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Abstract

This study revisits the relationship between electricity consumption and economic growth in Pakistan by controlling and investigating the effects of two major production factors - capital and labor. The empirical evidence confirms the cointegration among the variables and indicates that electricity consumption has a positive effect on economic growth. Moreover, bi-directional Ganger causality between electricity consumption and economic growth has been found. The findings suggests that adoption of electricity conservation policies to conserve energy resources may unwittingly decline growth and the lower growth rate will in turn further decrease the demand for electricity. Therefore, governments contemplating such conservationist policies should instead explore and develop alternate sources of energy as a strategy rather than just increasing electricity production per se in order to meet the rising demand for electricity in their quest towards sustaining development in the country.

Keywords: Electricity Consumption; Economic Growth; Ganger Causality
JEL classification: F15, B28

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1. Introduction

The causal relationship between electricity consumption and economic growth has important policy implications based on the following four hypotheses. First, if the causality runs from electricity consumption to economic growth, then electricity conservation policies should be discouraged as it would be counter-productive. Second, the electricity conservation policies can only be safely adopted if the causality runs instead from economic growth to electricity consumption. The third hypothesis states that if there is an existence of bi-directional causality between the two variables (feedback effect) which implies that reduction in electricity consumption may adversely affect economic growth and vice-versa, then a different policy approach would be needed. Fourth and lastly, if the neutral hypothesis holds true or if it is proven that there is no causal relationship between the two variables, therefore such a conclusion would reveal the surprisingly minor role of electricity consumption and its effects in the economic growth of a country.

Production growth and an expansion of economic activities in Pakistan are restrained by its under-developed energy infrastructure. Intentionally-engineered electrical power outages i.e. load-sheddings are frequently used to curb the increasing demand of electricity in the country. Khan and Ahmad [1] reported that the current electricity production in Pakistan is around 11,500 MW per day, whereas the electricity demand had jumped from 15,000 MW per day to 20,000 MW per day in the year 2010. This massive increase in demand suggests that the looming energy crisis in Pakistan will become even more severe in the near future. Hence, investigation of the relationship between electricity consumption and economic growth in the country are extremely important and doubly urgent to the policy makers, market players and consumers both domestic and industrial.

There are already some previous studies conducted in Pakistan such as Aqeel and Butt [2] and Zahid [3], however, these studies only investigated the wider scope of energy consumption instead of the narrower scope of electricity consumption. Jamil and Ahmad [4] is the only study that examined the relationship between electricity consumption and economic growth in Pakistan. However, they did not consider other potential and vital variables such as capital and labor in their analysis. Lütkepohl [5] argued that omission of important variables would risk providing potentially biased and inappropriate results. No causal relation is found in the bi-variate system due to these neglected variables. Bartleet and Rukmani [6] also recommended incorporating some pertinent variables in the analysis. Thus, we re-investigate the causality between electricity consumption and economic growth in Pakistan by incorporating in the effects of the capital and labor factors.

The relationship between electricity consumption and growth may also differ in the short-run period and the long-run period even within the same country. Our study also examines the relationship between electricity consumption and economic growth in both the short- and long-run periods which was omitted in Jamil and Ahmad [4]. This paper offers two new and fresh contributions to the existing literature. Firstly, we incorporate the effects of two important production factors, i.e. capital and labor in the analysis.

Secondly, we examine the relationship between the two variables in both the short-run and the long-run periods.

The rest of the paper is organized as follows: Section 2 reviews the existing literature. Methodology and data are introduced in Section 3. Section 4 discusses the empirical results and finally the conclusion and major policy implications are presented and discussed in Section 5.

2. Literature Review

There is extensive literature on the nexus of energy consumption and economic growth; beginning with the paper by Kraft and Kraft [7] to the recent studies such as Tsani [8], Shahbaz et al. [9] and Kouakou [10]. Moreover, we note that there was a complete survey of the literature on energy undertaken by Ozturk [11]. Since this paper is on electricity consumption, we will focus the literature review on electricity consumption only.

Empirical studies on the causality between electricity consumption and economic growth can be divided into cross country studies and country specific studies. The empirical evidence provided mixed results in cross country studies. For example, in ASEAN countries, Yoo [12] suggested unidirectional causality from real income per capita to electricity consumption in Indonesia and Thailand while in Malaysia and Singapore, bi-directional causality was found. In Africa, Wolde-Rufael [13] found economic growth Granger causes electricity consumption in Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe while the opposite case was found for Benin, Congo and Tunisia.

