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Electricity Consumption and Economic Growth: A Time-Series Study on Pakistan

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Abstract *In Socio-Economic development, the role of energy is very crucial, and often its consumption indicates the level of economic development and is considered as a vital ingredient of sustainable economic growth. Electricity as a key input variable plays a supreme role in the process of industrialization (IND), Economic growth (GDP) as well as technological progress (TEC) of a country. By utilizing time-series data from 1975 up to 2017, the study attempted to examine the nexus between EC and GDP of Pakistan in the Cobb Douglas production function framework. The study results reveal that EC, labor force, capital stocks, and technology, have positively and significantly affect Pakistan's GDP growth. The study concluded and recommended that economic performance cannot be improved in the absence of continuous usage of electricity. Therefore, to achieve the desired economic growth path, uninterrupted electricity consumption is pivotal.*

Key Words: Economic Growth, Electricity Usage, Industrialization.

JEL Classification: H40, P46, Q43

Introduction

Energy is considered one of the most important and necessities of today's modern world. In the socio-economic development of the county, the role of energy consumption is very important and it has been confirmed by various literature studies. Broadly speaking, energy is not only used as one of the production inputs, but it also proved itself as one of the strategic commodity, that shapes the world economy and politics in the present day time. The pioneering work of Kraft and Kraft (1978) triggered the interest of the writers in the energy consumption and growth debate. Until now, the two variables debate had produced conflicting and interesting outcomes. In most of the energy economics literature, it has been concluded that energy is not only used as the principal driver of economic development, but it has also been acknowledged as one of the most important strategic commodities (Sahir & Qureshi, 2007; Zaleski, 2001)

Because of its significant role that energy plays in economic development, it has enhanced upto a great extent the productivity of capital, labor, and other factors of production as well (Jumbe, 2004). The modernization and expansion of all economic sectors have increased the demand for energy and especially of electricity (Ouédraogo,

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2010) up to a great extent. Therefore factors like industrialization, urbanization, population growth, and a rise in the standard of living are regarded as the principal determinants of electricity demand (Gurgul & Lach, 2012).

Electricity being an important component of the energy sector, is considered as one of the basic ingredients and key indicators of the socio-economic prosperity of a country (Alter & Syed, 2011; Sharif & Raza, 2016; Nathan et al., 2016). They underline the importance of electricity in peoples' lives. Energy economists believe that electricity is a principal component of economic growth and its continuous availability is important for every sector of the economy. It has been argued that the power shortage detracts the economy from a growth path. In the annual report of 2018 International Energy Agency reports (IEA.2018) reported that the world electricity demand increased by 3.1 percent between 2016 and 2017. All the developed countries except the United States have witnessed an increase in demand for electricity. In emerging economies, demand for electricity has also surged and is positively correlated with their economic growth. According to the World Economic Outlook (WEO, 2018), 6 and 7 percent rise in electricity demand in China and India was due to their seven and twelve percent economic growth respectively. Similarly, in 2017 about 5.55 percent increase in EC was reported in Pakistan (Pakistan Economic survey 2016-17). Figure 1 graphically presents the trends of EC and per capita GDP of Pakistan from the year starting from 1971 to 2018 and reveals that both of the stated variables of this research paper are interrelated as both are moving in the same direction and hence affirmed their close association. It is obvious that the two variables there exist a co-movement between the variables, that is why electricity consumers, practitioners, policymakers, and all stakeholders take a keen interest in the association of EC and GDP growth.

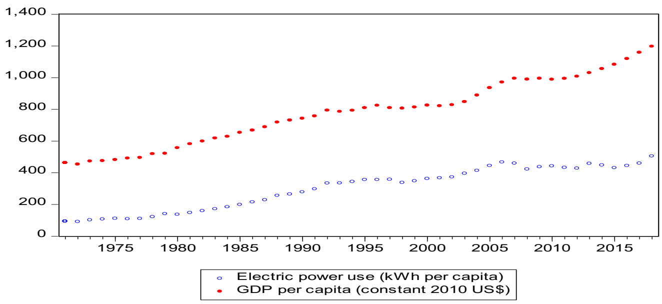

Figure 1. EC and GDP/capita in Pakistan from (1971-2018).

