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Author(s)

Aneeq Sarwar [1]
Uzma Hanif [2]

Affiliations

[1]BS Economics, Forman Christian College University, Lahore, Pakistan
[2]Assistant Professor, Forman Christian College University, Lahore, Pakistan

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Aneeq Sarwar[1]

Uzma Hanif [2]

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Abstract

The problem of energy is one that has plagued the economic growth of Pakistan for decades; the resulting domestic pressure has often led to the misallocation of resources, and therefore should be studied extensively for evidence based policy recommendation. The study in hand aims to envelope and analyze approximate factors responsible for determining electricity demand in the country. The study analyzes the aggregate demand for electricity in Pakistan from 1975-2016, by considering log-run climatic variable affecting electricity demand. The ADF, the Johansen Cointegration, and the ARDL techniques have been applied for the estimation of parameters and analysis. The scientific analysis found that in the short run and long run number of consumers, income (real GDP per capita) square of income and stock of appliances have a significant relationship with the demand of electricity. Where all significant relationships in the long run have a positive relationship with the demand apart from the square of income which may suggest a shift towards alternate means of energy production with a long term sustained growth in income. While, price is found to be insignificant determinant of

[1] BS Economics, Forman Christian College University, Lahore, Pakistan. Email: aneeq.alikhan@gmail.com

[2] Assistant Professor, Forman Christian College University, Lahore, Pakistan. Email: uzmahanif@fccollege.edu.pk

electricity demand in both short run and long run, which reveals that electricity is considered a necessity by Pakistan's electricity consumers. In the short run number of consumers, income, squared income, and stock of appliances, all have significant positive relationships with demand, and temperature has an insignificant positive relationship in the short run, but a significant positive relationship in the long run.

Keywords: Electricity, Demand Analysis, Pakistan**.**
***JEL Classification*:** Q41

1. Introduction

The very fabric of a society is held together by sufficient if not plenty resources, any resource base must meet the growth of the respective demand. One of the fundamental physical prerequisites of growth is a consistent supply of energy, where a sufficient base of energy does not exist, the supply will not meet the demand. Pakistan, like most other developing nations has faced systemic issues in its growth, which has been fractured and spurious, rather than sustained and consistent. One of the fundamental problems behind the lack of sustainable growth, apart from the plethora of governance issues, is the energy crisis. The failure to predict, measure, and analyze the energy demand and supply patterns that pave the way for a policy failure in respect to energy. The measurement of the demand for electricity then becomes an extremely important focus for economic development policies. There has been sufficient research for the effect of measuring the demand and the demand elasticity for electricity in Pakistan with respect to the domestic, industrial, and agricultural sectors, however, a small niche presents itself in recent years with the analysis for the past half-decade missing from popular literature. This paper aims to fill this niche by including the demand analysis years from 1975-2016.

Energy in the modern times has assumed a pivotal place in the social and economic life of a nation. There is a strong relationship between the stage of development of an economy and the consumption of electricity. Electricity economics, a subsector of Energy Economics is related to the economic theory and the pricing of electricity i.e. retail supply to an individual user, and the management of demand and supply accordingly.

Thus, electricity, the primary source of energy in Pakistan is not only life to the industry, commercial sector, and agricultural sector but also the household sector, Table 1 shows the breakup of sector-wise electricity consumption in Pakistan as documented by the Economic Survey of Pakistan from 2001-08.

As shown in Table 1, the major consumers of electricity in Pakistan are the households. Thus, any policy failure about energy or electricity would have the highest impact on the consumers, keeping in view the growing population of a developing country, cannot afford to have significant unrequired disturbances in their consumption or expenditure patterns. In this perspective, the fact that Pakistan has a high population growth rate in the world, which is one of the world's highest (Komal & Abbas, 2015), the electricity consumption is only bound to increase, with that in mind, it is of critical importance that the country has up to date respective policies.

Table 1: Sector Wise Electricity Consumption, Pakistan

Sectors	Percentage Share
Household	45.6
Commercial use	7.4
Industrial use	28.4
Agricultural use	11.8
Street Light	0.6
Other Govt.	6.2

Source: Pakistan Economic Survey, 2007-08

The demand for electricity is dynamic in its nature; it changes with changing demographics and lifestyles, especially in the face of the recent westernization of Asian societies. Pakistani households have seen a surge in the number and use of appliances, and they have seen radical changes in their infrastructure, which coupled with urbanization, global warming, and the urban heat wave effect have drastically changed the consumption of electricity in the last decade (Madlener & Sunak, 2011). The country has a sub-tropical climate, which means that the general weather in the country is hot and can often reach unbearable temperatures (Herring et al., 2016). Faulty and deficient energy policies in Pakistan and contemporary energy issues could be the cause of the failure of the energy policy in Pakistan.

An updated research enveloping the recent years would result in a comprehensive and cutting edge grounding for stakeholders. It would also grease the process of updating policies to reflect the dynamic nature of electricity consumption patterns. Pakistan is transitioning rapidly from a rural to an urban economy, and as statistics would suggest (Ranis, Stewart, & Ramirez, 2000) the demand and consumption for energy is bound to rise, which requires the adaption of policy and policy framework, thus the relevance of the current study. There also exists a research gap of recent electricity demand analysis in popular literature.