Similarly, Chen et al. [14] indicated that electricity consumption and economic growth are mutually interdependent but unidirectional causality was found from GDP to electricity consumption by utilizing the heterogeneous causality approach. In OPEC economies, Squalli [15] found unidirectional causality from electricity consumption to economic growth in Indonesia, Nigeria, UAE and Venezuela while economic growth Granger causes electricity consumption in Algeria, Iraq, Kuwait and Libya.

For OECD countries, Narayan and Prasad [16] showed unidirectional causal relation from electricity consumption to economic growth for Australia, the Czech Republic, Iceland, Italy, Portugal and the Slovak Republic, but the reverse case in Finland, Hungry and the Netherlands while the feedback hypothesis was validated in Korea and the UK. Alinsato [17] assessed the relationship between electricity consumption and economic growth in Togo and Benin. Cointegration was found in Benin with growth-led-electricity consumption.

For the panel analysis, Narayan and Smyth [18] reported bidirectional causal relationship in the Middle Eastern countries. Yoo and Kwak [19] reported that electricity consumption Granger causes economic growth in Argentina, Brazil, Chile, Columbia and Ecuador; while electricity consumption and economic growth Granger cause each other in Venezuela.

Payne [20] conducted a survey on studies of economic growth and electricity consumption and reported that electricity consumption has positive impact on economic growth through some stylized facts. Acaravci and Ozturk [21] did not indicate any existence of cointegration between the variables for 15 transitional economies[1]. However, the Granger causality test was not conducted in these two studies.

In some country specific studies, it was found that economic growth Granger causes electricity consumption, for instance, Ghosh [22] for India, Jumbe [23] for Malawi, Narayan and Smyth [24] for Australia, Yoo and Kim [25] for Indonesia, Mozumder and Marathe [26] for Bangladesh, Halicioglu [27] for Turkey, Aktas and Yilmaz [28] for Turkey, Pao [29] for Taiwan, Ciarreta and Zarraga [30] for Spain and Jamil and Ahmad [4] for Pakistan. On the contrary, there are findings that the causality is running from electricity consumption to economic growth, for example, Ramcharran [31] for Jamaica, Shiu and Lam [32] and Yuan et al. [33] for China, Altinay and Karagol [34] for Turkey, Ho and Sui [35] for Hong Kong, Chandran et al. [36] for Malaysia, Abosedra et al. [37] for Lebanon, Akinlo [38] for Nigeria, and Acaravci [39] for Turkey.

The feedback effect between electricity consumption and economic growth is also validated in many studies, for instance, Yoo [40] for Korea, Zachariadis and Pashouortidou [41] for Cyprus, Tang [42] and Lean and Smyth [43] for Malaysia, Odhiambo [44] for South Africa, Ouédraogo [45] for Burkina Faso and Lorde et al. [46] for Barbados. There exists empirical evidence of a neutral hypothesis between electricity

[1] Albania, Belarus, Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia, Slovak Republic and Ukraine

consumption and economic growth as well, for instance, Murry and Nan [47] for the developing economies, Asafu-Adjaye [48] for Asian countries and, Yusof and Latif [49] for Malaysia.

In the case of Pakistan, only a few studies had investigated the causal relationship between energy consumption and economic growth. Aqeel and Butt [2] used different indicators[2] to proxy the energy consumption. They found unidirectional causality running from economic growth to oil consumption. Although, there is no causal relation between natural gas consumption and economic growth but they found unidirectional causality from total electricity consumption to economic growth. On the other hand, Alam and Butt [50] and Qazi and Riaz [51] found bi-directional causal relationship between energy consumption and economic growth.

Khan and Qayyum [52] examined causal relationship between energy consumption and economic growth in South Asian economies including Pakistan. They suggested that the causality is running from energy consumption to economic growth in Pakistan. Zahid [3] also conducted a similar study in South Asian countries using different indicators for energy consumption i.e. petroleum, gas, coal, electricity and total energy consumption. In the case of Pakistan, unidirectional causal relation is found running from coal consumption to economic growth, also from economic growth to electricity consumption and also towards total energy consumption. The existing studies for Pakistan yielded

[2] Aqeel and Butt [2] used oil consumption, natural gas consumption, electricity consumption and overall energy consumption as indicators of energy consumption.

mixed results. Hence, it is difficult to provide appropriate direction and advice for the policy makers in formulating energy policies for the country.