Pakistan had surplus electricity over the period 1990 to 2005 however, mismanagement and underdeveloped energy infrastructure, rapid population growth, increased demand for electric appliances, circular debt, and low investment in the energy sector have contributed to demand and supply gap of over 6 Gigawatts (GW). The latest reports reveal that in Pakistan, about 27% of the total population has no access to electricity. Furthermore, the latest statistics show that about 9% of the urban and 38 % of the rural population here in this country has no access to electricity (CIA 2018). To meet the challenging demand of EC, the government has no option, except load shedding (Khan and Ahmad 2007; Shahbaz and Feridun 2012). It is due to the mismatch between demand and supply that the power shortfall was reached to a record high level of more than 9,000 megawatts (MW) in the last week of June 2018 leading to lengthy power cut off in the countrywide. The shortfall had resulted in 2 to 17 hours of power cutoff nationwide. The shortfall affected mostly the consumers of the three provinces they are Baluchistan, Sindh, and Khyber-Pakhtunkhwa (K-P) (The express Tribune-2018). Moreover, Khan and Ahmad (2007) stated that the huge electricity shortfall poses a big threat to the country's energy sector as well as other major macroeconomic variables and of course for its economic growth and development process. Since the uninterrupted power supply is a major prerequisite for industrial growth, its shortage has contributed to the industrial downfall and has adversely affected the country's economic growth process. Due to a severe energy crisis and long blackouts, the industrial sector in Pakistan has been unable to produce output at its optimal level. In Pakistan case, Industry (including construction), value added (% of GDP) was gradually declined from 25.528% in 2005 to 17.942% and 18.174% respectively in 2017 and 2018(WDI.2018). Since the uninterrupted power supply is a major prerequisite for industrial growth, its shortage has contributed to the industrial downfall and has adversely affected the country's GDP growth. Due to a severe energy crisis and long blackouts, the industrial sector in Pakistan has been unable to produce output at its optimal level. Despite the government's efforts to provide uninterrupted electricity to the residential and commercial sectors, it is predicted that power shortage will further increase and will reach 10844 megawatts by 2020. This means Pakistan needs to focus on the provision of continuous electricity supply if it wants to have a successful economy. Realizing the fact, Pakistan has been utilizing hydropower, natural gas, coal, oil, biomass, solar as well as wind and geothermal energy for meeting its ever-growing energy demand (Husain; 2010 and Amjad et al., 2011).

With this background, this study seeks to explore the nexus between EC and GDP of Pakistan within the framework of the neoclassical Solow growth model. By incorporating IND and TEC into the econometric framework of this study, confirms not only the nexus between the two stated variables i.e. EC and GDP but also want to establish the relationship between IND and GDP in Pakistan case. By using the instrumental variable approach for finding out the effect of EC on the GDP of Pakistan in the framework of Cobb Douglas production function. Annual data from the year 1975 to 2017 is used for conducting the analysis. The rest of the paper is divided into four distinct sections, where section two reviews past literature focusing on the nexus between economic growth an electricity consumption followed by section three that provides details about methodology and data. Section four of the study is about the empirical results, and then in section five, the study is concluded with some policy implications.

Review of Literature

Today there is available huge literature on empirical studies that have specifically focused on energy-economic growth nexus for developed and developing countries (Kraft and Kraft (1978), Asafu and Adjyae (2000), Ghosh (2002), Narayan and Smyth (2009), and Yoo & Kwak (2010) Nathan and Wong (2016). Such empirical literature provides mixed evidence regarding the effect of electricity consumption on economic growth Cheng, 1995; Wolde-Rufael (2006); Odhiambo (2009) and (Gurgul and Lach (2012). The difference in results may be due to differences in forms of energy consumed and consumption patterns in each country (Cifter and Ozun, 2007).

Kraft and Kraft (1978) explored the relationship between the GNP and energy consumption of the USA. In the analysis, the time series data of the US economy from 1947 to 1974 was used by the study. By following the Sims Granger methodology the study confirmed that GNP causes energy consumption. Similarly, Akarca and Long (1980) using the same methodology found no long-run cointegration between EC and GDP for the same country. The differences in results could be due to the time period instability of the data. Similarly, Erol and Yu (1987) focused on causality between EC and EG and found bidirectional causality between the said variables in Japan case, whereas in Canada case one-way causality was confirmed by him from EC to GDP. For Germany and Italy uni-directional causality from EG to EC was confirmed by the study. Furthermore, they found no causal association between EC and GDP in the case of France and England.