1.1. Research Question

The study in hand addresses the following question: Does a fluctuation in the price of electricity influences the demand of electricity in the long term?

1.2. Study Objectives

The objective of this study is to extensively analyze the demand for electricity in Pakistan, based on aggregate consumption patterns to recommend evidence based policy framework for efficient and effective energy planning in Pakistan.

2. Literature Review

This section analyzes existing literature relating to the topic.

Alter and Syed (2011) have attempted to look at the electricity demand in Pakistan. They have brought to use the time series analysis, and the Vector Error Correction and co-integration methods to evaluate the short and long run association between the demand of electricity and the causes of such associations. The study found that the demand of the electricity should be managed via policies related to peak load pricing policies, group pricing, and effective pricing.

Khan and Ahmed (2008) have used the time series data to analyze the trends in the disaggregate demand for energy in Pakistan. They have looked at the short and the long run relationship between the disaggregate demand of energy and its major determinants. They have also computed the income elasticities for the inputs which include coal, gas, and oil. The study finds the difference in the elasticities in all components in the energy and presents policy implications for taxation.

Shahbaz and Lean (2012) have evaluated the association between economic growth and electricity consumption in Pakistan. The Granger Causality method has been utilized to explore the relationship between the growth that the country has seen and the consumption of electricity. The study found that there have been negative effects of energy conservation policies on the growth of the country. The study suggests that a prerequisite to economic growth, energy conservation policies should not be adopted, further, alternate sources of energy must be explored and discovered.

Dilaver (2009) looked at the relationship between the total residential electricity consumption and the electricity prices in Turkey. They have used the Structural Time Series Modeling (STSM) technique on the electricity consumption data of Turkey for the years 1971-2006. The demand function for electricity in Turkey is a derived demand based on the households and the firm's production function. The study compares the earlier use of the electricity which was limited to lighting purposes, however, the households have expanded the horizon of their use to keep us with the technological changes in household appliances that now require more energy. The electricity consumption in Turkey has been on the rise on an average of 10 pc per year. The expenditure elasticity of the short run and the long run of the electricity consumption is 2.29 and 0.41 respectively. Whereas the price elasticities for the electricity demand are 0.57 for the short run and -0.01 for the long run. This is representative of the fact that in the short run we cannot work without electricity.

Nasir, Tariq, and Arif (2008) conducted a study on the residential demand for electricity in Pakistan. The study was conducted to measure the elasticity of electricity demand in Pakistan based on the income and household sizes, for the years 1979-2006, using time series data. The study concluded that the demand for electricity is price inelastic, thus categorizing electricity as a necessity in Pakistan. Furthermore, the income elasticity of demand was found to be positive, indicative of the fact that electricity in Pakistan is a normal good.

Nawaz, Iqbal, and Anwar (2013) used the Smooth Transition Autoregressive model (STAR) to estimate the electricity demand function for Pakistan from 1972-2012. Based on the findings of the study, the authors recommend that to sustain a level of six pc annual growth an increase of per annum nine pc in the electricity must be met. For the reason that there is a lack of alternative energy sources the price elasticity is low and there exists a relationship between the consumption of electricity, and the prices, and the real GDP per capita. The authors chose a standard Cobb-Douglas model functional form the electricity consumption elasticity against the GDP per capita, which was found to be > 1, with the conclusion that the changes in price of the electricity has minimal changes in the consumption.

Chaudhry (2010) delved into the firm level consumption of electricity in Pakistan. They constructed a panel data of 63 firms in the country and used the time series of 1998-2008. The results of the study found that a one percent increase in the income of the populace, measure against per capita income will lead to a 0.69 percent rise in the aggregate demand for electricity. Whereas for the price elasticity of demand for electricity for firms, the study found that a rise in the price of electricity will result in a 0.57 percent decrease in the demand for electricity.

Javaid and Qayyum (2014) explored the sectoral levels of electricity consumption such as residential, commercial, industrial, and agricultural sectors, they evaluated the relationship between the consumption of electricity, real economic activity, and the inflated prices of electricity from the range 1972-2012 in Pakistan. Their study while using the ARDL technique found that the supply of electricity in Pakistan is inefficient due to a serious incompetence of infrastructure, and unequal distribution.

Khan and Qayyum (2009) looked over the data from 1970-2006 from Pakistan and evaluated the relationship between the demand of electricity, adjusted against prices and income of the electricity number of consumers respectively, and the mean temperature and the number of consumers. They used the co-integration technique of ARDL Autoregressive Distributed Lag model to look at the long run relationship between the variables, and the error correction model for the short run. The study found that the number of consumers and real income have a positive relationship between the electricity demand in the long run and the prices have a negative relationship.

