic activity to electricity use. Khan, M. A., & Qayyum, A. (2009), analyzed the trend of electricity demand for the period 1970-2006. The income elasticity was found to be positive for all the groups while the price elasticity was negative. Similarly, Shahbaz, et al. (2012) analyzed how GDP and energy demand are related, using the period 1972-2011 and confirmed it to be positive. Nawaz, S., Iqbal, N., & Anwar, S. (2013) checked for the linear as well as nonlinear electricity demand function for the period of 1971-2012 by applying a model of logistic smooth transition regression. They proved that a long run relationship exists between electricity consumption, its prices and GDP per capita. They further concluded that the electricity consumption is basically influenced by development. The nonlinear estimates showed that the demand for electricity is insensitive to any price change beyond the threshold level. Later in 2014, Javid, M., & Qayyum, A. analyzed the relationship among electricity demand, its prices and real economic activity for aggregate as well as sectoral levels over the period of 1972-2010. The found that the nature of relationship among these variables was stochastic instead of linear and deterministic.

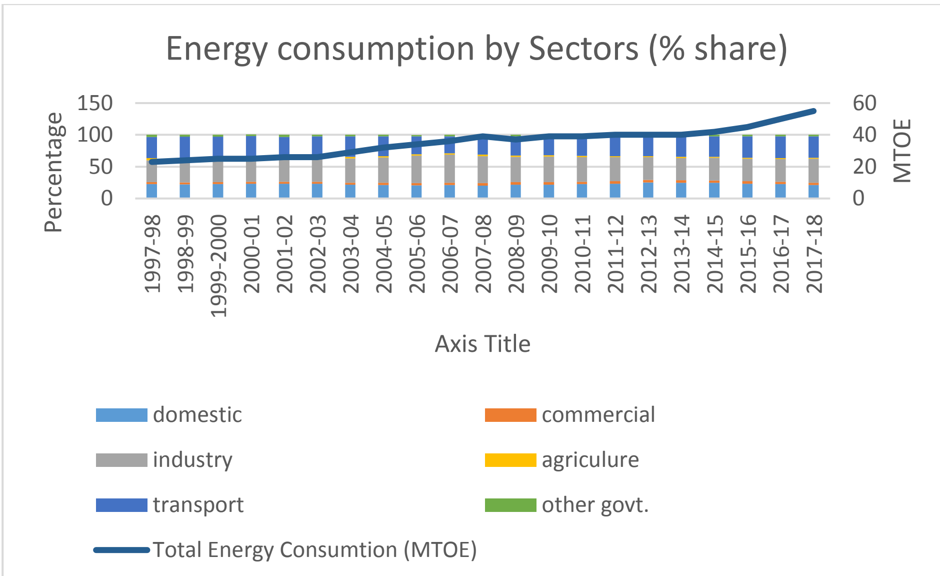
Recent study by Zaman and Khalid (2017), have analyzed the causal relationship of energy demand and agricultural technology. Their results shows that energy consumption and agricultural technology both have causal effect on each other. However, they have also analyzed the use of electricity ignoring other components of energy. The other energy sources like gas and petroleum products also contributes a considerable portion of the total energy demand so they should not be ignored. Moreover, in view of the depleting gas reserves, it has become necessary to analyze how the policy should be formulated. To examine the responsiveness of energy consumption to its determinants (energy prices, GDP, number of users etc.), this study has employed bound testing approach to cointegration (ARDL approach) developed by Pesaran et al. (2001) considering the non-stationarity of most of the variables. The ARDL cointegration approach is a better approach as compared to other cointegration methods such as Engle and Granger (1987), Johansen (1988) and ordinary least square procedures as used in the previous studies of energy demand in case of Pakistan. First the ARDL procedure has the advantage of being independent of classification of variables into I(0) and I(1) and there is no need of pre testing of variable for unit root. A single reduced form equation is employed to estimate long run relationship instead of a system of equations as used in the conventional cointegration procedures (Ozturk, I., & Acaravci, A., 2010). Secondly, ARDL modelling does not need large data samples for validity as required by Johansen cointegration techniques. It can test for cointegration with consistent parameters even when the data sample is small (Mah, 2000). Furthermore, ARDL allows for different optimal lags for variables which is not possible while using conventional cointegration procedures (Narayan, P. K., & Smyth, R., 2005).

The rest of the study is organized as follows: Section 2 analyzes the consumption trends of the economic sectors; Section 3 discusses the methodology and data used and Section 4 delves into the results and Section 5 gives the conclusion and policy implication of the study.

## 2. Energy Consumption in Pakistan (Sector Wise)

Over the last decades, the Pakistan has been facing severe energy crisis due to insufficient energy production to fulfill the escalating demand. The energy supply has increased by more than 40 times during the past 25 years, yet the demand outweighs the supply. Moreover, the inter-sectoral patterns of consumption have changed significantly over time (Figure 1). The industrial sector contributes to the highest share followed by the transport and household sector. After experiencing a high growth, the industrial consumption started to decline in the wake of global oil crises during 2008, with a rise in the transport share correspondingly. The total energy consumption showed a decline during 2008-09 which later on increased at a fast pace after 2014. On the other hand, the household sector has been witnessing a constant rise after 2008 with a peak of 25 percent in 2012-13.

Figure 1. Energy consumption by Sectors (% share)




Source: Pakistan Energy Yearbook (2019)

The fall in share of industry and the corresponding rise in share of transport can be attributed to several factors. Firstly, the slowing down of industrial growth due to declining growth momentum of the economy reduced demand for energy. Secondly, the rising oil prices post 2008 led to substitution of petrol/ diesel for CNG in the transportation sector, increasing energy demand in this sector. The energy needs are expected to increase three folds by 2050 while the supply situation is not very inspiring (Asif. M, 2009). The primary energy sources and their issues are discussed in details in the following subsections.

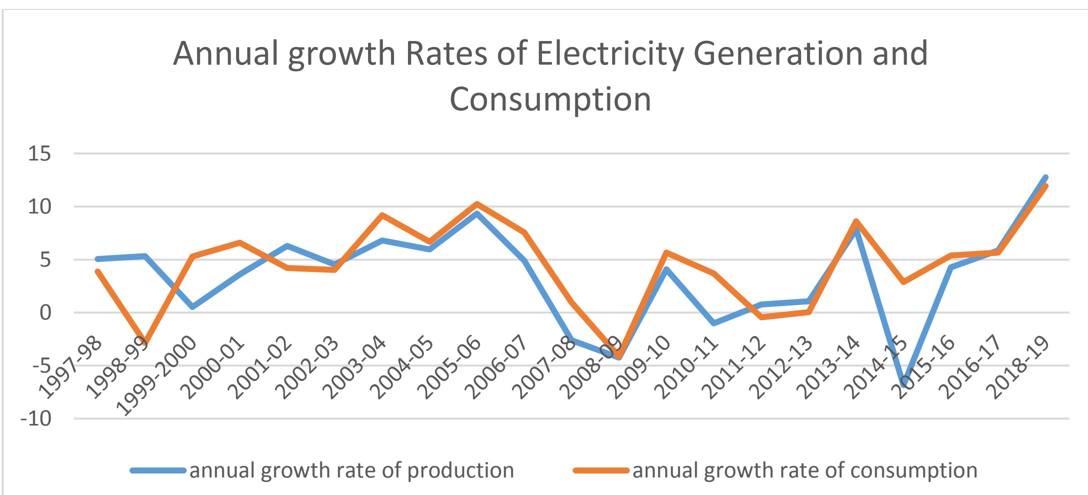
**2.1 Electricity**

Power shortage has become a challenge for Pakistan. Power shortage has become a challenge for Pakistan. For almost a decade, the power crisis is prevailing in the country resulting in routine power outages, called “load shedding” in both urban and rural areas. Since 2007, the electricity supply shortfalls (5000-5500MW) have led to load shedding of long hours which in some areas has even averaged up to 17 hours per day (IMF, 2013). According to Siddiqui, R., et al., (2008), the unserved energy due to power outages has caused an industrial output loss that is estimated to vary between 12% to

37% for Silakot, Faisalabad, Gujrat and Gujranwala. These shortfalls have not only raised the production cost through the arrangement of alternative energy for many firms, but also have caused delay in meeting supply commitments. The supply shortage was estimated to exceed more than 7,000 MW in 2015 (National Transmission and Dispatch Company, NTDC). Along with the power supply shortfalls, the shortage of natural gas is increasing, which is a primary energy source for the poor who do not have electricity access. In the hours of power cuts most households use gas fueled generators which adds to the inefficient use.

Electricity is a second source of energy yet it is indispensable not only for household but also for industry, transport, etc. There was an increase in the generation of electricity by thermal and hydel but the import of electricity remained at 335 Gwh in 2016. The installed capacity has increased by 30% in the phase of 2012-18 (from 22812MW to 29573 MW). Although the generation has increased yet the inefficiencies in the transmission and distribution (T&D) make the sustained supply of electricity impossible (as shown in Figure 2). The T&D loses in Pakistan are inevitably high due to a number of reasons such as theft through illegal connections, low voltage of distribution line, outdated generation plants, weak infrastructure etc. the distribution loses range from 9.5%-34.3% which is quite high as compare with the neighboring countries like China whose distribution loses amount to 5.8% (Annual Report, SBP 2015).