Jamil and Ahmad [4] is the only study that investigated the relationship between electricity prices, electricity consumption and real GDP in Pakistan. They found a long-run relationship and unidirectional causality from economic growth and electricity prices to electricity consumption. Their findings may be biased because they omitted two important variables in their model. Hence, we think it is highly important, if not absolutely necessary to re-visit the relationship by incorporating an appropriate investigation of capital and labor in the neoclassical production function to make the inference more reliable.

3. Methodology and Data

To investigate the relationship between electricity consumption and economic growth, we employ the neoclassical production function framework. The relationship can be expressed mathematically as follows:

$$Y_t = \alpha_1 + \alpha_{EC} EC_t + \alpha_K K_t + \alpha_L L_t + \mu_t \qquad (1)$$

where Y_t, EC_t, K_t and L_t are real GDP per capita, electricity consumption per capita in KWH, real capital used per capita and labor participation rate respectively, and μ_t is the error term. All variables are expressed in the natural log form. The annual time series data for all variables are obtained from World Bank's world development indicators (WDI, 2010) for the sample period of 1972 to 2009.

3.1 Saikkonen and Lütkepohl Structural Break Unit Root Test

The standard unit root tests such as ADF and PP may provide inefficient and biased results when the shift is prevailed in the time series. To circumvent this problem, we use the test proposed by Saikkonen and Lutkepohl [53] and Lanne et al. [54]. The equation is written as follows:

$$y = \mu_0 + \mu_1 t + f_t(\theta)' \gamma + \varepsilon_t \tag{2}$$

where $f_t(\theta)'\gamma$ indicates the shift function while θ and γ are considered as unidentified vectors, ε_t is generated by an $AR(p)$ process. A simple shift dummy variable with shift date T_B is used on the basis of exponential distribution function. This function i.e. $f_t' = d_{1t}\begin{cases} 0, t < T_B \\ 1, \geq T_B \end{cases}$ does not seem to entail any parameter θ in the shift term $f_t(\theta)'\gamma$ where γ is a scalar parameter. We follow Lanne et al. [54] to choose the structural breaks exogenously which allows us to apply ADF-type test to check the stationarity properties of the series. Saikkonen and Lutkepohl [53] and Lanne et al. [54] also suggested of using large autoregressive in finding break date to minimize the generalized least square error of the objective function.

3.2 ARDL Bounds Testing Approach to Cointegration and Granger Causality

We apply the ARDL bounds testing approach to cointegration advanced by Pesaran et al. [55] to examine the long-run relationship between the variables. There are three advantages in using this approach. First, the relationship in long-run and short-run can be estimated simultaneously. Second, it can be employed even though the variables have a mixed integration order. Third, it has better properties for small sample data sets.

The unrestricted error correction model (UECM) below is used for the estimation.

$$\Delta Y_t = \varphi_{y0} + \varsigma_y T + \pi_{y1} Y_{t-1} + \pi_{y2} EC_{t-1} + \pi_{y3} K_{t-1} + \pi_{y4} L_{t-1} + \sum_{i=1}^{p} \lambda_{yi} \Delta Y_{t-i} + \sum_{j=0}^{q} \gamma_{yi} \Delta EC_{t-j} + \sum_{i=0}^{r} \alpha_{yi} \Delta K_{t-i} + \sum_{i=0}^{s} \beta_{yi} \Delta L_{t-i} + \varepsilon_{1t} \tag{3}$$

$$\Delta EC_t = \varphi_{ec0} + \varsigma_{ec} T + \pi_{ec1} Y_{t-1} + \pi_{ec2} EC_{t-1} + \pi_{ec3} K_{t-1} + \pi_{ec4} L_{t-1} + \sum_{i=1}^{p} \lambda_{eci} \Delta EC_{t-i} + \sum_{j=0}^{q} \gamma_{eci} \Delta Y_{t-j} + \sum_{i=0}^{r} \alpha_{eci} \Delta K_{t-i} + \sum_{i=0}^{s} \beta_{eci} \Delta L_{t-i} + \varepsilon_{2t} \tag{4}$$

