Study of relationship between Electricity consumption, foreign assistance and GDP per capita using the ARDL approach: An investigation into Pakistan energy sector.

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ABSTRACT

Electricity having a wide range application in both domestic and industrial sectors is a major source of energy generation in Pakistan. Considering its increasing significance, the current study contributes in the area of research by employing ARDL[1] approach to study the short-term/long-term relationship between energy consumption, foreign assistance and GDP per capita in Pakistan. The time-series data from 1981-2015 is taken for the study. Empirical results shows no significant relationship between energy consumption and foreign assistance in short-run, a significant relationship between electricity consumption and foreign assistance in the long-run, and again no significant relationship between electricity consumption and GDP per capita both in short-run and long-run.

Keywords: Electricity consumption; foreign assistance; GDP[2] per Capita; ARDL; Pakistan

1. Introduction

Since the dawn of the current century, the global importance of energy sector has increased manifold. Furthermore, increase in general awareness and rapid technological advancement stipulates availability of abundant energy resources for domestic/industrial usage and efficient execution and completion of industrial processes. Primarily, energy is sourced from electrical power, natural gas, petroleum, coal and nuclear power although the use of these energy sources varies in every country (Nasir, Tariq, & Arif, 2008). However, the most adaptable and resourceful energy carrier in the modern era is electricity, and is highly imperative for social and economic development. Resultantly, increase in use of electricity as an energy source has surpassed other sources and still depicts considerable global expansion. Moreover, this trend is likely to continue into future especially in developing economies' rural population (Lenzen, 2010).

Electricity is considered a backbone for economic development and prosperity since it plays a significant role in the socio-economic development. Presently, extensive research is being carried

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[1] Autoregressive distributed lag model
[2] Gross domestic product

out in order to address the issue of ever-increasing demand for energy. In Pakistan, electricity is a major source of energy generation with wide range applications in industrial, commercial, agricultural and domestic sectors (Alter & Syed, 2011). According to a rough estimate, till 2008 86% of Pakistani population had access to electricity which increased to 99.14% in 2016 (World Bank Group, 2016), which indicates progressive access to electricity due to increasing demand. However, it also stipulates for appropriate planning and formulation of effective strategies in field of electricity demand management. Moreover, price fluctuation and adoption of advanced technology in various sectors has led to increase in consumption level of electricity (Khan & Abdul, 2008).

Since the last decade, Pakistan has been facing severe electricity shortfall, which not only affected the national growth but has also prevented the country's economy from reaching its full potential (Khan, Shah, & Khan, 2016). Simultaneously, the country is faced with ever-increasing demand for electricity, which has increased at an annual rate of 6% from 2001 to 2008 thus causing a massive gap between electricity demand and supply. The electricity shortfall was estimated at 6000 MW in 2012 (Kessides, 2013), which decreased to 4250 MW in 2013 but increased to 8000 MW in 2017. Moreover, experts predict that this shortfall is expected to reach 13000 MW in 2020 (Khan, Shah, & Khan, 2016). According to WAPDA[3], the installed generation capacity in the country would be expanded to 28000 MW. Presently, infrastructure transmission and distribution capacity is approximately 22000 MW, whereas demand for electricity consumption is approximately 25000 MW, which still leaves a deficit of 3000 MW (Rehman, 2018).

According to Economic Survey of Pakistan, in 2008, the consumption of electricity for domestic sector was (45.6%), industrial sector was (28.4%), agriculture sector was (11.8%) and commercial sector was (7.4%) whereas remaining 6.8% was utilized for miscellaneous purposes (Nasir, Tariq, & Arif, 2008). However, in 2018 the consumption of electricity increased to (51%) for domestic sector and 8% for commercial sector, whereas decreased to 25% for industrial sector and 10% for agriculture sector while remaining 6% was utilized for miscellaneous purposes (Finance Division, 2018).

Generally, economies initiate foreign assistance programs to respond to changing humanitarian needs and developmental goals. These programs constitute an essential part of a country's

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[3] Water and Power Development Authority

foreign policy. Furthermore, developed economies create a dependent relationship with the developing/underdeveloped economies through their distinct assistance policy. Moreover, foreign assistance both positively and negatively, could affect the dynamics of the recipient country. The school of thought that advocates foreign assistance states that it is necessary and highly beneficial for economic, social, and political development of an economy. On the other hand, the school of thought opposing foreign assistance considers it a hindrance in country's economic, social, and political growth and source of foreign influence in the country's affairs and policies (Abbass, 2013). Since 2008, Pakistan had been facing severe energy crisis along with several other global challenges such as terrorism, corruption, poverty etc. Additionally, poor economic planning and policy development has increased the country's dependence on foreign assistance in order to cope with these challenges.