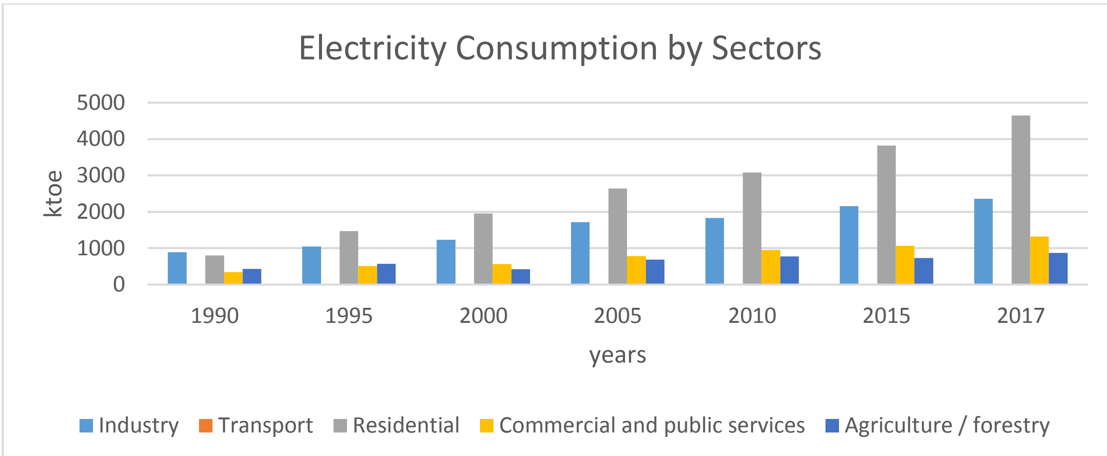
Figure 2. Annual growth Rates of Electricity Generation and Consumption




Source: Author's calculation (Pakistan Energy Yearbook, various issues)

On the other hand, the source wise consumption patterns of sectors shows that the domestic sector contributes the largest share in electricity consumption over many years (Figure 3). During 2018-19, the domestic share accounted for 49%, while industrial share contributed 26%, commercial share 8% and agricultural share accounted for 9%. There are severe consequences of such a large domestic share as the residential sector contribute more to the T&D losses than other sectors (State Bank, 2014). Moreover, this sector is also highly subsidized.

Figure 3. Sectoral Electricity Consumption



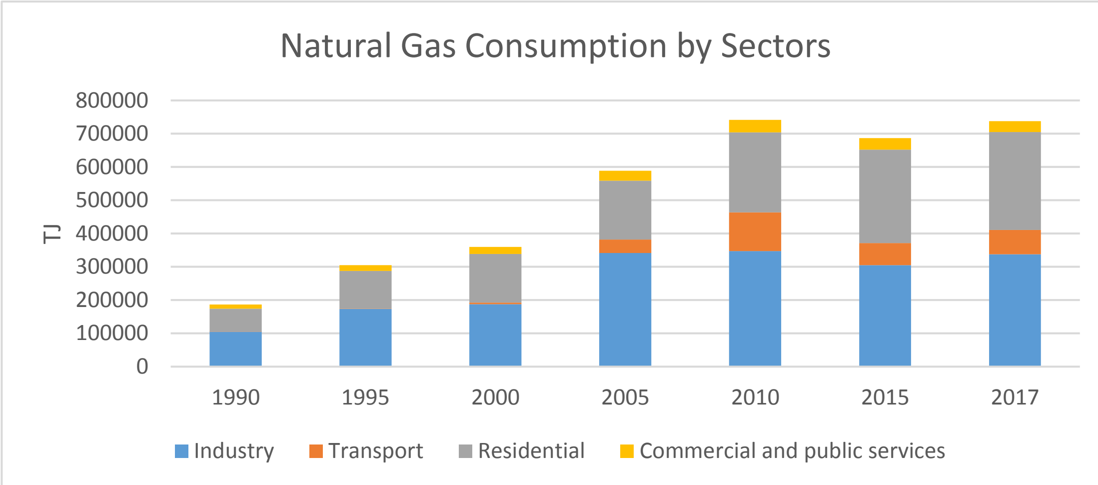

Source: Pakistan Energy Yearbook (various issues)

About fifty one million (27%) people of the population do not have access to power (IEA, 2017). Those that are connected have to experience load shedding of some hours on daily basis. In absence of reliable distribution network the rural households use LPG as a source of fuel which is more expensive as compared to the subsidized natural gas used by urban households.

## 2.2 Natural Gas

Analyzing the consumption pattern of natural gas reveals that the industrial sector constitutes the largest share in gas consumption. However, it is seen that from 2005 onwards the consumption share of natural gas of the transport sector has increased immensely. In order to reduce import bill on oil, the use of Compressed Natural Gas (CNG) as fuel for automobiles was encouraged through approval of marketing licenses of more than 3416 CNG stations by the state. However in view of the depleting gas reserves a ban has been placed on establishment of new gas reserves. The total consumption of natural gas showed a decline during 2010-2015 with decreasing shares of the industrial and transport sector (Figure 4). This decline in consumption of natural gas is accompanied by the increase in oil fuel consumption in response to the declining prices of petrol. During 2018-19 the share of domestic sector was 33%, the share of industrial sector was 38 % and that of transport sector was recorded as 8% of total gas consumption.

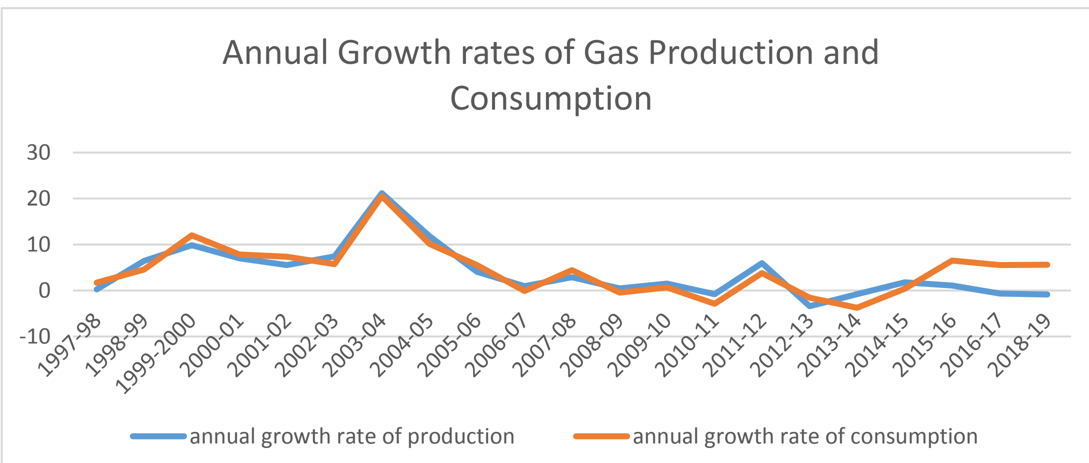
Figure 4. Natural Gas Consumption by Sectors




Source: Pakistan Energy Yearbook (various issues)

Despite being sufficient in gas supply Pakistan is also facing gas crisis in addition to electricity crisis. According to some estimates by O. Rauf et al., (2015), the country has entered the deficiency state after 2006. Before 2006, the local resources have fulfilled the demand of the domestic as well as the commercial and industrial consumers with an ample supply. The growth rate of as consumption increased rapidly during 2015-16 while the growth rate of production was 1.2% (Figure 5).

Figure 5: Annual Growth rates of Gas Production and Consumption



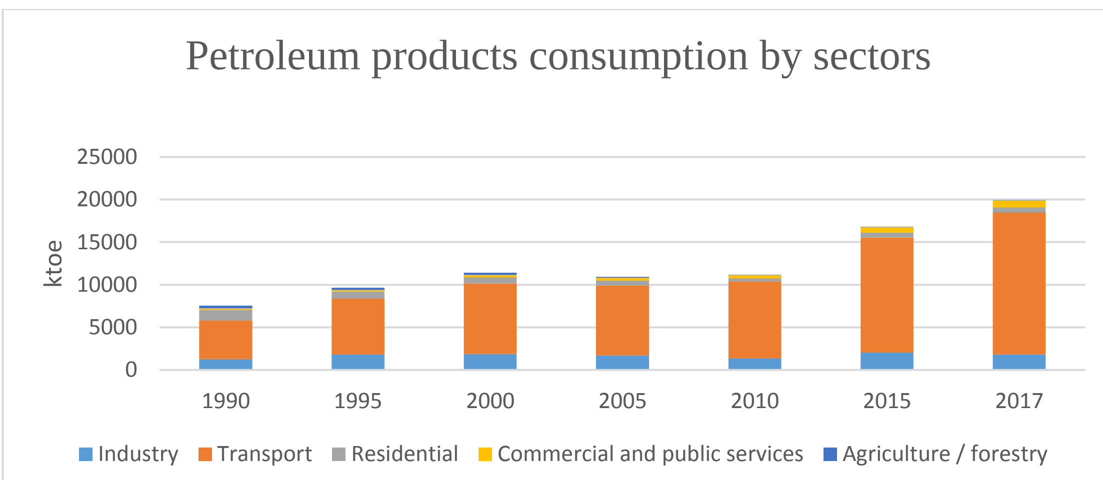

Source: Author's calculation (Pakistan Energy Yearbook, various issues)

The shortfalls of gas supply have leaded to gas load shedding and supply cuts especially in the winter seasons. The severity of this shortfall can be assessed by the decision of the government implementing load shedding of two days per week on CNG stations and industries since November 2009 to March 2010 (Khan, et. al., 2012). The shortage has been substituted by alternative fuels like diesel and kerosene during the phase of 2005-10 increasing the share of oil from 29%to 31%. Until 2007, the power sector had the largest share in gas consumption. However, the use of gas for generating power is declining gradually in Pakistan. The industrial sector is also facing similar situation of gas supply cut. It has been estimated that 80% of the textile industry relies upon supply of gas from SSGCL and SNGPL (All-Pakistan Textile Millers Association (APTMA)). Due to massive gas shortage the annual opportunity loss was more than 5 billion dollars during the last four years (Economic Survey of Pakistan 2018).