Ample literature discusses the shortage of electricity faced by the manufacturing sector in Pakistan, Mahmud (2000) talks about the future results and implication of this shortage in this work. His study uses the Partial Equilibrium Approach and the GL model, which revile that rising energy prices do not act as disincentives for investors. The capital remains unaffected in industries where as the cost of manufacture increases. The study reveals that consumers are most affected by a rise in energy prices as the product they buy gets expensive while the investors remain unaffected to a large extent. The author's model further suggests that there are substation policies between gas and oil; the two major sources of energy used in Pakistani industrial sector.

Ashraf, Javid, and Javid (2013) carried out an empirical investigation on exploring the relationship between economic growth and electricity consumption. In the study, a dataset of GDP per capita and electricity from 1971 to 2008 is used. Regression analysis revealed a relationship between the two variables indicating that electricity supply directly influences the growth of a country. The authors argue in favor of affective policies to tackle the electricity shortage that Pakistan faces. While drawing a conclusion the authors highlight that prolonged electricity shortages in the country have proved as an obstacle in achieving the goal of sustainable growth in GDP.

Abbas and Choudhury (2013) used data from Pakistan and India, two of the most densely populated regions in South Asia, to test a causality between electricity consumption and economic growth. Given that, both the countries' economy is highly dependent and involved in agricultural activities the authors' estimations were made with a focus on the agriculture sector. The results revalued different causality relationships for Pakistan and India, owing to differences in political and resources allocation trends of the countries. India's data analysis lead to the conformation of the conservative hypothesis which implies that the country's efforts to conserve electricity will not help meeting the growing demand of energy rather a policy directive to the increase generation of electricity will only help meeting the future demands. In case of Pakistan the conformation of the feed-back hypothesis implies that there is a bidirectional relationship making it hard to suggest a policy direction here.

Statistics indicate that supply and use of electricity to domestic units in Pakistan has constantly risen (Rehman, Tariq, & Khan, 2010). With the wave of technological gadgets becoming part of everyday life the use and reliance on electricity has become central to every household in Pakistan. In a case study from Peshawar regarding domestic electricity consumption patterns it was revealed that weather, level of education, price of electricity, and number of rooms in a house have a significant influence of electricity usage (Rehman et al., 2010). The researchers used data from 200 households sample survey from Peshawar and applied Multinomial Logistic model to derive the results. The case study provides meaningful answers but due to demographical, economic, and cultural variables cannot be applied to Pakistan holistically.

Amarawickrama and Hunt (2008) carried out a detailed study of the demand of electricity in Sri Lanka. Using a time series analysis the study applied six different econometric models on the dataset. The six models used predicted estimations for Sir Lanka's demand in electricity by 2025. The income of consumers and price elasticity varied widely in the six models but despite the differences in forecast, the models do promise reliable for use for future electricity forecasting in Sri Lanka.

As the Pakistani economy opened to the rest of the world in 1990's, with trade liberalization, the country's energy sector was pushed towards privatization. Qudrat-Ullah and Davidsen (2001) used a Dynamic Simulation model to trace out the impact of the creation of independent power projects (IPPs), CO_2 emissions and electricity supply in the past few decades in Pakistan. The study discovers that over the decades the country has neglected the potential of hydroelectric power and polices have favored to attract IPPs which use fossil fuels for energy production. Currently even with the presence of IPPs the energy crises looms over Pakistan. The study points the IPPs with their reliance of fossil fuels such as petrol, coal, and natural gas have had adverse environmental impacts such as high carbon emissions in Pakistan.

Espey and Espey (2004) used a wide range of studies for a Meta-Analysis of energy supply. The authors explored the effect of multiple factors on the estimated elasticity of domestic residential electricity demand. Price and the income elasticity were used as dependent variables whereas several models are estimated in the study. The authors used a Least Square Estimation of Semi Log model and a Gamma model to run the extracted information for the meta-analysis. The detailed survey of data is beneficial for policy makers and governments because it gives a comprehensive account of the responsiveness of domestic consumers to price and income fluctuations when using electricity in the United States.

To review the energy demands of a developed country, Australia is a useful study. A comprehensive study by Azad, Rasul, Khan, Omri, Bhuiya, and Hazrat (2014) revealed that the major chuck of energy consumption in the country is not the domestic sector rather it is transport, industrial activity, and electricity generations. The study explores the possible ways for the country to keep up with the demand of energy. Using time series data and energy model for economic growth, the authors revealed that dependence on a single source of production of energy is not a smart move in Australia. Diversifying the sources and increased reliance on non-renewable source were seen as two factors contributing positively to economic growth of the country with an added benefit of reduction in CO_2 emissions.

Ziramba (2008) used a time series data set from 1978-2005 to explore the relationship among different factors responsible for the demand of residential electricity. The author explored real gross domestic product per capita and the price of electricity during the time frame. With the help of bonds cointegration approach by Pesaran, Shin, and Smith (2000) and linear double-logarithmic specification is analyzed. The income of consumers and the price of electricity are kept as independent variables. The results reveal that income is the prime determinate of electricity demand for a consumer irrespective of the price of electricity in South Africa.