The fundamental purpose of foreign assistance is poverty alleviation, economic development and public welfare by analyzing important social/economic aspects e.g. population growth, human rights violations, law and order situation, maladies and environmental degradation (Khan, 2018). Economist predict that the incapability to generate required amount of electricity to satisfy the increasing demand would render the country dependent on foreign assistance for an unforeseeable period of time (Ahmed, 2007). Furthermore, Pakistan would also be required to maintain adequate levels of foreign currency reserves to ensure long-term energy security (Mangla & Uppal, 2014). World Bank has been providing financial assistance for several energy related investment projects and programs aimed at economic and social uplift. In 2005, it provided a loan of USD 200 million for improvement of electricity transmission and distribution infrastructure. Another major financial institution providing financial assistance to the electricity sector is Asian Development Bank, which has provided project-based financing worth billions for transmission/distribution enhancement projects, renewable energy development projects. Among other establishments providing financial assistance to electricity sector, the noteworthy ones are governments of Japan and Germany, UNDP[4], USAID[5], and CIDA[6] (Weynand, 2007).

The current paper examines the relationship between energy consumption, foreign assistance and GDP per capita in Pakistan for period 1981-2015. During the said period, Pakistan received extensive foreign assistance in the form of financial/technical aid, structured financing,

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[4] United Nations Development Programme
[5] United States Agency for International Development
[6] Canadian International Development Agency

emergency reliefs and commodity aid (Shirazi, Mannap, & Ali, 2009). Additionally, domestic sector is the largest consumer of electricity in the country, followed by industrial, agricultural and commercial sector. Moreover, the country's economy has been affected severely by political unrest, corruption, terrorism and energy crisis etc.

2. Literature Review

In this study, extensive review of existing literature has been carried out regarding the impact of foreign assistance on economic development of the recipient countries. This topic had the attention of the researchers and scholars with varied outcomes and results (Burnside & Dollar, 2000; Easterly, Levine, & Roodman, 2003; Clemens, Radelet, & Bhavnani, 2004; Bourguignon & Sundberg, 2007; Rajan & Subramanian, 2008). Inspite of several researches, there is no strong evidence regarding a positive or negative relationship between foreign assistance and economic growth of developing economies (Ferro, Portugal-Perez, & Wilson, 2012). Since the 1950s, shortcomings associated with foreign assistance have led to intense discussions among the economists (Bauer, 1976). The primary purpose of foreign assistance was to support beneficial and effective investments to assist developing economies in achieving economic growth, reduce poverty and improve living standards (Bjørnskov, 2013). Moreover, this aid might be a result of strong bilateral ties between two countries for any development project, natural disasters, human rights violation etc. (Niyonkuru, 2016). There are several successful examples of developing/underdeveloped countries in Far East utilizing this aid in a beneficial manner and stepping out from the list of aid dependent and low-income countries (Aime, 2010). Furthermore, majority of countries particularly the ones in Sub-Saharan African region who are yet categorized by low performance, low income, negative growth rate and increased poverty (Aime, 2010).

The importance of foreign assistance towards improving energy systems' inadequacy and development of electricity sector and providing essential resources for the same in developing economies is undeniable (Bouznit, Romero and Braza, 2018). Earlier researches have adopted case studies and qualitative analysis to study the impact of foreign assistance on public infrastructure development including the energy e.g. Japan Bank for International Cooperation carried out 16 case studies (Jerve & Nissake, 2008) whereas, 17 case studies have been carried out in Asia and Africa (Garnett, Nayyar-Stone, & Polen, 2009). However, the associated literature regarding provision of assistance to energy sector is limited (Gualberti, Martins, &

Bazilian, 2013).

With the passage of time, the changing energy needs and priorities of several countries have led to increasing foreign assistance to the energy sector (Gomez-Echeverri, 2013). Since 2000s, the declaration of the Paris Accord, the topic of energy has become an important part of the international development agenda. As per Millennium Development Goals, poverty reduction and sustainable energy development have been given significant importance on all current conferences on international development, donors' policy guidelines and international commitments (Gualberti, Martins, & Bazilian, 2013).