### 2.3 Petroleum Products

In case of petroleum products consumption, the transport sector has the largest share with an increasing trend especially after the fall in world oil prices. During 2018-19 transport sector had the largest share in petroleum products consumption (80%), followed by industry (9%), while commercial sector contributed a 4% share, domestic sector had 3% and agriculture sector had the smallest share of 0.1% (Figure 6).

Figure 6. Petroleum Products Consumption by Sectors

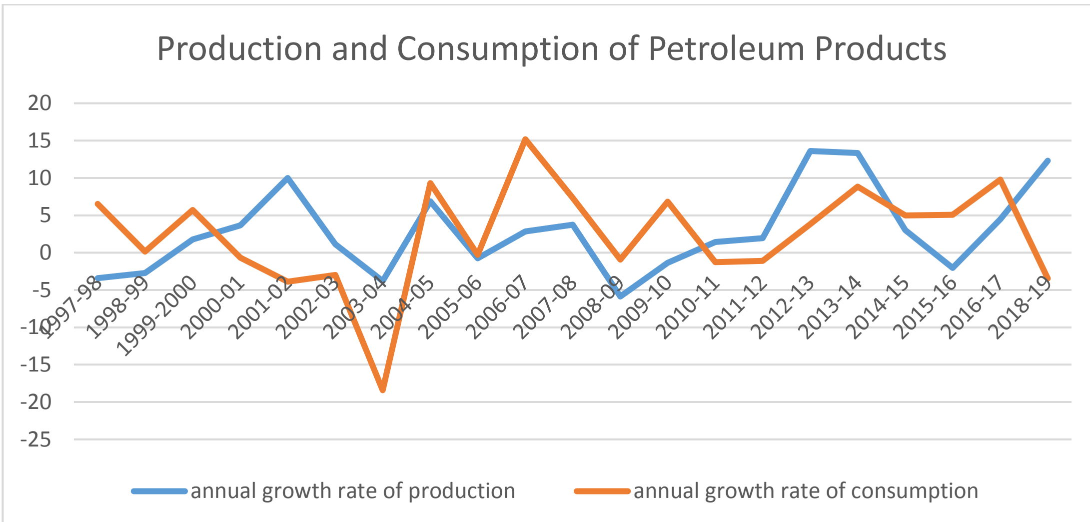



Source: Pakistan Energy Yearbook (various issues)

The energy requirements in Pakistan are mostly fulfilled by gas and oil. However the indigenous oil resources fall short of the growing demand which has led to the importation of oil and petroleum products in huge amounts from the Gulf countries. During fluctuations in the international oil prices, Pakistan has focused on reducing the reliance on importation of oil. The production of crude oil in 2016 was 24.02 million barrels while 4.98 MMt (million metric tons) was imported (Pakistan Economic Survey 2015-16). On the other hand the demand for petroleum products is also greater than the oil refining capacity which is why half of the imports constitute of refined products

(Figure 7). The import of petroleum products contributed to the import bill by 17% in 2017. As international oil prices remained high in 2018, the cost of imported energy escalated by 25% ($13.3 billion) raising the contribution of imported energy to 37% in the import bill (State Bank Annual Report 2018-19).

Figure 7. Annual growth rates of Petroleum Products




Source: Author's calculation (Pakistan Energy Yearbook, various issues)

In the coming years the demand of petroleum products is expected to grow at a faster pace as compared to the production making is impossible for Pakistan to gain self-sufficiency, given the volume of oil resources. During 2018-19, 20.03 million tones, of petroleum products were consumed, out of which, 2.8 million tons were domestically produced. In order to overcome the high cost of imported oil and petroleum products, there is a need to improve the necessary infrastructure of the oil refineries which requires considerable amount of investment. Although the government has introduced several incentives to attract investment by the private sector in the Petroleum policy 1997, still it has failed to achieve satisfactory results.

## 3. Empirical specification, Methodology and Data

### 3.1. Data

This study uses annual data for the period 1984-2019 collected from different sources to estimate the demand functions of each energy item. Data for Gross domestic product (GDP) is used from Pakistan Economic Survey, data for consumption of energy sources and their prices is taken from Energy year book (various issues). Following Ahlborg H., et al., (2015), the institutional quality index has been constructed by taking the average of 6 variables from the ICRG data that best fits with the theoretical perceptions about the role of institutes in provision of energy goods. The variables included are (1) Law and order, (2) Corruption, (3) Government Stability, (4) Investment Profile, (5) Democratic accountability and (6) Bureaucratic Quality. The data for urbanization has been taken from WDI which measures urbanization as percentage of total population. Table 1 summarizes the descriptive statistics for the variables used.

Table 1. Descriptive statistics of variables.

| Variables | Definitions | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| **Dependent variable** | | | | | |
| **EC (H)** | Electricity Consumption (residential sector) | 14.46 | 0.52 | 13.34 | 16.04 |
| **EC (C)** | Electricity Consumption (commercial sector) | 12.66 | 0.37 | 12.06 | 13.18 |
| **EC (I)** | Electricity Consumption (industrial sector) | 14.38 | 0.59 | 13.81 | 16.11 |
| **EC (A)** | Electricity Consumption (agriculture sector) | 13.34 | 0.29 | 12.81 | 14.10 |
| **GC (H)** | Gas Consumption (residential sector) | 14.60 | 0.43 | 13.60 | 14.70 |
| **GC (C)** | Gas Consumption (commercial sector) | 12.97 | 0.53 | 12.08 | 13.76 |
| **GC (I)** | Gas Consumption (industrial sector) | 14.96 | 0.30 | 14.19 | 15.83 |
| **Sk** | Consumption of super kerosene oil | 12.13 | 0.29 | 11.62 | 12.59 |
| **FO** | Consumption of furnace oil | 13.74 | 0.57 | 12.19 | 14.56 |
| **MS** | Consumption of motor spirit | 13.91 | 0.44 | 13.13 | 15.06 |
| **HSD** | Consumption of high speed diesel | 15.38 | 0.49 | 14.34 | 15.88 |
| **LDO** | Consumption of low diesel oil | 6.71 | 0.53 | 5.87 | 7.57 |
| **Independent Variables** | | | | | |
| **Y** | Gross domestic product | 15.45 | 0.47 | 14.58 | 16.18 |
| **IQ** | Institutional Quality Index | 3.94 | 0.12 | 2.84 | 4.08 |
| **UR** | Percentage of urban population to total population | 3.47 | 0.04 | 3.58 | 3.34 |
| **NEH** | No. of electricity users in the residential sector | 15.97 | 0.55 | 14.93 | 16.73 |
| **NEI** | No. of electricity users in the industrial sector | 12.13 | 0.29 | 11.62 | 12.59 |
| **NEC** | No. of electricity users in the commercial sector | 14.37 | 0.20 | 14.19 | 14.74 |
| **NEA** | No. of electricity users in the agriculture sector | 12.07 | 0.32 | 11.55 | 12.60 |
| **NGH** | No. of gas users in the residential sector | 15.06 | 0.39 | 14.65 | 15.84 |
| **NGI** | No. of gas users in the industrial sector | 8.65 | 0.34 | 8.37 | 9.28 |
| **NGC** | No. of gas users in the commercial sector | 10.96 | 0.18 | 10.72 | 11.30 |
| **TR** | No. of cars, taxis, motorcycles | 14.06 | 0.57 | 12.93 | 15.00 |
| **C** | No. of cars, taxis, motorcycles | 12.44 | 0.45 | 11.61 | 13.09 |
| **PeA** | Price of electricity for agriculture sector | 0.44 | 0.69 | 0.60 | 0.45 |
| **PeC** | Price of electricity for commercial sector | 0.89 | 0.57 | 0.25 | 1.06 |
| **PeH** | Price of electricity for residential sector | 0.49 | 0.54 | 0.42 | 0.93 |
| **PeI** | Price of electricity for industrial sector | 0.53 | 0.12 | 0..55 | 0.70 |
| **PFO** | Price of electricity of furnace oil | 2.13 | 0.50 | 2.02 | 2.63 |
| **PgC** | Price of gas for commercial sector | 4.84 | 0.14 | 3.93 | 5.02 |
| **PgH** | Price of gas for residential sector | 4.40 | 0.13 | 3.38 | 4.51 |
| **PgI** | Price of gas for industrial sector | 4.80 | 0.29 | 3.37 | 5.40 |
| **PHSD** | Price of high speed diesel oil | 2.62 | 0.19 | 2.11 | 2.72 |
| **PLDO** | Price of low diesel oil | 2.42 | 0.24 | 2.01 | 2.58 |

| | | | | | |
|---|---|---|---|---|---|
| **PMS** | Price of motor spirit | 3.06 | 0.37 | 2.98 | 3.61 |
| **PSK** | Price of super kerosene oil | 2.51 | 0.26 | 2.11 | 2.65 |