To think that energy shortages are a developing country's problem is myopic, developed countries like the US also face shortages but their strong institutions and affective policy directives control the damage. Faruqui, Hledi, and Sergici (2009) investigate the effectiveness of policy suggestions made to counter the 2000-2001 electricity shortages faced by the United States of America. The authors used data from multiple studies conducted around the time to see if pricing the product (electricity) leads to a reduction in its use. The installation of dynamic pricing meters is a onetime cost that the authors argue gets coved when energy is less in demand and the production cost is cut in the long run. The Meta-Analyses of pilots of the projects revealed that indeed consumers cut down their energy use with expensive electricity.

In the UK and European Union the governments have invested in smart meters. These meters are different for conventional meters because they give a detailed to the consumer and providers of electricity consumption by a particular household. The data has been valuable in advising households to reduce wastage and adapt to practices that reduce energy usage. Laicane, Blumberga, Rosa, and Blumberga (2014) undertake a demand side management approach of electricity consumption. The authors targeted two appliances, washing machines and dishwashers, to ask a sample of households about their usage patterns. Using data from the smart meters and the household usage patterns the authors were able to device suggestions for domestic users reading the appliance. With a load shifting strategy households can save up to 24% on washing machines' and 13.5% on dishwashers' electricity consumption (Laicane et al., 2014).

3. Methodology

This section outlines the opted methodology for the study.

3.1. Theoretical Framework

The standard law of demand governed popular thought in Economics, it laid the foundation of most economic policy and theory. The standard law of demand theorizes that any increase in the price of a good results in a decrease in the demand of that good. However, with the advent of consumer societies and the greater understanding of individual consumer expenditure behavior economics began to categorize demand in multiple forms, depending on the nature of the good; normal, inferior and luxury goods.

3.2. Income Elasticity of Demand

This is the measure of the change in the demand of a commodity against the changes in the income of the consumer. Where the changes in the income results in changes in the demand of the good greater than the change in the income are called relatively income elastic goods, as opposed to relatively income inelastic goods (Samuelson, 2001).

This paper measures the aggregate demand of electricity over the course of several decades in Pakistan; electricity is in the 21st century classified as a necessity and a near perfectly inelastic commodity with respect to the changes in price. A recent study of energy policies in Pakistan shows us drastic changes in the price of electricity and that it can be at times unpredictable (Muneer & Asif, 2007). This has pushed most people belonging to higher income classes to shift to alternate sources of energy, such as miniature solar or fossil fuel based generation facilities that are primarily home based. Whereas consumers belonging to the middle and lower income classes have little to no choice with regards to such a maneuver, they generally resort to electricity storing appliances which can provide power at times of outages. Thus this paper hypothesizes that electricity in the long run will remain unaffected by changes in the price of electricity, since most of the consumers belong to the middle and lower income classes, and when it comes to consumption patterns are mostly consuming energy that goes towards appliances that are needed in daily life, and thus hard to cut down on. The upper income classes are either unaffected by changes in price because they have little care for minor changes in their expenditure with regards to necessities or they are majorly reliant on alternate sources for energy. Thus any radical increases, which have become the norm are harmful towards the maintenance of a dignified standard of living for the majority of the population, electricity should thus be heavily subsidized, and should not have outages. The cost of both should be born via an extremely progressive method, in order to aid a proper redistribution of wealth, which is a necessity especially in the face of the rampant inequality that the world faces today.

The purpose of the paper is to measure the effect of changing prices of electricity on the demand for electricity. To account for changes in the demand due to other variables such as an increase in the number of consumers, and the price of electricity both have been included in the model, so as to determine the extent of the effect of change in the prices of electricity in the long run. Symptomatic to a developing country is vast and uncontrolled population growth, which results in changes in the demand for electricity, thus the model must account for such changes. Whereas, mean temperature also effects demand in a country like Pakistan so it is also included.

3.3. Data Description

This study is primarily dependent upon secondary data. The data has been obtained from various sources, which includes the Pakistan Energy Year Book (2017). Additionally, some data has been obtained from the World Development Indicators (2017). The time series data from 1975-2016 is used for the analysis. Lastly, the data of electricity demand have been obtained from Pakistan Bureau of Statistics, and the electricity generating and distributing authority (i.e. Pakistan Electric Power Company (PEPCO)).

3.4. Variables

The variables are; LAD (log of aggregate electricity consumption demand), LTNC (log of total number of electricity consumers), LAP (log of average prices), and LGDP (log of Real GDP per capita), LSOA (log of stock of appliances), LTEMP (log of average annual temperatures), LGDP2 (log of Square of GDP Per capita), DUM is a structural break variable accounting for significant regime change using Bai and Perron (1998) method in order to stabilize the model, the variables which have been used to compute the aggregate demand for electricity in the model. The log of the variables has been used as a replacement for the direct numbers of the variables as the values vary by a great degree, whereas a log of the values would standardize them to a great degree and will allow us to compare and contrast the changes in the variables without the effect of the difference in the measurement units. Which would have otherwise affected the analysis of the variables.