$$\Delta K_t = \varphi_{k0} + \varsigma_k T + \pi_{k1} Y_{t-1} + \pi_{k2} EC_{t-1} + \pi_{k3} K_{t-1} + \pi_{k4} L_{t-1} + \sum_{i=1}^{p} \lambda_{ki} \Delta K_{t-i} + \sum_{j=0}^{q} \gamma_{ki} \Delta Y_{t-j} + \sum_{i=0}^{r} \alpha_{ki} \Delta EC_{t-i} + \sum_{i=0}^{s} \beta_{ki} \Delta L_{t-i} + \varepsilon_{3t} \tag{5}$$

$$\Delta L_t = \varphi_{l0} + \varsigma_l T + \pi_{l1} EC_{t-1} + \pi_{l2} Y_{t-1} + \pi_{l3} K_{t-1} + \pi_{l4} L_{t-1} + \sum_{i=1}^{p} \lambda_{li} \Delta L_{t-i} + \sum_{j=0}^{q} \gamma_{li} \Delta Y_{t-j} + \sum_{i=0}^{r} \alpha_{li} \Delta EC_{t-i} + \sum_{i=0}^{s} \beta_{li} \Delta K_{t-i} + \varepsilon_{4t} \tag{6}$$

where Δ is the first difference operator, φ is the constant, π_s are the long-run coefficients; $\lambda, \gamma, \alpha, \beta$ represent the short-run dynamics and ε_t is the error term which is assumed to be white noise. The time trend is indicated by T. Akaike Information Criteria (AIC) is used to select the optimal lag length.

The null hypothesis of no cointegration is $H_0: \pi_{y1} = \pi_{y2} = \pi_{y3} = \pi_{y4} = 0$ against the alternative hypothesis of cointegration $H_a: \pi_{y1} \neq \pi_{y2} \neq \pi_{y3} \neq \pi_{y4} \neq 0$ for equation (3). The same hypotheses can be derived for equations (4) to (6). The computed F-statistics are $F_Y(Y/EC,K,L)$, $F_{EC}(EC/Y,K,L)$, $F_K(K/Y,EC,L)$ and $F_L(L/Y,EC,K)$ for equations (3) to (6) respectively. If the computed F-statistic is more than the upper critical bound, then the null hypothesis is rejected and there is cointegration between the variables. The hypothesis of no cointegration can be concluded if the computed F-statistic is less than the lower critical bound. Nevertheless, the results will be inconclusive if the calculated F-statistic is between the lower and upper critical bounds[3]. We use critical bounds generated by Turner [56] which are more suitable for small samples as compared to the Pesaran et al. [55] study. In addition, to examine the stability of the ARDL bounds testing approach to cointegration, stability tests namely CUSUM and CUSUMSQ are applied.

The long-run relationship between economic growth and the other variables can be shown as follows, given that the variables are cointegrated:

$$Y_t = \Phi_0 + \Phi_1 EC_t + \Phi_2 K_t + \Phi_3 L_t + \mu_t \tag{7}$$

where $\Phi_0 = \varphi_{y0}/\pi_{y1}, \Phi_1 = -\pi_{y2}/\pi_{y1}, \Phi_2 = -\pi_{y3}/\pi_{y1}, \Phi_3 = -\pi_{y4}/\pi_{y1}$ and μ_t is the iid error term.

3.3 VECM Granger Causality

Morley [58] pointed out that if there is long-run relationship between the variables, there must be Granger causality. We employ VECM Granger causality to detect the direction of causality between electricity consumption and economic growth in the presence of capital and labour. The direction of causality between the variables provides a clearer

[3] Error correction method is appropriate and reliable to investigate the cointegration (Bannerjee et al. [57]).

picture to the policy makers in formulating the electricity efficient economic policies. Given the existence of long-run relationship among variables, an error correction term is added in the framework of VECM as follows:

$$(1-L)\begin{bmatrix} Y_t \\ EC_t \\ K_t \\ L_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} b_{11i}b_{12i}b_{13i}b_{14i} \\ c_{21i}c_{22i}c_{23i}c_{24i} \\ d_{31i}d_{32i}d_{33i}d_{34i} \\ e_{41i}e_{42i}e_{43i}e_{44i} \end{bmatrix}\begin{bmatrix} Y_t \\ EC_t \\ K_t \\ L_t \end{bmatrix} + \begin{bmatrix} \theta \\ \vartheta \\ \varphi \\ \rho \end{bmatrix}[ECT_{t-1}] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \tag{8}$$

where $(1-L)$ is the difference operator, ECT_{t-1} is the lagged error correction term and $\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}$ and ε_{4t} are the iid error terms. If there is significant relationship in the first p difference of the variables, it will show the short-run causal relationship through the significance of F-statistics. A significant coefficient of ECT_{t-1} via its *t*-statistic shows the long-run causality. For example, $b_{12,i} \neq 0 \forall_i$ indicates that electricity consumption Granger causes economic growth in the short-run. The joint short- and long-run Granger causality is investigated by the significance of joint χ^2-statistic on the lagged error correction term and first difference lagged concerned independent variable.