A study conducted by Tirpak and Adams (2008) investigated the impact of bilateral and multilateral foreign assistance on the energy sector emphasizing primarily on renewable energy sources and established that foreign financial assistance is mandatory to mitigate risks arising due to introduction of new technologies and strengthening the developing economies to adopt a more eco-friendly energy approach. Additionally, a study conducted by Michaelowa and Michaelowa (2011) adopted econometric approach to investigate the political and economic determinants of shift toward foreign assistance for renewable energies and energy efficiency. The results indicated that approval of international environmental accords e.g., Kyoto protocol did not had any favorable repercussions.

The identification of determinants of electricity consumption, e.g. growing population, rural electrification, industrialization, agricultural needs, extensive urbanization, rising per capita income, and rapid growth in domestic demand is essential to develop an understanding towards increasing electricity consumption since the last decade (Faisal, Tursoy, Resatoglu and Berk, 2018). Several studies have been carried out to study the impact of income on electricity consumption (Jamil & Ahmad, 2010; Javid & Qayyum, 2013). Moreover, impact of economic growth on the consumption of electricity is due to several reasons viz: **(i)** higher disposable domestic income, **(ii)** industrial and commercial sector expansion and **(iii)** constant growth in the agriculture and transport sector (Ibraheim, 2018).

3. Research Methodology

Several empirical studies have highlighted the significance of energy sector in stipulating economic growth e.g. Riaz (1984), Moroney (1992), Stern and Cleveland (2003), and Aqeel and Butt (2001). Likewise, extensive research has been carried out to examine the impact of foreign assistance on economic growth e.g. Chenery and Strout (1966), Islam (1972), Mallik (2008), and

Moyo and Mafuso (2017). However, the studies investigating the relationship between foreign assistance and electricity consumption are relatively scarce. Therefore, the current study carries much significance since it utilizes electricity prices as explanatory variable to investigate the relationship between foreign assistance and electricity consumption. From the theoretical perspective electricity price is an important determinant of electricity demand.

The study adopts an exploratory research design to address the research problem arising due to scarcity of associated literature in order to predict an outcome. The exploratory research design stresses on acquiring observations and understanding for further analysis or at initial phase of investigation of research problems (Cuthill, 2002). Furthermore, since the study focuses on objective measurements and statistical analysis of data collected through questionnaires, surveys or existing numerical data collected using computational techniques therefore it employs quantitative research approach (Babbie, 2010). This study uses time series data from 1981 to 2015, which is beneficial in obtaining substantial sample statistics, and three variables, i.e. foreign assistance (Million USD), GDP per Capita (PKR) and electricity consumption (Gigawatt hours – GWh). Additionally, natural log has been taken for foreign assistance and electricity consumption data. Moreover, International Monetary Fund (IMF), World Bank (WB) and Asian Development Bank (ADB) have provided foreign financial assistance that was assigned to the respective recipient year and funding agency. Furthermore, Moyo and Mafuso (2017) identified in their study that the foreign aid inflows through the financial institutions in its respective year therefore similar approach was adopted by the study. As examined by Augmented Dickey-Fuller (ADF) (Shrestha & Chowdhury, 2005), the time series data becomes stationary when its mean and variance are time-independent. Hence, it assists in identifying characteristics of fundamental data producing procedure of a series. In the absence of unit root, the time series varies around a constant long run mean, entailing that it has limited variance that is not time reliant (Nelson & Plosser, 1982). Therefore, several methods were applied to execute the unit root test, such as Dickey- Fuller (DF), Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) test methods (Shrestha & Chowdhury, 2005). However, in this study, in order to test the stationarity of each series, ADF (Augmented Dicky Fuller) test has been used at data levels and first difference. Mallik (2008) and Siddiqui (2004) in their studies regarding foreign aid and energy demand have used stationary time series and ADF.

The ADF test is an augmented version of the Dickey-Fuller test, which aims at improving its

suitability for some forms of serial correlations and larger and complex set of time series models (Usman & Sarpong, 2009). This study employs the unit root test to estimate the relationship between foreign assistance, GDP per capita and electricity consumption. Moreover, after testing for data stationarity, the study used Autoregressive Distributed Lag (ARDL) model for estimating the long-term and short-term association between foreign assistance, GDP per capita and electricity consumption.