3.5. Econometric Model

Following is the estimation equation which this study will be using.

$$LAD_t = \alpha + \beta_1 LTNC_t + \beta_2 LAP_t + \beta_3 LGDP_t + \beta_4 LGDP_t^{\,2} + \beta_5 LSOA_t + \beta_6 LTEMP_t + \beta_7 DUM_t + \varepsilon_t \quad \textbf{(1)}$$

Since this data is time series hence it is expected that variables will be weakly exogenous and have order of integration higher than 0. For the purpose unit root will be tested using Augmented Dickey Fuller test. The Johansen and Juselius (JJ) (1990) cointegration method and Pesaran et al. (2000) cointegration method will be used to check the long run relationship. Both of these co-integration tests will ensure robustness of the relationship between the variables (Johansen & Juselius, 1990; Pesaran et al., 2000). The model will finally be estimated using the ARDL model which provides long run and short run estimates irrespective of the order of integration of the variables.

3.6. Unit Root Test

As per the findings of the literature review, the model most popularly used in similar studies is the multivariate cointegration technique. Dickey and Fuller (1979) developed the first order auto regressive model to check the stationarity of the variables. This process was developed to capture the process in which a series is generated, as under white noise or as opposed to the random walk process. These models are tested for the unit root test to examine the stationarity of the variables.

Ho: Non stationary ($\delta = 0$) Ha: Stationary ($\delta < 0$)

To check the stationarity of the variables we use the probability values or t ratios. However, since the Dickey Fuller test assumes that the error term is uncorrelated, and that may not be true for every model, ADF must be applied. Later on, Dickey and Fuller (1981) developed a new model to address the respective problem via a model called the Augmented Dickey Fuller Test. By including the lagged difference term of the dependent variable as an independent variable, this test takes care of the problem of serial correlation (Cheung & Lai, 1995).

3.7. Long run and Short run Relationship Test

Johansen (1988) and Johansen and Juselius (1990) have defined steps for deriving reliable results. These steps are discussed below: For the application of Johansen Co-integration technique, all-time series variables of the study, should be integrated of order one [I (1)]. For the second step, on the basis of minimum values of Akaike Information Criterion (AIC), Final Predication Error (FPE), and Hannan and Quinn information criterion (HQ) lag length of the variables would be chosen using VAR model. For the third step, suitable model in context of the deterministic factors in the multivariate system are to be chosen. Johansen (1988) and Johansen and Juselius (1990) analyzed two methods for determining the number of co-integrating relations and both cover the matrix Π estimation. Maximal Eigen value statistics and trace statistic are used in 4th step for no of co-integrating relationships and as well as for the values of coefficients and standard errors in the context of econometric model (Johansen & Juselius, 1990).

Also many of the economists used ARDL model to examine the co-integration among variables. All techniques have certain conditions, for the JJ technique the dependent variables must be stationary at first difference while in Johansen approach dependent as well as independent variables must be stationary at first difference. After the application of the Johansen technique, to find out the short run relationship the vector error correction method is applied. The ARDL model is also used for the short run relationship test.

4. Estimation and Analysis

This section comprises of data analysis and estimation.

4.1. Unit Root Test Results

The results of the ADF is presented in Table 2, the results show that all variables are stationary at first difference except the average annual temperatures. As per the results of this test we proceeded to execute a test to detect the long run relationship of the variables. As it follows from economic theory, where the variables may in some cases deviate from the steady state in the short run, they will eventually converge to said steady state in the long run. To this end we shall utilize the Johansen and Juselius (1990) method.

Table 2: Unit Root Test Results

Variables	Level	1^{st} Difference
Demand	-0.10	-6.66
	0.99	0.00*
Consumers	-0.73	-5.76
	0.96	0.00*
Price	-1.95	-4.66
	0.60	0.00*
Income (GDP)	-2.00	-4.62
	0.58	0.00*
Stock of Appliances	-2.71	-5.44
	0.23	0.00*
Average Annual Temp	-5.69	-8.48
	0.00*	0.00*
Square of GDP	-1.95	-4.37
	0.30	0.00*

Note:* significant p values at 1%

4.2. Cointegration Tests

According to the results of the unit root test, the data series are integrated at mixed order. This study will use both Johanson and Persaran based co-integration tests to ensure robustness of the relationship. The VECM technique is used to examine the relationship between the variables, the AIC and the SC criterion have been used to determine the lag length of the VAR model. This study used the lag order 1 as per the results of the above examination and will proceed henceforth. The Trace and Max Eigen results are as shown in Table 3 and 4. Similarly ARDL cointegrating bounds test is also shown in Table 5 which confirms the presence of cointegration.