Unlike previous literature studies in the field of energy economics Masih and Masih (1996) for the six Asian economies, they are Malaysia, the Philippines, India, Singapore, Pakistan, and Indonesia. By following Johansen's co-integration tests, the study revealed the existence of co-integration between energy use and real income. Furthermore the study with the application of vector error-correction modeling approach (VECM), and concluded that out of the stated six Asian economies, no causal relationship was found for Malaysia, Philippines, and Singapore cases. Whereas unidirectional causal linkage from energy use to GNP was confirmed by the study in India case, and at last in Indonesia case one-way causal association was confirmed by the study from GNP to EC.

Ghosh (2002) conducted a study to examine the causal relationship between the per capita electric power consumption and GDP. The country of his study was India, and the data he used ranging from 1950 to 1997. With the application of Autoregressive Distributed Lag (ARDL) bounds testing method, he has established no co-integration among the variables. But with the Engle-Granger test for causality, the study confirmed unidirectional causality running from Ec to real GDP. Similarly in an empirical study on a Chinese province Shanghai, Rufael (2004) concluded in unidirectional causality that runs from EC towards EG for the period from 1952 to 1999. He applied Toda and Yamamoto (1995) test for causality. On the other hand, Chen et al. (2007) examined the association between GDP and EC for a panel of Asian countries. Through Panel data investigation the study has confirmed the existence of co-integration between the two variables of the study namely EC and GDP for all countries except China and Malaysia. On the causal association, the study has confirmed bi-directional causality in the long run, while in short-run uni-directional causality was established by the study for the selected Asian countries running from GDP to EC.

Later on, Rufael (2009) focused on seventeen Sub-Saharan African States and found no causal link between EC and EG for Cameron and Africa. For Benin, Egypt, Algeria, Tunisia, Nigeria, South Africa, Zambia, Sudan, Ivory Coast, Morocco, and Senegal, the study was confirmed unidirectional causality running from EG to EC. For Gabon, Togo, Ghana, and Zimbabwe the study concluded two-way causality. Similarly, Tang (2009) examined the nexus between EC and GDP for Malaysia. With the application of ARDL, he confirmed the long-run co-integration between the stated variables of his research study. Furthermore, with the application of the Granger causality test, two-way causal linkages instead of one way between EC and GDP for the stated country of the study were confirmed. On the same footings Yoo and Kwak (2010) in an empirical study on seven Latin American states, and the study confirmed unidirectional causality running from EC to EG. These states include Brazil, Peru, Argentina, Chile, Columbia, Venezuela, and Ecuador. Then a year later Kouakou (2011) in his time-series study on Cote d'Ivoire by using the data ranging from 1971 to 2008. He investigated the association between electricity consumption and GDP. With the co-integration and Granger causality test, the study confirmed the long run as well as the causal association between the study variables. Bi-directional causality was confirmed by the study between GDP and EC for Cote d'Ivoire.

Nadeem and Munir(2016) analyzed the association between energy consumption at the disaggregated level and Pakistan GDP. The study uses the annual time series data from 1972 to 2014. With the application of the ARDL Bound test and Granger test for causality, they revealed that there exists a long-run association between the two said variables. Furthermore, they also revealed that there exists no causal relationship of GDP with aggregate and disaggregate oil consumption levels. While the study revealed the existence of Conservation Hypothesis in aggregate and disaggregate electricity, gas and coal usage, and GDP. In Pakistan case specifically Khan, et al. (2009), Jamil and Ahmad (2010), Kalar and Khilji (2011) and also Shahbaz and HooiHooi (2011), Shahbaz and Feridun (2011) and many others confirmed the long-run co-integration between EC and GDP, but on causal nexus, they provided different results. In Pakistan's perspective Jamil and Ahmad (2010), confirmed a one-way causal association from GDP to EC. But a year later unidirectional causal relationship from EC to GDP was confirmed by Kalar and Khilji (2011), for the same country. Then on the nexus between GDP and EC, Shahbaz and Feridun (2011) with the use of ARDL confirmed the long-run association between the two stated variables. They also with the application of Toda Yamamoto like the econometrics approach confirmed the existence of the Growth Hypothesis. To conclude, in the review of the empirical literature, we found that, it provides mixed evidence about the nexus between EG and EC around the world. Differences in the results in this literature may be due to the differences of the datasets, country characteristics, variables used, and of course the use of different estimation methods. Therefore this research study aims to empirically test the relationship between EC and GDP within the neoclassical Solow growth framework. By considering the following extended Cobb–Douglas production function framework. Extended in the sense that we also incorporating the variables of industrialization and technology into the stated framework.