4. Empirical Results

The results of Saikkonen and Lutkepohl [53] unit root test are reported in Table 1. We use an impulse dummy to detect the structural break for all variables. We find that real GDP per capita is stationary at first, with a difference and the presence of a structural break in 1992. That date is consistent with the implementation of a structural adjustment program in the country. The same inference can be drawn for electricity consumption. Nevertheless, labor and capital are also stationary at first, with differences and structural breaks occurring in 1997 and 2004 respectively.

Table 1: Saikkonen and Lütkepohl Unit Root Test Results

Variables	Break date	Statistics (k)
Y_t	1992	-0.5223 (0)
ΔY_t	1992	-3.8819* (0)
EC_t	1992	-1.3284 (0)
ΔEC_t	1992	-4.6414 ***(0)
L_t	1997	0.5178 (1)
ΔL_t	1997	-3.2234**(0)
K_t	2004	-0.9813 (0)
ΔK_t	2004	-3.6862***(1)

Note: (1) ***, ** and * denote the significance at 1%, 5% and 10% level respectively. (2) k indicates lag order, the lag selection is based on AIC. (3) Critical values are -3.55, -3.03 and -2.76 at 1%, 5%, and 10% respectively from Lanne et al. [54]

Selection of the appropriate lag length is necessary for the ARDL bounds testing approach to co-integration because the calculation of the F-statistic is sensitive to any lag order. Several selection criteria have been considered and the appropriate lag length is 2 based on AIC. Lütkepohl [59] pointed out that AIC is superior for small sample. Results of ARDL bounds test in Table 2 suggest that the hypothesis of cointegration is accepted when Y_t, EC_t and K_t as dependent variables respectively. This empirical evidence confirms the long-run relationship between the variables in Pakistan.

Table 2: Results of Bounds Testing to Cointegration

Estimated Model	$F_Y(Y/EC,K,L)$	$F_{EC}(EC/Y,K,L)$	$F_K(K/Y,EC,L)$	$F_L(L/Y,EC,K)$
Optimal Lag Length	(2, 1, 1, 1)	(2, 2, 1, 2)	(2, 2, 2, 2)	(2, 2, 2, 2)
F-statistics	6.4095*	12.2451***	8.1691**	4.3891
Critical values#	1 per cent level	5 percent level	10 percent level	
Lower bounds	7.397	5.296	4.401	
Upper bounds	8.926	6.504	5.462	
Diagnostic tests				
R^2	0.6249	0.8707	0.7271	0.7426

Adjusted- R^2	0.3486	0.7686	0.4371	0.4691
F-statistics	2.2617**	8.5305*	2.5078**	2.7157**
Durbin-Watson	2.3541	1.2854	2.1518	2.2343

Note: *, ** and *** denote the significance at 10%, 5% and 1% level respectively. The optimal lag structure is determined by AIC. #Critical values bounds are from Turner [56].

We also conduct Johansen and Juselius [60] cointegration approach to check the robustness of a long-run relationship. Results in Table 3 confirm that the long-run relationship between the variables is valid and robust.

Table 3: Results of Johansen Cointegration Test

Hypothesis	Trace Statistic	Maximum Eigen Value
$R = 0$	125.1119***	75.4751***
$R \leq 1$	49.6367**	27.8837**
$R \leq 2$	21.7530	12.1759
$R \leq 3$	9.5770	9.5617
	0.0153	0.0153

Note: *** and ** show the significance at 1% and 5% level respectively.

The long-run coefficients in Table 4 reveal the significant positive effect of electricity consumption on economic growth. It is noted that a 1 percent increase in electricity consumption will stimulate economic growth by 0.3 percent. There is also a positive effect of capital and labor on economic growth and they are statistically significant at 1% level of significance. These results imply that capital and labor together with electricity are the important factors of production in Pakistan. Our findings are comparable with Yuan et al. [61] for China and Erbaykal [62] for Turkey.