Table 3: Cointegration rank test (Trace Statistic)

Hypotheses	Trace Test	P- Value**	Decision
H0: r=0, r>0*	213.75	0.00***	Trace Test results indicate that there are only two co-integrating vectors
H0: r<1, r>1*	129.41	0.00***	
H0: r<2, r>2	72.46	0.14	
H0: r<3, r>3	48.73	0.16	
H0: r<4, r>4	28.14	0.22	
H0: r<5, r>5	12.01	0.30	
H0: r<6, r>6	1.23	0.26	

Note: *** Significant p values at 1%
**MacKinnon-Haug-Michelis (1999) p-values
* denotes rejection of the hypothesis at 0.05 level

Table 4: Cointegration rank test (Max Eigen Value)

Hypotheses	Max Eigen Test	P-Value**	Decision
H0: r=0, r>0*	84.34	0.00***	Max Eigen test results indicate that there are only two co-integrating vectors
H0: r<1, r>1*	56.65	0.00***	
H0: r<2, r>2	22.02	0.66	
H0: r<3, r>3	20.59	0.50	
H0: r<4, r>4	16.12	0.40	
H0: r<5, r>5	10.78	0.32	
H0: r<6, r>6	1.23	0.26	

Note: *** Significant at 1%
**MacKinnon-Haug-Michelis (1999) p-values
* denotes rejection of the hypothesis at 0.05 level

Table 5: ARDL Bounds Test to test for Cointegration

Sample: 1978 2016
Included observations: 39
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	6.833	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

4.3. Short Run Estimation

This standard specific form has been applied in Table 6 to estimate the short run coefficients and to define the pace of adjustment of the variables.

The results in Table 6 are representative of the fact that there is a short run relationship between demand and the number of consumers, stock of appliances, the income and squared income, are significant and have a positive relationship with demand, which goes to show that the greater the number of consumers the greater the demand for electricity, and similarly for the income, that the greater the income the greater the demand for electricity, and for stock of appliances yet the price is having a negative relationship, it is insignificant, which goes to show that either price is not a major determinant or perhaps there is inelasticity towards price with respect to a lack of suitable alternatives or the inability to reduce consumption in short run, both which may be true in the context of the Pakistan economy. Temperature is also seen as insignificant in the short run, which goes to show that consumption is not affected by changes in temperature in Pakistan.

Table 6: Short Run dynamic analysis on ARDL model

Variable	Coefficient (Standard Error)	t-Statistic	Prob.
D(LAP)	-0.019 (0.06)	-0.28	0.77
D(LAP(-1))	0.13 (0.07)	1.86	0.07
D(LAP(-2))	-0.09 (0.05)	-1.74	0.09
D(LTNC)	0.99 (0.30)	3.27	0.00*
D(LGDP)	15.02 (8.36)	1.79	0.08
D(LGDP(-1))	-39.16 (10.22)	-3.83	0.00*
D($LGDP^2$)	-2.56 (1.41)	-1.81	0.08
D($LGDP^2$(-1))	6737565 (1.77)	3.79	0.00*
D($LGDP^2$(-2))	0.05 (0.05)	1.00	0.33
D(LSOA)	0.04 (0.03)	1.77	0.09
D(LSOA(-1))	-0.04 (0.03)	-1.40	0.17
D(LTEMP)	0.42 (0.26)	1.59	0.12
D(DUM)	0.01 (0.01)	1.14	0.26
CointEq(-1)	-0.89 (0.18)	-4.99	0.00*

Note: *Significant at 1%, D means First difference (Δ)

Table 7: Results on Long Run analysis on ECM model

Variable	Coefficient (Standard Error)	t-Statistic	Prob.
LAP	-0.02 (0.04)	-0.44	0.66
LTNC	0.72 (0.16)	4.49	0.00*
LGDP	24.49 (3.50)	6.99	0.00*
$LGDP^2$	-4.20 (0.60)	-6.96	0.00*
LSOA	0.13 (0.03)	3.69	0.00*
LTEMP	0.86 (0.50)	1.71	0.10
DUM	0.02 (0.13)	1.27	0.22
C	-37.82 (5.01)	-7.54	0.00*

Note: *Significant at 1%

The above results in Table 7 show the long run relationship which reveal that the stock of appliances, income, squared income, temperature and number of consumers have a positive relationship with the demand and are significant in the long run. Whereas the square of the income has a negative relationship and is significant which means that as income grows and people climb the income range, they are more likely to shift to alternate sources of energy, either environmentally friendly such as solar or unfriendly such as diesel power generation, a separate study would be required to determine which way the shift is. This represents the fact that with increases in income, with a saturation of demand, consumers shift towards alternate sources, as perhaps they are able to afford these alternate sources of energy. This shows that income is forming inverted U shape relationship with the electricity demand. Further this non-linear pattern depict that if incomes are increased by 2.9% then people will start shifting towards energy alternatives. [3]

[3] For optimal level of income

$$LAD = 24.49 LGDP - 4.20 LGDP^2$$

$$\partial LAD / \partial LGDP = 24.49 - (2 * 4.20) LGDP = 0$$

$$LGDP = 24.49 / (2 * 4.20) = 2.91$$

The price is however insignificant, although the relationship is negative and conforms to the law of demand, the insignificance represents the fact that consumers are not able to respond to changes in price. This can be due to the fact that electricity is a necessity, and consumers do not have an option or the ability to make an active decision regarding the consumption of electricity. This is representative of the price inelasticity of demand of electricity in the long run. Which may also support the negative relationship of the squared income, as consumers who have a certain level of disposable income shift to alternate sources of energy such as diesel generators, and domestic solar plates so as not to be dependent on the fluctuations in energy supply and price.