### 3.2. Empirical Specification

The energy sector is divided in two ways i.e. by different energy source (electricity, petroleum products and natural gas) and by different user groups (household, industry, commercial and others). The energy consumption function for each category is specified as under:

#### 3.2.1. Electricity Consumption

Following Galindo (2005), electricity consumption function is specified for each sector as:

$$lnEc_{it} = \alpha_0 + \alpha_1 lnP_{it}^{e} + \alpha_2 lnP_{jit} + \alpha_3\ lnY_t + \alpha_4 lnN_{it} + \alpha_5 lnUR_t + \alpha_6 lnIQ_t +\ \varepsilon_t \quad (1)$$

Where $Ec_{it}$ is the electricty consumption for sector "i" respectively, for period t. $P_{it}^{e}$ is electricity price faced by each sector "i" and $P_{jit}$is the price of related substitutable energy sources like gas, furnace oil, kerosene oil etc. $Y_t$ gives the total ouput (GDP). $NI_t$ is the number of users sector i. Due to the unavailability of data on price of appliances in time series form it was not included in the model.

#### 3.2.2. Gas consumption

The consumption function of gas is specified in a similar manner for each sector

$$lnGc_{it} = \alpha_0 + \alpha_1 lnP_{it}^{g} + \alpha_2 lnP_{jit} + \alpha_3 lnY_t + \alpha_4 lnN_{it} + \alpha_5 lnUR_t + \alpha_6 lnIQ_t + \varepsilon_t \quad (2)$$

Where $Gc_{it}$ is the gas consumption for sector "i" respectively, for period t. $P_{it}^{g}$ is the gas price faced by each sector "i" and $P_{jit}$is the price of related substitutable energy sources like electricity in each sector. The gas price also includes the surcharge imposed by government. $Y_t$ gives the total ouput (GDP). $I_t$ is the number of users sector i. The demand for gas and electricity is also affected by the price of appliances using these energy sources but since the data for this variable is not available it is not added in the demand function.

#### 3.2.3. Petroleum Products consumption

The consumption analysis of each petroleum product (Super Kerosene, Furnace oil, Motor spirit, High speed and Low diesel oil) can be classified according to the consumption of its users. For instance, the industry consumes more than 60% of furnace oil while the domestic sector consumes about 70% of super kerosene oil is consumed by the residential sector. Similarly, the consumption of high speed diesel, low diesel oil and motor spirit is predominantly from the transport sector. The consumption function of the petroleum products is given accordingly

$$lnKc_{ht} = \alpha_0 + \alpha_1 lnP_{ht}^{k} + \alpha_2 lnP_{jht} + \alpha_3 lnY_t + \alpha_4 lnpop_t + \alpha_5 lnIQ_t + \varepsilon_t \quad (3)$$

$$lnFOc_{it} = \alpha_0 + \alpha_1 lnP_{it}^{fo} + \alpha_2 lnP_{jit} + \alpha_3 lnY_t + \alpha_5 lnY_{it} + \alpha_6 lnIQ_t + \varepsilon_t \quad (4)$$

$$lnHSDc_{rt} = \alpha_0 + \alpha_1 lnP_{rt}^{hsd} + \alpha_2 lnP_{jrt} + \alpha_3 lnY_{rt} + \alpha_4 lnBT_t + \alpha_5 lnIQ_t + \varepsilon_t \quad (5)$$

$$lnLDOc_{rt} = \alpha_0 + \alpha_1 lnP_{rt}^{ldo} + \alpha_2 lnP_{jrt} + \alpha_3 lnY_{rt} + \alpha_4 lnBT_t + \alpha_5 lnIQ_t + \varepsilon_t \quad (6)$$

$$lnMSc_{rt} = \alpha_0 + \alpha_1 lnP_{rt}^{ms} + \alpha_2 lnP_{jrt} + \alpha_3 lnY_{rt} + \alpha_4 lnC_t + \alpha_5 lnIQ_t + \varepsilon_t \quad (7)$$

Where $Kc_{it}$is the Kerosene consumption by the household sector in period t. $P_{ht}^{k}$ is kerosene price and $P_{jit}$is the price of related substitutable energy sources like electricity and gas for the residential sector. $Y_t$ gives the total ouput (GDP) and pop stands for the population.

$FOc_{it}$ is furnace oil consumption of the industrial sector. $P_{it}^{fo}$is the price of furnace oil and $P_{jit}$ is the price of other related energy sources. $Y_{it}$is the value added by industry.

Similarly $MSc_{rt}, HSDc_{rt}$, $LDOc_{rt}$ are the motor spirit, high speed diesel and low diesel oil consumptions respectively by the transport sector. $P_{rt}^{i}$ is the price of the ith fuel and $Y_{rt}$is the value added by the transport sector. Since the consumption of these fuels is also affected by the number of vehicles hence the number of buses and trucks ($BT$) and the number of cars, taxis, motorcycles ($C_t$)are also included.

### 3.3. Econometric Methodology

There are two steps in the bound testing approach. In the first step the long run relationship is established between the variables of the consumption function. The long run and short run coefficients are calculated in the following step provided that cointegration exists (Pesaren et al., 2001). The ARDL procedure to cointergration is explained as under

Consider a vector of two variable Zt where $z_t = (y_t, x_t')'$, $y_t$is the dependent variable and xt is a vector of regressors. The data generating process of zt is p-order vector autoregression.

$$\Delta y_t = \beta_0 + \beta_1 t + \pi_{yy} y_{t-1} + \pi_{xx} x_{t-1} + \sum_{i=1}^{p} \vartheta_i \Delta y_{t-i} + \sum_{j=0}^{q} \emptyset_j' \Delta x_{t-j} + \theta w_t + u_t \quad (8)$$

Here, $\pi_{yy}$and $\pi_{xx}$are long run multipliers, $\beta_0$is the drift, t is the time trend and $w_t$is a vector of exogenous components. The bound testing procedure entails the following hypothesis

$$H_0, \pi_{yy} = 0, \ \ \pi_{yx.x} = 0'$$

$$H_0, \pi_{yy} \neq 0, \ \ \pi_{yx.x} \neq 0' \text{or} , \pi_{yy} \neq 0, \ \ \pi_{yx.x} = 0' \ or \ \pi_{yy} = 0, \ \ \pi_{yx.x} \neq 0'$$

These hypothesis are estimated using the F statistic. If the F stat is below the lower bound than the null of no cointegration cannot be rejected and if it is greater than the upper bound the null is rejected. The energy demand literature mostly (implicitly) assumes that explanatory variables used in equation (1) to equation (7) are exogenous. However, in the presence of endogeneity an adequate number of lagged values of these variables have to be included (Bentzen and Engsted, 1999)

## 4. Empirical Results

Before applying the ARDL model, the variables have been checked for presence of unit root using Ng and Perron (2001). The results are given in the appendix (Table A1) which show that most of the variables are non-stationary at level as the P-value is insignificant even at 10% significance level. However, at first difference all of the variables turn out to be stationary.

### 4.1 Electricity consumption

The existence of long run relationship was tested in eq (1) for electricity consumption. The maximum number of lags were set equal to 2 in the ARDL model for all the sectors. The computed F stat are reported in Table 2.

Table 2. Results of the Bounds Test for cointegration

| **Electricity consumption** | **Variables included** | **F-statistic** |
|---|---|---|
| Household | $Ec_{Ht}, P^e_{Ht}, P_{Hjt}, Y_t, UR_t, N_{Ht}, , IQ_t$ | 12.08* |
| Industry | $Ec_{It}, P^e_{It}, P_{Ijt}, Y_t, Y_{it}, N_{it}, IQ_t$ | 7.80* |
| Commercial | $Ec_{ct}, P^e_{ct}, P_{cjt}, Y_t, Y_{ct}, N_{it}, IQ_t$ | 6.77* |
| Agriculture | $Ec_{At}, P^e_{At}, P_{Ajt}, Y_t, Y_{At}, N_{At}, IQ_t$ | 9.86* |

Note: Critical values are given in Pesaran et al. (2001).
* Indicates significance at the 1 percent level

Table 1 shows that the computed F-statistics is greater than the upper bound of the critical values, giving evidence of cointegration among the variables of the household, industrial, commercial and agriculture sectors. Now equation 2.1 was further estimated by using the following ARDL (m,n,p,q,r) specification.

$$lnEc_{it} = \alpha_0 + \alpha_1 \sum_{i=1}^{m} lnEc_{t-i} + \sum_{i=0}^{n} \alpha_2\, lnY_{t-i} + \sum_{i=0}^{p} \alpha_3 lnP^e_{t-i} + \sum_{i=0}^{q} \alpha_4 lnP^j_{t-i} + \sum_{i=0}^{r} \alpha_5 lnYi_{t-i} + \sum_{i=0}^{s} \alpha_6 lnICT_{t-i} + \sum_{i=0}^{t} \alpha_7 lnIQ_{t-i} + \varepsilon_t \quad (9)$$

For each sector (i) a maximum lag was selected according to the minimum value of the SBC criterion. The empirical results obtained for each of the sector for the long run are reported in Table 2.2. Panel “a” of the table represents the estimated long run results while panel “b” fives the results for short run.