Table 4: Long and Short Runs Results

Dependent Variable: Y_t			
Long Run Results			
Variable	Coefficient	Std. Error	t-statistic
Constant	6.1316	0.2881	21.2768***
EC_t	0.3142	0.0272	11.5364***
K_t	0.1191	0.0322	3.6999***
L_t	0.2984	0.0453	6.5809***

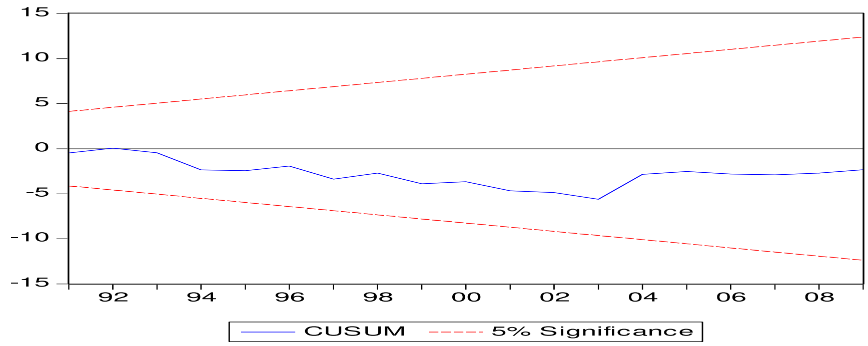
Short Run Results			
Variable	Coefficient	Std. Error	t-statistic
Constant	0.0074	0.0056	1.3061
EC_t	0.2575	0.0690	3.7281***
K_t	0.1279	0.0446	2.8635***
L_t	0.1108	0.1023	1.0827
ECM_{t-1}	-0.5699	0.1943	-2.9331***
R^2	0.4241		
$Adj-R^2$	0.3498		
F-statistic	5.7082***		
Diagnostic Test	F-statistic	Prob. value	
χ^2 *NORMAL*	1.4342	0.4881	
χ^2 *SERIAL*	0.6601	0.5248	
χ^2 *ARCH*	0.3716	0.5464	
χ^2 *WHITE*	1.5649	0.2092	
χ^2 *REMSAY*	1.1272	0.2971	

Note: *** shows the significance at 1% level.

The short-run coefficients also show that electricity consumption and capital have a significant positive impact on economic growth but the positive impact of labor is insignificant in the short-run. We also note that the coefficient of lagged error correction term (ECM_{t-1}) is negative and statistically significant at 1% level of significance. The significance of coefficient of ECM_{t-1} corroborates the established relationship among the variables of interest. Moreover, the negative sign implies that deviation in short-run towards long-run is corrected by 57% from the previous period to the current period.

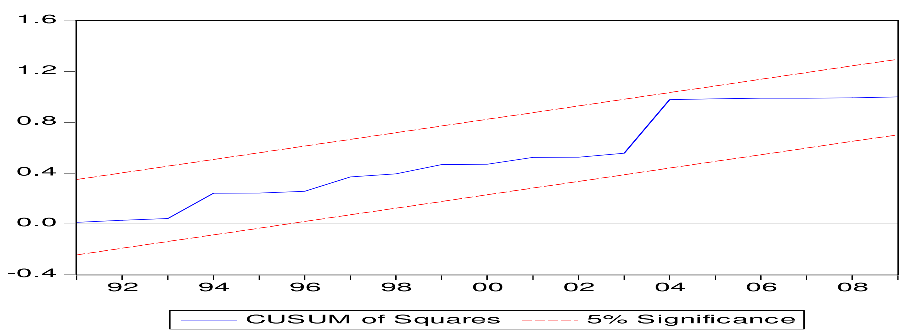
The CUSUM and CUSUMSQ tests are applied to examine the stability of long-run parameters. Both graphs of CUSUM and CUSUMSQ statistics are plotted in Figure 1 and Figure 2 respectively. The plotted data points are within the critical bounds implying that the long-run coefficients are stable.

Figure 1: Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.

Figure 2: Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.

VECM Granger Causality Analysis

The results of Granger causality are reported in Table 5. Since the variables are cointegrated, the direction of causality can be divided into short- and long-run causations. Begining with the long-run causality, the coefficient of ECT_{t-1} is having a negative sign and statistically significant in all equations except when labor acts as the dependent variable. This implies that bi-directional causality between economic growth, electricity consumption and capital is found in the long-run period. In addition, if the system is exposed to a shock, it will converge to the long-run equilibrium at a relatively high speed for economic growth (77%) and electricity consumption (51%).