The below Figure 1 shows that the model is normally distributed, and the tests below in Table 8, 9 and 10, show that there is no autocorrelation, heteroskedasticity or mis-specification.

Figure 1: Normality Test

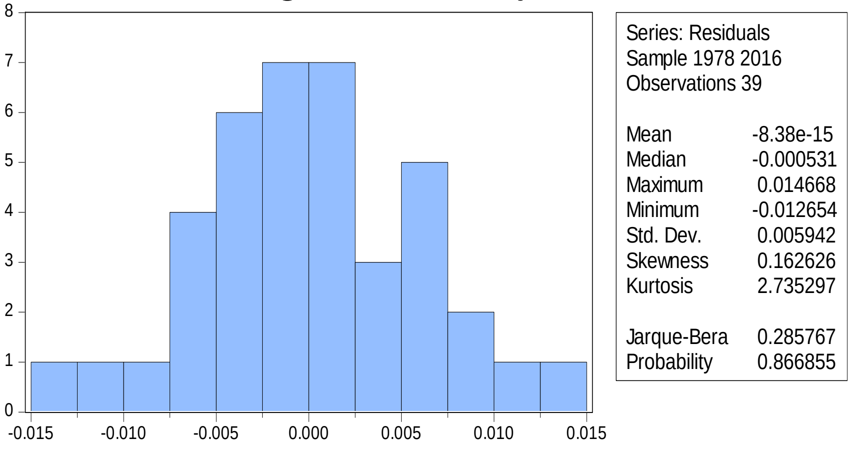


Table 8: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.56	Prob. F(1,17)	0.46
Obs*R-squared	1.24	Prob. Chi-Square(1)	0.26

Table 9: Heteroskedasticity Test

F-statistic	0.52	Prob. F(20,18)	0.91
Obs*R-squared	14.35	Prob. Chi-Square(20)	0.81
Scaled explained SS	2.65	Prob. Chi-Square(20)	1.00

Table 10: Ramsey RESET Test

	Value	Df	Prob.
T-statistic	0.25	17	0.80
F-statistic	0.06	(1,17)	0.80

Further CUSUM and CUSUM sq. graphs are drawn to test the stability of the mean and standard deviation of the coefficients of the model. The Figure 2 and 3, shows that the estimates of the model are stable.

Figure 2: CUSUM Graph

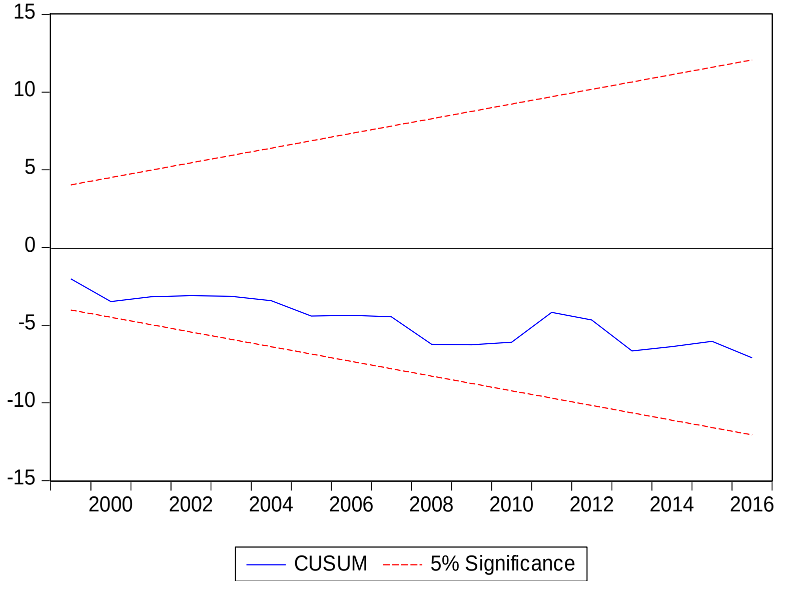
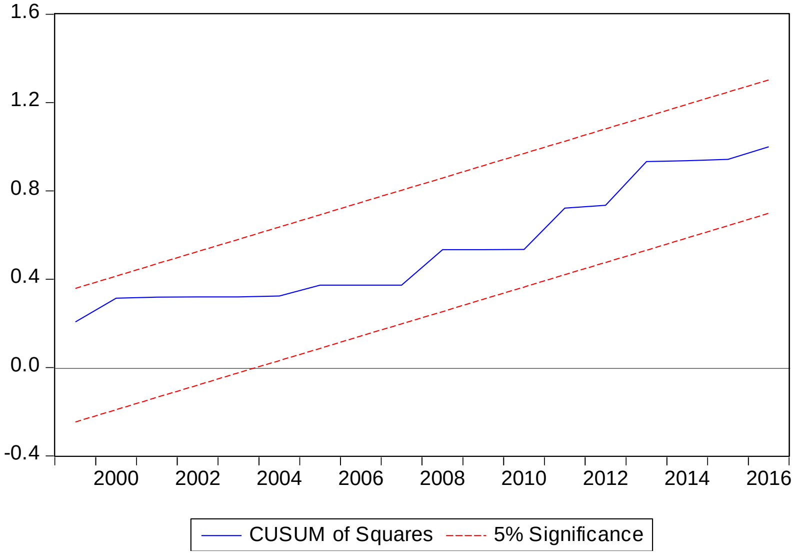