In a study conducted by Pesaran et al (1996b) Autoregressive Distributed Lag (ARDL) model was proposed to measure long-term relationship through co-integration or bound testing, which tests for short or long-term irrespective of underlying variables are I(0), I(1) or both thus its application for cointegration gives realistic and accurate estimates. Simple equation of ARDL (1, 1) is

$$yt = \alpha 0 + \alpha 1 yt{-}1 + \beta 0 xt + \beta 1 xt{-}1 + \varepsilon$$

The current ARDL employs (0, 1, 1), which was proposed by Schwarz Bayesian Criterion.

$$yt = \alpha 0 + \beta 01(fa)1t + \beta 1(fa)x1t{-}1 + \beta 01(gdppc)1t + \beta 1(gdppc)x1t{-}1 + \varepsilon$$

In order to calculate speed of adjustment to the long-run equilibrium

$$yt = \alpha 0 + \beta 01(fa)1t + \beta 1(fa)x1t{-}1 + \beta 01(gdppc)1t + \beta 1(gdppc)x1t{-}1 + ECMt{-}1 + \varepsilon$$

The error correction term (ECT) accounts for the speed of adjustment parameter or feedback effect and is derived as error term from the cointegration model.

In their respective studies regarding study of relationship between electricity demand and foreign aid with economic development, Siddiqui (2004) and Sothan (2018) have used the ARDL technique and considered it appropriate to estimate the relationship. Results from these statistics are given below

Table 1 – Unit Root Test

Variable	ADF		Order of Integration
	Level	First Difference	
Electricity Consumption	-8.828*	-2.660	I(0)
Foreign Assistance	-1.973	-5.225*	I(1)
GDP Per Capita	-0.411	-8.418*	I(1)

Results shows data series stationarity at I(0) for electricity consumption (-8.828), at I(1) for foreign assistance (-5.225) and at I(1) for GDP per capita (-8.418). Accordingly, ARDL technique is appropriate in case of stationarity of data series at different orders I(0) & I(1).

In ARDL approach, Bound testing is employed to study the long-term relation between foreign assistance, GDP per capita and electricity consumption, since it gives the value of F-statistic (measure of cointegration) to predict long-term relation between the three variables.

Table 2 – ARDL Bound Test for Cointegration

F-statistic	7.560
5 % Critical Values	
Lower Bound	3.790
Upper Bound	4.850
K= 2	

The critical bound values were extracted from (Pesaran et al. 2001). The lag length k=2 was selected based on the Schwarz criterion (SC). The value of F-statistic (7.560) is greater than lower (3.790) and upper bound (4.850) values, which indicate existence of long-term relationship between electricity consumption, foreign assistance and GDP per capita.

Table 3 – Estimation of Long-run coefficients

Regressor	Coefficient	Std. Error	t-statistics	Prob.
Constant	0.5776	0.10486	5.509104	0.0000
Foreign Assistance	0.0234	0.00990	2.369318	0.0247
GDP Per Capita	0.0197	0.05472	0.361421	0.7204

ARDL (0, 1, 1) has been selected by Schwarz Bayesian Criterion whereas coefficient value is 0.0234. However, in the long-term there is a significant positive 0.0234 unit change in electricity consumption (y) because of foreign assistance to energy sector (x). On the contrary, coefficient value is 0.019; which indicated no long-term relationship between GDP per capita and electricity consumption since the p value 0.7204 > 0.05.
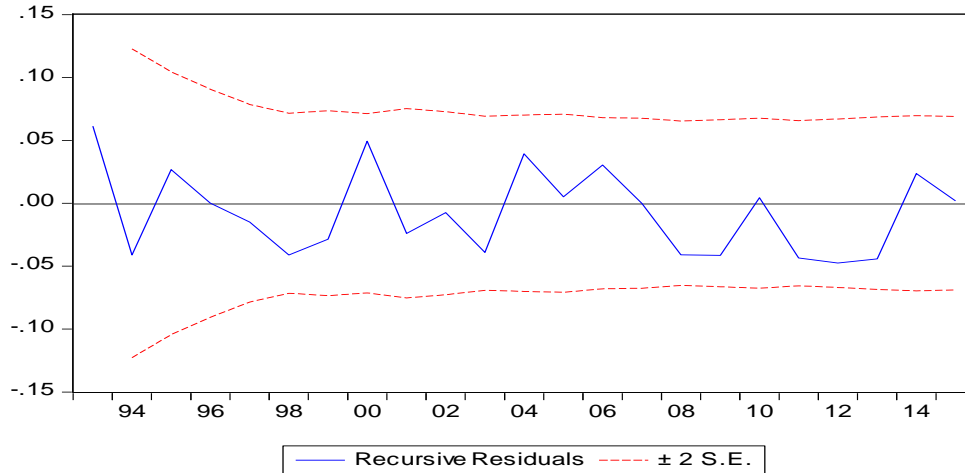
Figure1: Recursive Estimates

Recursive estimation of errors is depicted in the graph above, which suggest regression coefficients stability over the selected period due to cumulative sum plotted based on recursive residuals as shown in Figure 1. However, it does not provide any evidence of statistically significant breaks. The CUSUM plot below shows the stability of the electricity consumption function.