Methodology and Data

The current understanding of economic growth is largely based on the neoclassical growth model developed by Solow (1956). The neoclassical growth models ignored the energy role, and therefore they did not include it as a factor of production. As they are of the view, that only capital and labor are the sole determinants of producing goods. However, the role played by energy being used as an important factor of production cannot be ignored and has received much attention in recent decades around the globe. The most widely used production function is the Cobb-Douglas one, which is known as an appropriate instrument for finding the relationship between output and economic variables. It can be written as:

$$Y_t = A_t \quad K^{\alpha}{}_t \, L^{\beta}{}_t$$

Where aggregate production is expressed by Y at time t, K_t is capital stocks, L_t is labor force, and A is the technology parameter. In the above function α and β measure output elasticity concerning capital and labor. From the recent literature in energy economics (Nourzad 2000; Yuan et al., 2008; Liao et al., 2010; Sharma, 2010; Anwar & Sun, 2011).We confirmed that they all are agreed upon the central role-playing by capital stock, labor force, technological progress, and energy in the economic growth process. Therefore, this study also builds its economic growth model based on five variables such as capital stocks, labor force, electric power consumption, industrial development, and technology. This study, therefore, tries to explore the nexus between EC and GDP in the framework of the extended Cobb-Douglas production function, as was incorporated by Omri (2010), Sharma (2010), Anwar and Sun (2011), and Sharif & Raza,(2016) in their respective research study. The following augmented Cobb-Douglas production function in its general form is used by the study:

$$Y_t = f(K_t,\ Lab_t,\ Ec_t,\ Ind_t,\ Tec_t) \qquad (4.1)$$

The study now transformed the series of equation 4.1by taking logarithm into account, as the simple linear specification provides inefficient estimates (Karagol, 2006). It must also be noteworthy that if a model is a log linearly specified then it will produce unbiased as well as best empirical results (Sezgin.2004. Hence equation 4.1 in the logarithmic form can now be written as:

$$y_t = \alpha_0 + \alpha_1 k_t + \alpha_2 lab_t + \alpha_3 ec_t + \alpha_4 ind_t + \alpha_5 tec_t + u_t \qquad (4.2)$$

Here α_1, α_2, α_3, α_4, $\alpha_5$represent returns to scale connected with gross fixed capital formation, labor force, electric power usage; industrial development and technology respectively. Equation (4.2) is a linear transformation of non-linear Cobb-Douglas production function. A rise in EC is associated with a rise in real income ($\alpha_3 > 0$). This happens because electricity is used in various commercial and noncommercial activities and thus results in an increase in economic growth (Sharma, 2010). Industrial development also affects economic growth positively ($\alpha_4 > 0$).The availability of labor force ($\alpha_2 > 0$) and capital ($\alpha_1 > 0$) also exert a positive and significant effect on GDP. Since these variables are important determinants of economic growth hence their rise is associated with an increase in real national income (De Mello, 1997). Technological progress has also a positive impact on GDP. Technological progress reduces the cost of production and improves the productivity of factors of production. Hence technological development causes economic growth in the country.

This research paper is, therefore, treating the three major variables namely per capita electric power use, industrial development, and GDP (y) as endogenous. The following simultaneous equations model (SEM), has been used by the study.

$$y_t = \alpha_0 + \alpha_1 k_t + \alpha_2 lab_t + \alpha_3 ec_t + \alpha_4 ind_t + \alpha_5 tec_t + u_t \qquad (4.2)$$

$$ec_t = \beta_0 + \beta_1 k_t + \beta_2 lab_t + \beta_3 y_t + \beta_4 ifdi_t + \beta_5 pop_t + v_t \qquad (4.3)$$

$$ind_t = \sigma_0 + \sigma_1 k_t + \sigma_2 lab_t + \sigma_3 ec_t + \sigma_4 tec_t + \varepsilon_t \qquad (4.4)$$

The study has treated the variables i.e. $y, ec\ and\ ind$ as endogenous. While $k, lab, tec, fdi\ and\ pop$ was treated by the study as predetermined variables. μ_t, v_t and ε_t in the above SEM are the stochastic error terms. The Greek letters α, β, and σ are the coefficients of structural parameters. For this purpose therefore this research paper has developed the above SEM by following the footsteps of Uddah (2010) and Omri, & Kahouli, B. (2014). Moreover, it will be worth mentioning that GDP(y) and industrial development (ind) equations of this study have been specified in the footsteps of Udah's (2010) research study which was conducted by him on Nigeria. And for the determination of electricity consumption it has specified equation (4.3) as was specified by Omri, & Kahouli, B. (2014) in their respective research work. In his empirical investigation of the nexus between electricity consumption and real GDP for Malaysia, Sharma (2010) has confirmed a long-run relationship between the stated variables. He concluded that a rise in energy consumption leads to an increase in per capita GDP in Malaysia. He therefore directly associated the use of energy with the economic prosperity (GDP) of a country. Moreover, Uddah (2010) and Ellahi (2011) established the significant role that industrialization performs in the process of economic growth (GDP per capita) in their respective research studies. Furthermore like De Mello (1997) this research paper has also incorporated capital (K) and employment (Lab) as one of the key determinants of GDP growth.