Figure 3: CUSUM Sq Graph



5. Conclusion and Policy Implications

5.1. Conclusion

This section expands on the conclusions of the study that are substantiated by the literature and the estimation results of the study. The above results are representative of the fact that there is a short run significant relationship between demand and the number of consumers, and the income, income squared, stock of appliances, and an insignificant relationship in the short run between demand and temperature, all however are positive relationships and conform to theory. This represents the fact that in the short run any increases in consumers, i.e. the electricity connections, income, and temperature result in an increase in the demand for electricity. Where an increase in income may result in an increase in the stock of appliances and their use, however in the long run the income squared has a negative and significant relationship with demand because in sustained income increases after a saturation of demand consumers are displaying the tendency to shift to alternate sources of energy, possibly because such sources of energy provide a more stable and continuous supply of power, however, it remains to be seen whether this shift is towards alternates that are environmentally friendly or not. The latter would have dire consequences for Pakistan's environment. In the long run temperature, stock of appliances, income and number of consumers have a positive significant relationship with demand, all of which conforms with theory in the fact that any increase in the number of consumers, stock of appliances, temperature, or income would lead to an increase in the demand for electricity. The price has a negative relationship in the long and short run, while that conforms with theory, it is insignificant, which goes to show that either price is not a major determinant in the decision to consume demand or perhaps there is inelasticity towards price as there is an absence of electricity alternative/s or the inability to reduce consumption, both which may be true in the context of the Pakistan economy. It can also be the fact that the consumption of electricity is not always a conscious decision, such as the running of lights, fans, and other household items that are seen as a necessity, and thus it deprives consumers of the ability to make decisions of consumption of electricity which respond to changes in price. As the above results are representative of, the Error Correction Term for the period, which in this case is the annum, shows that though there is divergence from the equilibrium in the short run or in other words the 'steady state', in the long run there is the return to the equilibrium by the factor of the coefficient of the ECM i.e. -0.89. The negative sign implies a return to the equilibrium or more specifically a convergence in the model. Lastly, considering the fact that the demand for electricity in price inelastic and the number of consumers is rapidly rising with the rise in population the management of the supply is needed to control the rising prices and to meet the supply. Which can be projected to increase drastically with the population bomb, thus future initiatives must be taken to foresee and meet the demand to prevent a shortfall and any sudden increase in prices.

5.2. Policy Implications

Following are the policy impactions of the study with respect to the findings: Demand for electricity is price inelastic in both, short and long run, represented by its insignificance with relationship to demand, because electricity is a necessity. Policy makers should attempt to keep in control the price of electricity because this inelasticity would mean that the consumers would have to sacrifice other expenses to pay for any price increases, keeping other factors constant.

As electricity, demand increases with the income in real GDP per capita in the short run and long run. While , an increase in income (represented squared GDP per capita) in the long term results in a decrease in the demand for electricity, which may indicate the fact that individuals with more disposable income shift to alternate sources of energy. Thus, electricity planning should be closely associated with per capita income change. Average annual temperature is continuously increasing around the globe due to global warming; Pakistan is not immune to this phenomenon. Average annual temperature is also found as a significant variable in the demand of electricity for Pakistan. As average annual temperature in Pakistan is rapidly increasing, with increases in temperature the demand for electricity increases for cooling equipment, which coupled with the increase in population will mean that the electricity demand will see rapid increase in the long run. Policy makers must not only aim to meet this demand under the future projection for temperature in Pakistan, but also consider environmental factors to abate global impact of climate change on domestic electricity demand and to develop electricity production sources that will not negatively impact the environment.

Number of consumers has a significant positive relationship with electricity demand, and keeping in mind that the number of consumers is continuously rising with the rise in population of the country, future initiatives must be planned to foresee and meet future demand to prevent a shortfall, which must be in line with projected population growth.

As the stock of household appliances increases, the demand for electricity also increases to run these appliances, this is confirmed by the significant positive relationship of the stock of appliances with demand in both short run and log run. To target policies to reduce the use of home appliances could decrease the living standard of the country. Therefore, policies should be framed to plan to electricity production in accordance with increase in home appliances in the country.

5.3. Limitations

The following section deals with the limitations of the study, which are as follows:

This is a quantitative study where as a qualitative study is required to determine the exact detriments of the consumption of electricity across income groups.

This study is an aggregate demand analysis and sectoral electricity consumption patterns must be chartered for an effective overview of the particular sector of the economy.

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