The results show the income elasticity for all the sectors is statistically significant with a positive value, except for the domestic sector in the long run. This implies that the income effect on electricity consumption of households is positive but negligible. The own price effect is statistically significant with a negative sign for all sectors. The coefficient of own price effect (in absolute terms) is bigger for the residential sector as compared to other sectors. The price effect of natural gas is statistically insignificant while in case of kerosene oil the price effect is positive and statistically significant. These results imply that the residential sector uses super kerosene as a substitute of electricity. The impact of number of consumer on electricity demand is positively significant. While, the impact of income is significantly positive in the short run. The estimated values of own price effect and cross price effect (kerosene oil) have similar signs as of the long run estimates, however they are smaller in magnitude and are statistically significant. The number of users is positive but has an insignificant impact for short run. This means that in case of domestic sector the key factors determining electricity consumption are electricity price, kerosene oil price and number of users.

Table 3. Long-run Estimates and Short-run Error-Correction Representation

| **Dependent variable** | **Independent Variables** | **Coefficient** | **S.E** |
|---|---|---|---|
| **Panel (A): Long-run Estimates** | | | |
| **EC(H)** | Y | 0.48 | 1.51 |
| | PeH | -0.98** | 0.43 |
| | PgH | 0.08 | 0.21 |
| | Pfo | -0.06 | 0.04 |
| | Psk | 0.64** | 0.30 |
| | IQ | 1.56*** | 0.22 |
| | UR | 1.41** | 0.56 |
| | NH | 1.29** | 0.49 |
| **EC(C)** | Y | 0.47*** | 0.16 |
| | PeC | -0.38** | 0.17 |
| | PgC | 1.04 | 0.67 |
| | Pfo | 0.01 | 0.05 |
| | IQ | 0.96*** | 0.16 |
| | Yi | 0.33** | 0.15 |
| | NC | 3.35*** | 0.85 |
| **EC (I)** | GDP | 0.67*** | 0.26 |
| | PeI | -2.36* | 1.16 |
| | Pfo | -0.80*** | 0.23 |
| | PgI | -0.16 | 0.11 |
| | IQ | 0.58** | 0.21 |
| | UR | 1.23*** | 0.29 |
| | NI | 4.79** | 1.81 |
| **EC(A)** | GDP | 4.81** | 2.24 |
| | PeA | -0.12 | 0.08 |
| | IQ | 1.4*** | 0.38 |
| | NA | 3.57* | 1.96 |
| **Panel (B): Error-correction representation** | | | |
| **∆EC(H)** | D(EH(-1)) | 0.38** | 0.18 |
| | D(Y) | 0.22*** | 0.08 |
| | D(Y(-1)) | 0.16 | 0.09 |
| | D(PeH) | -0.17** | 0.08 |
| | D(PgH) | 0.07 | 0.18 |
| | D(Pfo) | -0.05 | 0.04 |
| | D(Psk) | 0.53* | 0.27 |
| | D(IQ) | 0.88** | 0.31 |
| | D(IQ(-1)) | 0.86*** | 0.28 |
| | D(UR) | 0.62** | 0.23 |
| | D(NH) | 0.27 | 0.53 |
| | CointEq(-1) | -0.82 | 0.23 |
| **∆EC(C)** | D(Y) | 1.41 | 1.05 |
| | D(PeC) | -0.20*** | 0.05 |

| | | | |
|---|---|---|---|
| | D(PgC) | -0.04 | 0.19 |
| | D(PgC(-1)) | -0.58 | 0.48 |
| | D(Pfo) | 0.003 | 0.02 |
| | D(IQ) | 0.10 | 0.27 |
| | D(Yc) | 0.17*** | 0.05 |
| | D(Yc(-1)) | 0.01 | 0.04 |
| | D(NC) | 1.78*** | 0.35 |
| | CointEq(-1) | -0.53*** | 0.15 |
| **ΔEC(I)** | D(Y) | 0.58*** | 0.23 |
| | D(Y(-1)) | 0.32** | 0.11 |
| | D(PeI) | -0.39*** | 0.05 |
| | D(PeI(-1)) | -1.85** | 0.70 |
| | D(Pfo) | 0.22 | 0.15 |
| | D(Pfo(-1)) | 0.97** | 0.42 |
| | D(PgI) | -0.18 | 0.12 |
| | D(IQ) | 1.23*** | 0.21 |
| | D(IQ(-1)) | 0.58** | 0.43 |
| | D(Yi) | 0.28** | 0.12 |
| | D(NI) | 0.74*** | 0.14 |
| | CointEq(-1) | -0.66*** | 0.11 |
| **ΔEC(A)** | D(EA(-1)) | 0.27 | 0.17 |
| | D(Y) | 0.28* | 0.13 |
| | D(GDP(-1)) | 2.54 | 2.69 |
| | D(PeA) | -0.77* | 0.36 |
| | D(PeA(-1)) | -0.36 | 0.27 |
| | D(IQ) | 0.04 | 0.18 |
| | D(Ya) | 0.24*** | 0.23 |
| | D(Ya(-1)) | 0.26** | 0.08 |
| | D(NA) | 3.04* | 1.64 |
| | D(NA(-1)) | 0.47 | 1.40 |
| | CointEq(-1) | -0.57** | 0.21 |

Note: *Statistical significance at 10% level.
**Statistical significance at 5% level
***Statistical significance at 1% level

In case of the industrial sector, the price effect is negative and statistically significant though its value is quite small. The cross-price effect for natural gas and furnace oil are statistically insignificant. The impact of number of consumers is positive and significant but is smaller in magnitude as compared to the commercial and agriculture sectors. While, in case of commercial sector the income elasticity has a significant positive value. The estimated price elasticity has a significant negative value, however it has a very small magnitude. This means that for the commercial sector electricity demand is relatively inelastic and smaller in magnitude than the rest of the sectors. The number of consumers is positive and statically significant in the long as well as the short run. For the agricultural sector the income effect is positive showing an increase in income would raise the consumption of electricity. However the price effect is negative but insignificant. These results coincide with the findings of Siddiqui (2004) and Qayyum (2014). The reason for insignificant price effect could be the subsidized prices for the agricultural sector. Moreover the consumption of the agriculture sector is far less than the other sector. However the price effect is significant in the short run but with a very small magnitude showing relatively inelastic demand.

The results for the institutional quality index are in line with our theoretical expectations have statistically significant positive values for all the sectors in the long run. These results indicate consistency with the perception that if the politicians are able to implement large electrification projects, the electricity consumption is more likely to increase.

### 4.2 Gas consumption

The existence of long run relationship was tested in eq (2) for gas consumption. The maximum number of lags were set equal to 2 in the ARDL model for all the sectors. The computed F stat are given in Table 4.

Table 4. Results of the Bounds Test for cointegration

| Gas consumption | Variables included | F-statistic |
|---|---|---|
| Household | $Gc_{Ht}, P_{Ht}^{g}, P_{Ht}^{j}, Y_t, UR_t, IQ_t, N_{ht}$ | 8.61* |
| Industry | $Gc_{It}, P_{It}^{g}, P_{It}^{j}, Y_t, N_{it}, Y_{it}, IQ_t$ | 7.99* |
| Commercial | $Gc_{ct}, P_{ct}^{g}, P_{Ct}^{j}, Y_t, N_{ct}, Y_{ct}, IQ_t$ | 6.16* |

* Indicates significant at the 1 percent level

In each model the computed $F_{EC}(.)$ is higher than the upper bound critical value. Thus the null hypothesis of no cointegration cannot be accepted. Now equation 2.2 was further estimated by using the following ARDL (m,n,p,q,r) specification.

$$lnGc_{it} = \alpha_0 + \alpha_1 \sum_{i=1}^{m} lnGc_{t-i} + \sum_{i=0}^{n} \alpha_2\, lnY_{t-i} + \sum_{i=0}^{p} \alpha_3 lnP_{t-i}^{g} + \sum_{i=0}^{q} \alpha_4 lnP_{t-i}^{j} + \sum_{i=0}^{r} \alpha_5 lnN_{t-i} + \sum_{i=0}^{r} \alpha_6 lnYi_{t-i} + \sum_{i=0}^{t} \alpha_7 lnIQ_{t-i} + \varepsilon_t \quad (10)$$

For each sector (i) a maximum of lag 2 was used based on minimizing SBC criterion. The empirical results obtained for each of the sector for the long run are reported in Table 5. Panel a of the table represents the estimated long run results while panel b fives the results for short run.