In the short-run, there is bi-directional causality between electricity consumption and economic growth. This empirical evidence provides support to the findings of Yoo [40] for Korea, Odhiambo [44] for South Africa and Lorde et al. [46] for Barbados. However, our results show contradictions with the evidences by Aqeel and Butt [2], Zahid [3] and Jamil and Ahmad [4] for Pakistan. This contradiction can be argued upon with a plausible view that those findings are biased or have been skewed due to their exclusion of potentially important variables such as capital and labor. There is also bi-directional causality between capital and economic growth which implies that both capital and economic growth are important if not vital complements for effective consideration. This finding is consistent with Arbay and Batool [63].

Results of joint short- and long-run causalities (Nasir and Rehman [64]) are also pasted in Table 5. We find significant combined short- and long-run effects in all equations except the labor equation. These results imply that there exists “strong bi-directional Granger causality” (Oh and Lee [65]) which is to be found between electricity consumption and capital, and again once more between electricity consumption and economic growth in Pakistan.

Table 5: Results of Granger Causality

						Joint (short and long-run)			
	Y_t	EC_t	K_t	L_t	ECT_{t-1}	$\Delta Y_t, ECT_{t-1}$	$\Delta EC_t, ECT_{t-1}$	$\Delta K_t, ECT_{t-1}$	$\Delta L_t, ECT_{t-1}$
Y_t	–	4.0832** [0.0282]	5.4844** [0.0100]	0.3234 [0.7264]	-0.7668*** [-3.4667]	–	5.8877*** [0.0032]	6.0810*** [0.0027]	4.0940** [0.0162]
EC_t	5.9449*** [0.0073]	–	2.0233 [0.1518]	0.8659 [0.4320]	-0.5086** [-2.6608]	8.6887*** [0.0003]	–	2.7546* [0.0619]	3.5786** [0.0268]
K_t	3.3018* [0.0521]	2.0848 [0.1439]	–	0.0327 [0.9679]	-0.3501** [-2.7571]	4.6249*** [0.0098]	3.4314** [0.0310]	–	2.7911* [0.0596]
L_t	1.2149 [0.3124]	1.4189 [0.2594]	2.5211* [0.0991]	–	0.0952 [0.8586]	1.1879 [0.3203]	1.2688 [0.3049]	1.9239 [0.1495]	–

Note: The asterisks ***, ** and * denote the significance at 1, 5 and 10 per cent respectively.

5. Conclusion

This paper re-visits the dynamics relationship between electricity consumption and economic growth in Pakistan. The empirical evidence indicates that electricity consumption, economic growth, capital and labor are in the long-run equilibrium. We also find that electricity consumption, capital and labor have positive and significant impact on economic growth. Bi-directional causal relationship between electricity consumption and economic growth or feedback hypothesis exist in Pakistan for both the short-run and long-run periods. Bi-directional causal relation is also found between capital and economic growth.

These results imply that electricity conservation policies may inversely affect the rate of economic growth and in turn, cause a decline in economic growth and will in turn lower the demand for electricity. This fact suggests that the Government of Pakistan must change their policy focus to support research and development expenditures to explore new sources of energy in order to meet the rising demand for electricity and power; and adopt more advanced technology to produce and save energy. The adoption of advanced technology will not only prevent environmental degradation but also sustain economic development in the country. Additionally, alternative energies such as solar power, hydro power, and wind power should be seriously considered because these alternative energy production methods are environmentally friendly compared to the current fossil fuel powered production infrastructure.

Our model has the potential to investigate the relationship between electricity consumption and economic growth by including other variables such as: electricity prices and exports as indicated by Lean and Smyth [43]; financial development and exchange rate mentioned by Karanfil [66] and also international trade which was suggested by Halicioglu [67] and Narayan and Smyth [18]. The relationship between electricity consumption at disaggregated levels and economic growth could be explored such as in the case of Pakistan and South Asian Association for Regional Corporation countries which had been conducted by Payne [68] in the US. Analysis on disaggregated electricity consumption and economic growth will be more useful for policy makers to formulate a comprehensive policy with a view towards saving energy and reducing environmental degradation.

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