Table 4 – Lagrange Multiplier

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.352387	**Prob**.	0.7062

In case of error term of variance not being constant then value of x could lead to abnormal prediction of y. In above equation the value of F statistics = (0.352) and the p value = (0.706) > 0.05 indicate homoscedasticity of data and constant variance.

Table 5 – Re-parameterization of ARDL Model into Error Correction Model

Regressor	Coefficient	Std. Error	t-statistics	Prob.
ECT(-1)	-1.0810	0.3201	-3.377	0.0017
Foreign Assistance	0.0246	0.0125	1.947	0.0600
GDP Per Capita	-0.0897	0.0704	-1.273	0.2130

In re-parameterization equation, both the coefficient values of foreign assistance (0.0125) and GDP per capita (0.0897) indicate no short-term relationship with electricity consumption owing to the p values 0.600 > 0.05 & 0.213 > 0.05 respectively. The error correction term (ECT)

coefficient of -0.0897 p value $(0.001 < 0.05)$ is significant however it postulates a moderate speed of convergence to equilibrium in the long-term.

Table 6 – Lagrange Multiplier

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.327878	Prob.	0.2846

In above equation the value of F statistics = (1.327) and the p value = (0.284) > 0.05, which indicates data homoscedasticity and constant variance and depicts dynamics of re-parameterization equation with error correction term.

4. Discussion

The long-term relationship between foreign assistance and electricity consumption could be perceived by the fact that since 2011 over 42.2 million of country's population has been benefiting from the efforts being made by USAID to add around 3,500 MW electricity to Pakistan's national electricity grid. This addition increased the operating efficiency of the industrial sector thus generating employment and hence contributing to economic uplift of the country (USAID Energy, 2019). In any country, increase in employment level directly influences its GDP per capita due to existence of positive relationship between economic growth and employment (Patrick, 2014). Another major reason for electricity consumption equilibrium, foreign assistance and GDP per capita of Pakistan is the positive relationship between the industrial output and energy consumption. Hence, electricity sector infrastructure plays a significant role in developing countries in improving the overall infrastructure and electricity sector productivity. Moreover, there exists a positive relationship between economic growth and GDP since increase in GDP contributes to economic growth in long run (Patrick, 2014). Although, the studies that have researched the role of electricity in economic uplift are relatively scarce, several studies would corroborate the results of the current study e.g. (Ho and Sui, 2007) found out similar results while researching on economy of Hong Kong. The results revealed that economy of Hong Kong is positively affected by industrial expansion, which in turn affects electricity production and consumption.

5. Conclusion

Due to fact that economy of many developing countries is based on performance of the

manufacturing industry, which requires ample amount of electricity for smooth running of its operations. Additionally, a major chunk of population is employed in the manufacturing sector. This phenomenon indicates existence of a relationship between GDP per capita and electricity situation of a country (Dhungel, 2014). However, this does not hold true for Pakistan's scenario since this study did not find any relationship (short-term, long-term) between GDP per capita and electricity consumption. Moreover, in case of developing countries, increase in electricity consumption causes an abrupt increase electricity production, which leads to infrastructure development as well as employment generation thus contributing to economic growth (Ho and Sui, 2007). Moreover, in case of developing countries foreign assistance plays a significant role in electricity projects development, generation and consumption patterns (Sothan, 2018). The current study stipulates that electricity consumption and foreign assistance are positively associated in the long-term. Moreover, due to massive electricity shortfall in Pakistan, the industrial sector operates at marginal capacity therefore considerable investment and planning is required to close the gap between electricity demand and supply (Ashraf et al., 2013). On the contrary, since Pakistan is a developing country and due to scarcity of investment and resources is not in a position to expand electricity infrastructure for increase electricity production. Therefore, foreign assistance is mandatory to solve the problem electricity production.

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