Table 5. Long-run Estimates and Short-run Error-Correction Representation

| Dependent variable | Independent Variables | Coefficient | S.E |
|---|---|---|---|
| **Panel (A): Long-run Estimates** | | | |
| **GC(H)** | Y | 1.37*** | 0.34 |
| | PgH | -0.24** | 0.11 |
| | PeH | 0.75 | 0.46 |
| | Psk | 0.39** | 0.16 |
| | IQ | 0.24*** | 0.03 |
| | UR | 1.77*** | 0.57 |
| | NH | 2.07** | 0.79 |
| **GC(C)** | Y | 0.79*** | 0.08 |
| | PgC | -0.02* | 0.01 |
| | PeC | 0.15*** | 0.05 |

| | | | |
|---|---|---|---|
| | Pfo | -0.06*** | 0.02 |
| | IQ | 0.78* | 0.49 |
| | Yc | 0.59** | 0.23 |
| | NC | 0.21 | 0.19 |
| **GC(I)** | GDP | 5.00*** | 0.89 |
| | PgI | -0.63*** | 0.08 |
| | PeI | 0.25*** | 0.05 |
| | Pfo | -0.44*** | 0.08 |
| | IQ | 0.54 | 0.53 |
| | Yi | 0.15*** | 0.04 |
| | NI | 3.24*** | 0.80 |
| **Panel (B): Error-correction representation** | | | |
| **∆GC(H)** | D(Y) | 1.37*** | 0.33 |
| | D(PgH) | -0.24* | 0.09 |
| | D(PeH) | 0.10 | 0.47 |
| | D(Psk) | 0.33** | 0.13 |
| | D(IQ) | 0.26** | 0.08 |
| | D(UR) | 0.24* | 0.11 |
| | D(NH) | 0.24*** | 0.03 |
| | CointEq(-1) | -0.57** | 0.21 |
| **∆GC(C)** | D(Y) | 0.41** | 0.17 |
| | D(PgC) | -0.01** | 0.00 |
| | D(PeC) | 0.08* | 0.04 |
| | D(Pfo) | -0.03*** | 0.01 |
| | D(IQ) | 0.10*** | 0.03 |
| | D(Yc) | 0.13*** | 0.03 |
| | D(NC) | 0.11 | 0.06 |
| | CointEq(-1) | -0.52** | 0.23 |
| **∆GC(I)** | D(Y) | 1.27*** | 0.08 |
| | D(GDP(-1)) | 1.23*** | 0.16 |
| | D(PgI) | -0.02*** | 0.01 |
| | D(PeI) | 0.04 | 0.19 |
| | D(Pfo) | -0.02*** | 0.00 |
| | D(IQ) | 0.07 | 0.06 |
| | D(IQ(-1)) | 0.21** | 0.08 |
| | D(Yi) | 0.82*** | 0.25 |
| | D(NI) | 0.14*** | 0.00 |
| | CointEq(-1) | -0.04** | 0.01 |

Note: *Statistical significance at 10% level.
**Statistical significance at 5% level
***Statistical significance at 1% level

In case of the domestic sector the income elasticity has a positive value while, the price elasticity is significantly negative with a small magnitude, showing that gas consumption is relatively price inelastic. The cross price elasticity for electricity is insignificant which confirms out earlier result for electricity. However, the cross price effect for kerosene oil has a significant positive value which shows that it is a substitute of gas in the domestic sector. This finding is similar to that of Siddiqui (2004), which shows kerosene oil is used as a substitute for gas for cooking and lighting purposes. The number of consumers exert a positive impact on the gas consumption, however the magnitude is very small in the short run.

For the industrial sector the income effect has the expected positive sign. The price elasticity has a significant negative value but the small magnitude of price effect shows that the price effect of gas consumption is relatively inelastic in case of industrial sector. The price effect of electricity has a significant positive value, while in case of petroleum products, such as furnace oil, it is significantly negative. These results suggest that natural gas may substitute electricity while furnace oil complements electricity. However, the cross price effect of electricity is insignificant for short run, while cross price effect of furnace oil has a significant negative value. Whereas, the gas consumption of the commercial sector is positively related to income and number of users. The price elasticity has the expected sign but the magnitude is very small in case of short run. The institutional quality index is significant for all the sectors in the long run, which coincides with the earlier findings for electricity showing that with the increase in provision of natural gas by the government projects, the gas consumption increases. The value added also shows significant results for all the sectors. These results are in accordance to the previous studies on energy demand (Siddiqui (2004) and Iqbal (1983)) which conclude high income effect and low price effect for natural gas.

### 4.3 Petroleum Products Consumption

The existence of long run relationship was tested for petroleum products consumption. The maximum lags were set as 2 in the ARDL model for all the sectors i.e. households, industrial and transport sector using minimum values of SBC. The computed F stat are given in Table 6 which shows that there is cointegration in each model as the computed $F_{GC}(.)$ is greater than the critical value.

Table 5. Results of the Bounds Test for cointegration

| Petroleum Products Consumption | Variables included | F-statistic |
|---|---|---|
| Kerosene oil | $SKc_{Ht}, P_{Ht}^{sk}, P_{Ht}^{j}, Y_t, Pop_t, IQ_t$ | 4.01** |
| Furnace oil | $FOc_{It}, P_{It}^{fo}, P_{It}^{j}, Y_t, Y_{It}, IQ_t$ | 3.75*** |
| High speed diesel | $HSDc_{Tt}, P_{Tt}^{hsd}, P_{Tt}^{j}, Y_t, Y_{Tt}, TR_t, IQ_t$ | 6.26* |
| Low diesel oil | $LDOc_{Tt}, P_{Tt}^{ldo}, P_{Tt}^{j}, Y_t, Y_{Tt}, TR, IQ_t$ | 7.36* |
| Motor spirit | $MSc_{Tt}, P_{Tt}^{ms}, P_{Tt}^{j}, Y_t, Y_{Tt}, C, IQ_t$ | 49.28* |

Now equations 2.3 to 2.7 was further estimated by using the following ARDL (m,n,p,q,r) specification.

$$lnPc_{it} = \alpha_0 + \alpha_1 \sum_{i=1}^{m} lnPc_{t-i} + \sum_{i=0}^{n} \alpha_2\, lnY_{t-i} + \sum_{i=0}^{p} \alpha_3 lnP_{t-i}^{p} + \sum_{i=0}^{q} \alpha_4 lnP_{t-i}^{j} + \sum_{i=0}^{r} \alpha_5 lnYi_{t-i} + \sum_{i=0}^{t} \alpha_6 lnIQ_{t-i} + \varepsilon_t \quad (11)$$

For each sector (i) a maximum of lag 2 was used based on minimizing SBC criterion. The empirical results obtained for each of the sector for the long run in Table 7. Panel "a" of the table represents the estimated long run results while panel "b" fives the results for short run.

Results show that the income effect is positive for all of the petroleum products and statistically significant indicating that with the increase in income their consumption will also increase. The own price effect is significantly negative in case of all the petroleum products. The number of vehicle has a positive impact on the consumption of petroleum products. In case of cross price elasticities the results match our previous findings of kerosene being a substitute for electricity and natural gas.

Table.7 Long-run Estimates and Short-run Error-Correction Representation

| **Dependent variable** | **Independent Variables** | **Coefficient** | **S.E** |
|---|---|---|---|
| **Panel (A): Long-run Estimates** | | | |
| **SK** | Y | 0.22** | 0.08 |
| | Psk | -0.83*** | 0.20 |
| | PgH | 0.95* | 0.52 |
| | Psk | 0.29** | 0.04 |
| | IQ | 0.27* | 0.13 |
| | Pop | 0.81*** | 0.16 |
| **FO** | Y | 1.09** | 0.40 |
| | Pfo | -0.49*** | 0.14 |
| | Phsd | 1.08747 | 1.01 |
| | IQ | 0.42** | 0.12 |
| | Yi | 0.32** | 0.15 |
| | IND | 6.31** | 2.72 |
| **HSD** | Y | 1.72*** | 0.160 |
| | Phsd | -0.40*** | 0.094 |
| | Pms | 0.02 | 0.07 |
| | IQ | 0.73*** | 0.11 |
| | Yt | 1.71*** | 0.50 |
| | NTC | 0.59** | 0.21 |
| **MS** | Y | 4.50*** | 0.88 |
| | Pms | -0.33*** | 0.08 |
| | Phsd | 0.15 | 0.10 |
| | IQ | 0.42** | 0.12 |
| | Yt | 0.53*** | 0.16 |
| | NC | 0.36** | 0.16 |
| **LDO** | GDP | 1.34** | 0.56 |
| | Pldo | -0.27* | 0.13 |
| | IQ | 0.02 | 0.07 |
| | Yt | 0.39* | 0.20 |
| | NTC | 0.23*** | 0.07 |