This study, therefore, has specified equations (4.3) and (4.4), to empirically investigate the key drivers of electricity consumption as well as industrial development of Pakistan respectively. The main reason for introducing equation (4.3) is to investigate the determinants of electricity consumption (ec). Economic growth (y) in equation (4.3) exerts a positive impact on electricity consumption. It means that a rise in y brings to raise the demand for energy consumption as proved by Zhang and Cheng (2009), Halicioglu (2009), Belloumi (2009), Lotfalipour et al (2010) in their respective research studies. Moreover like Lorde *et al.* (2010) and Sari *et al.* (2008) this paper has also incorporated both *k and lab* as key determinants of electricity consumption. And also like Omri, & Kahouli, B. (2014); and Zaman *et al.*, (2012) we have incorporated foreign direct investment (FDI) in equation (4.3) of this study. Like Barliwala and Reddy (1993) this study also treats the population as one of the strong determinants of energy consumption. Similarly, the study has specified the industrial development equation (4.4) in the footsteps of Uddah (2010) work. Therefore the variables, namely K, Lab, ec, and Tec have been used in the determination of industrial development in Pakistan.

After the specification of SEM, this study will now identify every equation. In this regard, both the necessary and sufficient conditions for identification were fulfilled by the application of both order and rank conditions tests. By order and rank conditions tests, we confirmed that all the three structural equations of the SEM are identified. It must be worth mentioning to note that out of three equations i.e. (4.2) and (4.3) of the SEM are exactly identified, while the last equation i.e. (4.4) is over-identified. That is why we have preferred to use the 2SLS estimation approach. As the primary motive of this paper to investigate the nexus between electricity consumption and Pakistan economic growth, therefore we only show the results of equation (4.2) by applying the 2SLS estimation technique. Two stages at least square is a specific method of instrumental variable approach and is widely used as an estimation procedure. It requires the equality of instruments and endogenous variables.

This study uses annual data from 1975 to 2017. World Bank World Development Indicators (WDI) and also the Pakistan Economic Survey (various issues) are the two major sources of this study. The study based its analytical framework on per capita GDP ( ), Gross fixed capital formation is used as proxy measuring capital stock ( ), Total Labor force in numbers ( ), Per capita, electricity consumption in kWh ( ), Industry (including construction) value added at constant 2010 US$ ( ) represents industrial development, Technical cooperation grants measuring technology ( ) and Population total in numbers (popt) like variables.

Results

Before estimating equation (4.2) through 2SLS, the Augmented Dickey-Fuller (ADF) test is used for testing and confirming the time series unit root properties of the study. ADF test findings are given in table 1. It is apparent from the table that at a level all variables are non-stationary, but become stationary by taking the first difference. From table 1, it can be concluded that all variables are integrating of order one *I* (1).

Table 1. ADF Unit Root Test

Variable	**Intercept and Trend**		**Outcome**
	Log Level	**Log 1st Difference**	
ec_t	-1.219	-5.460 ^{a}	*I*(1)
ind_t	2.935	-4.537 ^{a}	*I*(1)
k_t	-0.572	-5.262 ^{a}	*I*(1)
lab_t	4.383	-4.111 ^{a}	*I*(1)
tec_t	-2.289	-5.162 ^{a}	*I*(1)
y_t	0.513	-3.736 ^{a}	*I*(1)

Critical values are MacKinnon (1996) one-sided p-values
Note: a shows a 1% significance level.

Table 2 below shows that except for industrial sector growth all variables are positively and significantly affect the economic growth (GDP) of Pakistan at a 1% significance level. This can be interpreted that a rise in these variables is associated with an increase in EG proxies with GDP/capita. The table further exhibits the coefficient of electricity consumption as 0.375 (see table 2), which means that a 1% rise in the consumption of electric power raises the GDP growth by the amount of 0.375%. These results resemble the results of Sharma (2010), and Omri, & Kahouli, B. (2014). Because they all conclude concluded and agreed upon the positive and significant role that energy consumption plays in the GDP growth process of a country. Similarly, the coefficients of the Labor force, capital, and technology are positive and significant as well. Table 2 reveals that by bringing a 1 % change in the lab, k and tec leads to 1.778%, 1.115%, and 1.922% change in the country's economic growth process respectively. Our results are consistent with Sharif & Raza, (2016). On the other hand, the Industrial sector estimate is significant and negative. The table reveals that bringing a 1% change in ind leads to a decrease in the economic growth process by the amount of 1.142 %. This means industrial sector development hampers the economic growth of the country. This may be due to that Pakistan is an agro-based economy with poor industrial base due to government negligence since the emergence of the country.

Table 2. Economic Growth Equation Estimates (2SLS).

Variable	Coefficient	Standard Error	t-Statistic	P-Values
ec_t	0.375 ^{a}	0.053	7.017	0.000
ind_t	-1.142 ^{a}	6.687	-2.112	0.042
k_t	1.115 ^{a}	1.620	6.884	0.000
lab_t	1.778 ^{a}	5.179	3.434	0.002
tec_t	1.921 ^{a}	3.136	6.126	0.000
R^2	0.99		$\overline{R}^2$	0.99
F-Statistic	2221.20		F-Statistic Probability	0.00
N	43		Durbin Watson Statistic	1.60

Note: a shows the significance of the estimated parameters at the level of 1% significance level percent significance level.

Durbin Watson test statistic is 1.60 which is close to 2 implying the absence of serial correlation in the stochastic disturbance. R^2 and $\overline{R}^2$ the value indicates that capital formation (k_t), the total labor force (lab_t), EC (ec_t), industrialization (ind_t), and Technology (tec_t) having the power to explain 99.67 percent variation in GDP (y_t) of the country. This is further confirmed by F-statistic which is quite high thus rejecting the null that the joint effect of all included independent variables in the equation on the dependent variable is zero.

Table 3 shows that residuals properties are satisfied. There is an absence of serial correlation and heteroscedasticity in the estimated model. Furthermore, the residuals also satisfy their normality condition.

Table 3. Residual Tests

Test Statistic	Test Values	Probability
LM F Statistic	1.54	Prob of F (2.35) = 0.229
$Obs * R^2$	3.472	Prob Chi Square (2) = 0.176
JB	2.514	0.285

Model stability results are shown by the CUSUM test statistic given in figure 2. It is apparent from figure 2 that CUSUM statistics do not violate 5 percent critical regions thus confirm that the estimated model is stable. Based on residual's test statistics, coefficient of variation, and F statistic we conclude that the model is well fitted.

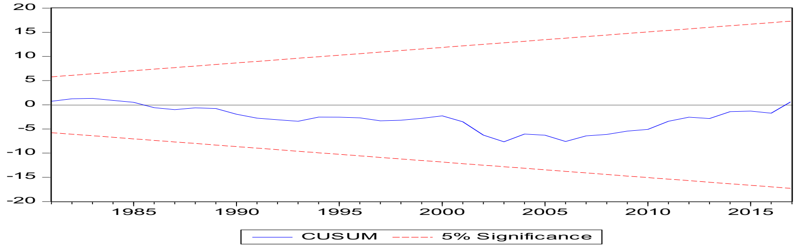

Figure 2. Cumulative Sum Test (Model Stability Test).

Conclusion

This study empirically investigated the nexus between EC and GDP of Pakistan using the instrumental variable method and time-series data from 1975 to 2017. This approach enabled us to avoid inconsistency and biases in estimated parameters that resulted from the simultaneous determination of EG and EC. Results show a significant positive effect of EC on EG. Other variables that have a significant positive effect on EG are capital stock, labor force, and technological progress. Industrial sector growth on the other hand hampers the growth process of the country. Based on the results of its empirical findings, it is suggested that the government needs to give special attention to the uninterrupted electric power supply, capital stocks, labor supply especially skilled labor and technological advancement for ensuring industrial development as well as sustainable economic growth in Pakistan. The government needs to revisit its energy policy and primarily focus only on renewable energy projects. These projects will not only be responsible to fulfill the sectorial energy demands efficiently and economically but also save the outflow of precious foreign exchange reserves. If we heavily rely on the import of fossil fuels (oil) for our energy needs, we will never be able to develop and boost the country's industrialization process.

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