**Panel (B): Error-correction representation**

| | | | |
|---|---|---|---|
| **SK** | D(Y) | 0.10* | 0.13 |
| | D(Y(-1)) | 0.17* | 0.04 |
| | D(Psk) | -0.02 | 0.13 |
| | D(Psk(-1)) | 0.28* | 0.15 |
| | D(PgH) | 0.29* | 0.15 |
| | D(PgH(-1)) | 0.33** | 0.13 |
| | D(PeH) | 0.42** | 0.13 |
| | D(IQ) | 0.27* | 0.13 |
| | D(POP) | 0.64 | 0.45 |
| | CointEq(-1) | -0.57*** | 0.13 |
| **FO** | D(GDP) | 0.74** | 0.16 |
| | D(Pfp) | -0.02** | 0.01 |
| | D(Phsd) | 0.18 | 0.12 |
| | D(IQ) | 0.34* | 0.19 |
| | D(Yi) | 0.29*** | 0.09 |
| | D(IND) | 1.06** | 0.43 |
| | CointEq(-1) | -0.29** | 0.04 |
| **HSD** | D(HSD(-1)) | 0.26* | 0.13 |
| | D(GDP) | 1.37*** | 0.24 |
| | D(Phsd) | -0.241* | 01 |
| | D(Phsd(-1)) | 0.20** | 0.06 |
| | D(Pms) | 0.01 | 0.08 |
| | D(IQ) | 0.34* | 0.19 |
| | D(NTC) | 0.39** | 0.16 |
| | D(Yt) | 0.66** | 0.21 |
| | CointEq(-1) | -0.79*** | 0.16 |
| **MS** | D(MS(-1)) | -0.26979 | 0.20 |
| | D(Y) | 0.77** | 0.22 |
| | D(Y(-1)) | 2.48*** | 0.29 |
| | D(Pms) | -0.17** | 0.04 |
| | D(Phsd) | 0.03 | 0.01 |
| | D(IQ) | 0.04 | 0.10 |
| | D(NC) | 1.07*** | 0.13 |
| | D(NC(-1)) | 0.97*** | 0.09 |
| | D(Yt) | 0.39*** | 0.07 |
| | D(Yt(-1)) | 0.54** | 0.07 |
| | CointEq(-1) | -0.66** | 0.11 |
| **LDO** | D(LDO(-1)) | 1.09** | 0.40 |
| | D(Y) | 0.97* | 0.23 |
| | D(Y(-1)) | 0.33** | 0.13 |
| | D(Pldo) | -0.24*** | 0.03 |
| | D(IQ) | 0.25 | 0.53 |
| | D(NTC) | 1.29** | 0.49 |

| | | |
|---|---|---|
| D(NTC(-1)) | 0.73*** | 0.11 |
| D(Yt) | 0.47*** | 0.16 |
| D(Yt (-1)) | 0.38** | 0.17 |
| CointEq(-1) | -0.53*** | 0.15 |

Results show that the income effect is positive for all of the petroleum products and statistically significant indicating that increased income raises the consumption. The own price effect is negative and significant in case of all the petroleum products. The number of vehicle has a positive impact on the consumption of petroleum products. In case of cross price elasticities the results match our previous findings of kerosene being a substitute for electricity and natural gas. The results of institutional quality shows significant results in case of all petroleum products except for LDO in the long run showing a positive impact of institutional quality on petroleum consumption. While the value added by transport sector shows significant impact on petroleum consumption. In case of the remaining fuels the cross price elasticities are not significant. These results are in accordance to the previous finding of Siddiqui (2004) on the demand for petroleum products.

Table 7. Results of Diagnostic Tests

| Model | Serial Correlation | Functional Form | Normality | Heteroscedasticity |
|---|---|---|---|---|
| **EC(H)** | 1.04(0.08) | 1.17(0.27) | 3.36(0.18) | 2.38(0.04) |
| **EC(C)** | 1.58(0.45) | 1.20(0.29) | 0.74(0.69) | 3.58(0.81) |
| **EC(I)** | 0.34(0.84) | 1.39(0.23) | 1.42(0.48) | 1.75(0.12) |
| **EC(A)** | 1.46(0.48) | 0.03(0.85) | 0.25(0.88) | 0.39(0.53) |
| **GC(H)** | 2.28(0.31) | 0.75(0.29) | 1.37(0.02) | 6.09(0.41) |
| **GC(C)** | 0.46(0.79) | 2.77(0.09) | 1.24(0.53) | 1.74(0.94) |
| **GC(I)** | 4.41(0.11) | 1.53(0.22) | 2.07(0.06) | 1.26(0.23) |
| **SK** | 2.48(0.28) | 0.07(0.94) | 1.28(0.52) | 0.69(0.75) |
| **FO** | 1.59(0.45) | 2.17(0.15) | 2.55(0.27) | 4.47(0.61) |
| **HSD** | 2.25(0.18) | 0.75(0.10) | 1.12(0.57) | 7.16(0.78) |
| **MS** | 0.03(0.85) | 0.22(0.66) | 0.25(0.88) | 1.93(0.75) |
| **LDO** | 1.12(0.60) | 2.15(0.20) | 0.02(0.98) | 2.60(0.18) |

Table. 7 shows the results of the diagnostic tests, which shows that the models are well fixed. Moreover the cumulative tests and cumulative sum of squares test were also used to check for the stability of each model. The results for CUSUM and SUSUMSQ (refer to appendix table A2) show that the parameters remain stable for the period of 1984-2019.

## 5. Conclusion

This study analyzes the factors affecting energy demand of the economic sectors (household, commercial, industrial and agricultural) of Pakistan. The energy sector of Pakistan has undergone several changes over the previous years, due to the increasing energy consumption. The pricing policy has also undergone a number of changes. The main focus of the energy policy has been to increase the supply capacity of energy at the national level. In order to fulfil this objective several rural electrification programs and natural gas provision programs have been conducted. This study aims to determine the extent to which the energy consumption is affected by the institutional quality. In this regard it analyzez the demand functions of energy sources (electricity, petroleum products and natural gas) by four main economic groups (i.e., residential, industry, commercial and agricultural sectors) over a period of 35years (1984-2019). In order to examine the relationship between energy consumption and its determinants (energy prices, GDP, number of users etc.) this study has employed bound testing approach (ARDL approach) developed by Pesaran et al. (2001) as most of the variables analyze are integrated of order 1.

The results suggests that the number of users and income have a positive effect on energy (gas, electricity and petroleum products) consumption in all the sectors (household, industrial, commercial and agricultural) while, the own price exerts negative impact on the energy demand with expected signs. The short run elasticities are much lower than the long run estimates which suggests that the demand management policies will have a stronger effect over time. However, the magnitude of the price elasticities is quite small. Moreover the income elasticities are found to be insignificant in most of the cases. These results are similar to the findings of Al- Faris (2002) and Narayan and Smyth (2005). The results for institutional quality index, measured by using the average of government stability, government accountability, investment profile, law and order and bureaucratic quality, show significant impact on energy consumption.

The policy implication that stems out of this study is that targeting energy prices in order to reduce the fiscal burden may be a suitable policy by the government. Such a decision should be carefully designed as it will adversely affect the poor adversely. Future studies should focus on how the households of different income groups will be affected by increasing energy prices. However, increasing the prices of energy alone may not be affective for energy conservation purposes. The government should create awareness in the public for the use energy saving appliances along with their provision. Secondly, the growth rate of population should also be given serious attention. Moreover, the results also indicate that the energy sector reforms should also pay attention towards institutional constraints in addition to capacity building efforts. Although, village electrification and natural gas provision programs which require large scale infrastructure have been carried out by the state, there is now a need to focus on decentralized development plans. Such small scale decentralized generation and distribution efforts will require a lower cost as compared to the expansion of the grid at national level. These results are beneficial not only for policymakers but also private investors as they provide important insights regarding the market for energy consumption. These results are beneficial not only for policymakers but also private investors as they provide important insights regarding the market for energy consumption.

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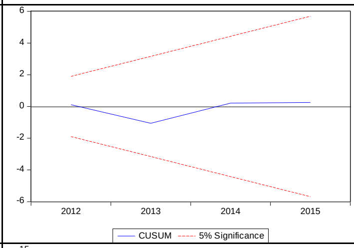
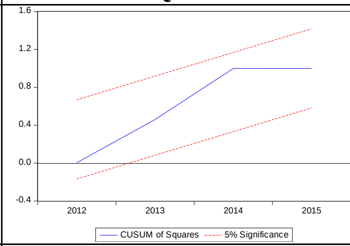
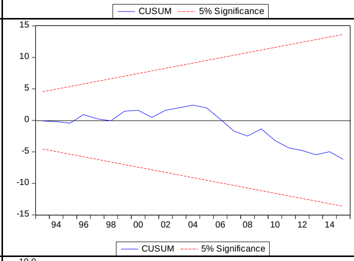
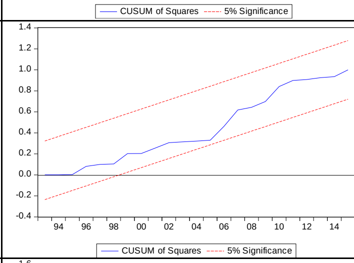
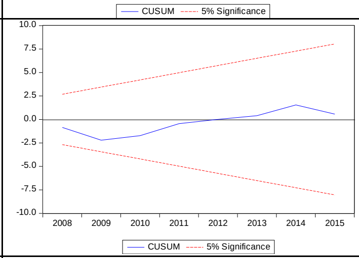
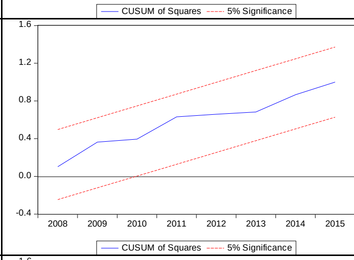
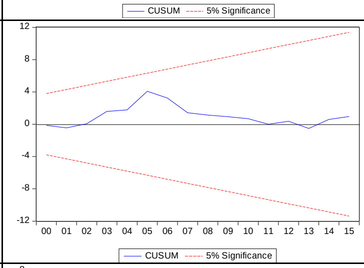
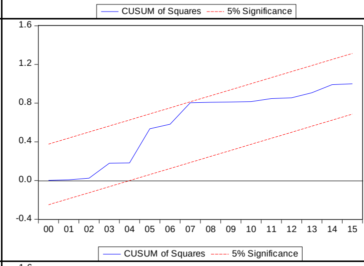
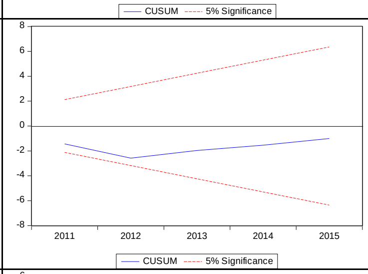
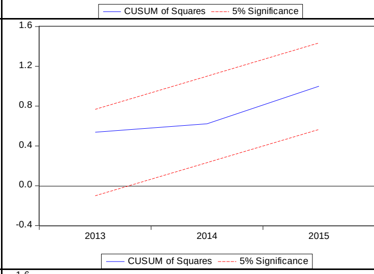
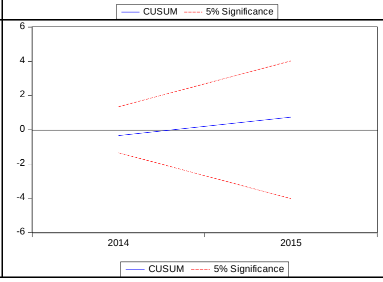
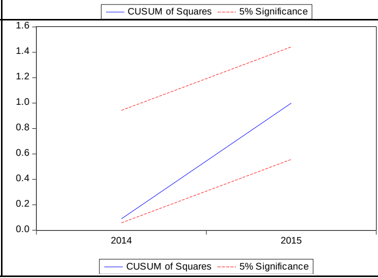
# APPENDIX

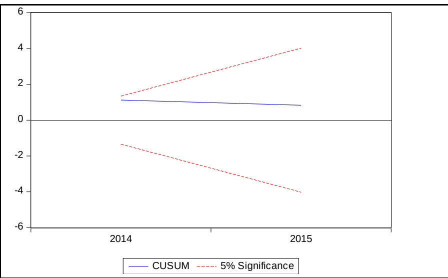
Table A1. Results of ADF Test

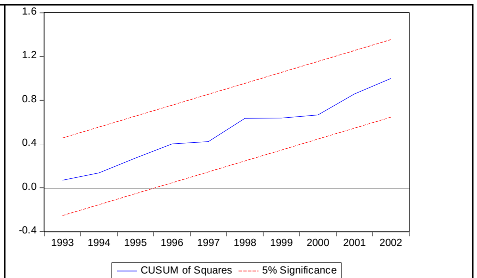
| | ADF | |
|---|---|---|
| Variables | Level | 1st Diff |
| GDP | -2.71 | -4.09*** |
| EC (AGRI) | -2.97** | -6.65*** |
| EC (COM) | -2.97** | -9.48*** |
| EC (DOM) | -1.42 | -5.82*** |
| EC (IND) | -2.23 | -5.64*** |
| GC (DOM) | -2.21 | -9.35*** |
| GC (COM) | -1.62 | -4.41*** |
| GC (IND) | -1.30 | -3.31** |
| FO | -3.13** | |
| HOBC | -1.12 | -3.15** |
| HSD | -3.01** | |
| LDO | -2.00 | -5.47*** |
| MS | -0.18 | -7.281*** |
| SK | 0.630 | -4.80*** |
| EN (AGR) | -0.51 | -5.65*** |
| EN (COM) | 0.494 | -3.25** |
| EN (DOM) | -1.77 | -5.433** |
| EN (IND) | -0.99 | -5.82*** |
| GN (COM) | -0.48 | -3.30** |
| GN (DOM) | 3.159 | -3.76*** |
| GN (IND) | -1.93 | -3.37** |
| EP (IND) | 0.775 | -5.34*** |
| EP (COM) | 1.268 | -5.13*** |
| EP (DOM) | 0.550 | -5.47*** |
| EP (IND) | 1.243 | -4.53*** |
| TC | -1.93 | -6.18*** |
| GP (COM) | -0.54 | -6.44*** |
| GP (DOM) | 1.089 | -5.24*** |
| GP (IND) | -1.48 | -5.84*** |
| SKP | 0.169 | -6.43*** |
| HSDP | 0.37 | -7.13*** |
| FOP | -3.600** | |
| MSP | -2.34 | -4.56*** |

**Table A2 ARDL Stability Tests Result**

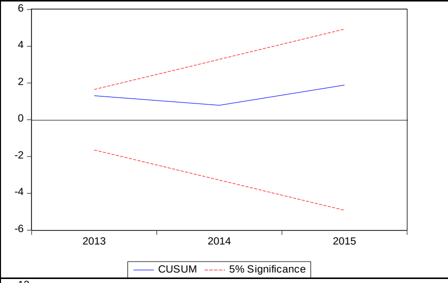
| Model | CUSUM Test | CUSUMSQ Test |
|---|---|---|
| EC(H) |   |   |
| EC(I) |   |   |
| EC(C) |   |   |
| EC(A) |   |   |
| GC(H) |   |   |
| GC(I) |   |   |

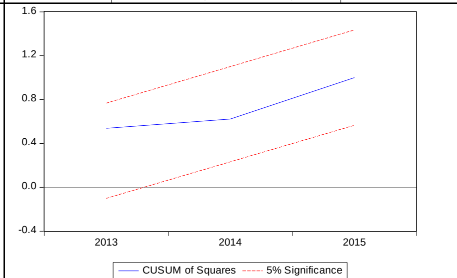
GC(C)



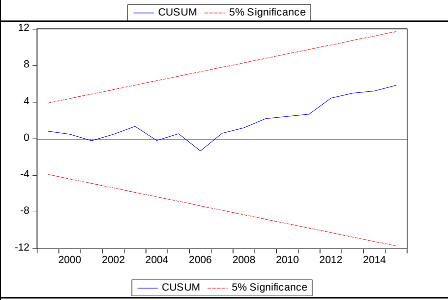



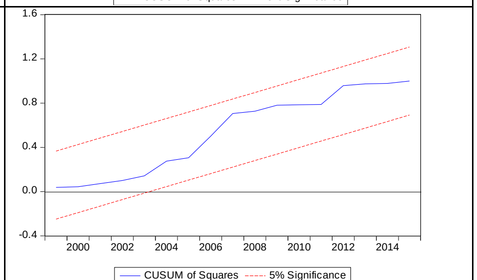

SK



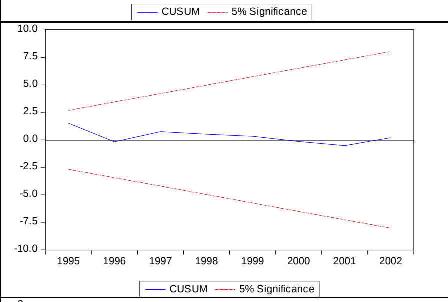



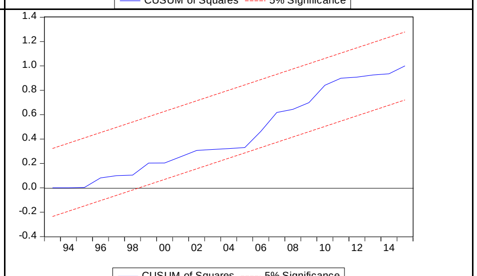

FO



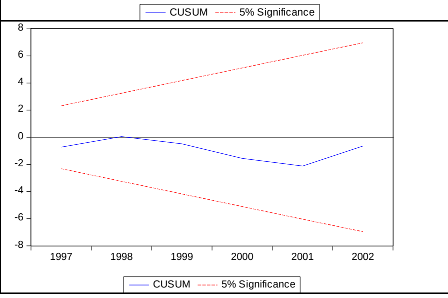



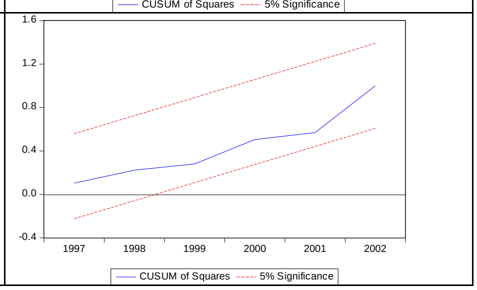

HSD




MS



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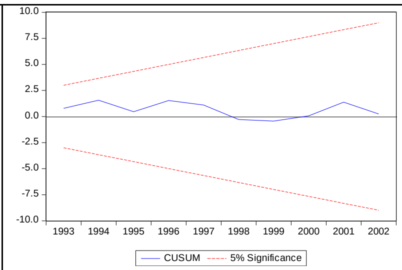
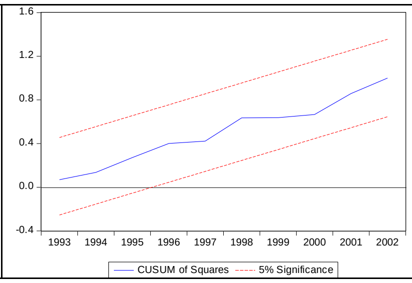
| LDO |  |  |