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Nexus of Electricity Demand, Circular Debt and Economic Progress: An Evidence from Pakistan

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ABSTRACT

In the context of Pakistan, this research examines circular debt and energy usage effects on per capita income. It uses quarterly data from 2005 to 2020 and an autoregressive distributed lag model to look at the link over the short- and long-term. According to the empirical study, whereas circular debt has a long-term significant negative association with per capita income, it has a significant positive link with per capita income in the short term. This demonstrates how using power contributes to economic expansion. Additionally, a rise in circular debt reduces per capita income in the near term, but the long-term convergence of the system to equilibrium is confirmed by the error correction term's considerable negative value. In addition, study shows that consistent provision of electricity with the help of new technologically advanced electricity plants would help in attaining high economic growth.

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1. Introduction

Over the last few years, many studies, such as (Adom, 2011; Pirlogea & Cicea, 2012), examined energy effect on economic growth as a new factor without using the traditional growth models. Moreover, various studies elucidate bidirectional and unidirectional causality between consumption of electricity and economic progress (Gurgul & Lach, 2012; Hu & Lin, 2013; Nazlioglu, Kayhan, & Adiguzel, 2014; Ogundipe & Apata, 2013). As time passes, economic growth will be heavily dependent on electricity consumption. Furthermore, Akarca and Long II (1979); Glasure and Lee (1998); Masih and Masih (1996, 1997, 1998) investigate energy demand and economic progress association in several countries, while these countries exhibit different relationship across the different time period. Various studies estimated the substitution elasticity among energy and capital (Apostolakis, 1990; Berndt & Wood, 1979; Stern, 1999). Thus, energy is a primary factor for production and leads to economic progress. In addition, it has been explored that the apprehension of electricity consumption is affecting the environment because of global warming and climate change (Bennett, 2014). According to neo-classical school of thought, energy and capital are suitable for each other (Solow, 2017).

Several studies Altinay and Karagol (2005); Atif and Siddiqi (2010); Shiu and Lam (2004) estimate unidirectional electricity demand to economic progress causality. On contrary to the above discussion, some studies such as (Adom, 2011; Akinwale, Jesuleye, & Siyanbola, 2013; Ciarreta Antuñano & Zárraga Alonso, 2007; Hye & Riaz, 2008; Ozun & Cifter, 2007) elucidates the causality running from economic progress to electricity demand, while many researchers show an insignificant relationship between consumption of electricity and energy consumption (Aktaş & Yilmaz, 2008; Ciarreta Antuñano & Zárraga Alonso, 2007; Eden & Hwang, 1984; Gillani & Sultana, 2020). In addition, the progress of a country is measured by economic growth, which indicates how much the country's productive capacity increases over time. Energy is considered an important input for producing several commodities with the passage of time. However, economic growth and socio-economic activities in our daily life lead to economic development. It is important to note that energy cannot play its role effectively without financial development. Moreover, an increase in industrial value addition and urbanization increases the consumption of energy in long-run. A 10% rise in domestic credit leads to a 1.4% increase in energy demand, a 10% rise in industrial price increases energy demand by 2% and a 1% rise in urban population increases energy demand by 0.9% (Shahbaz & Lean, 2012a).

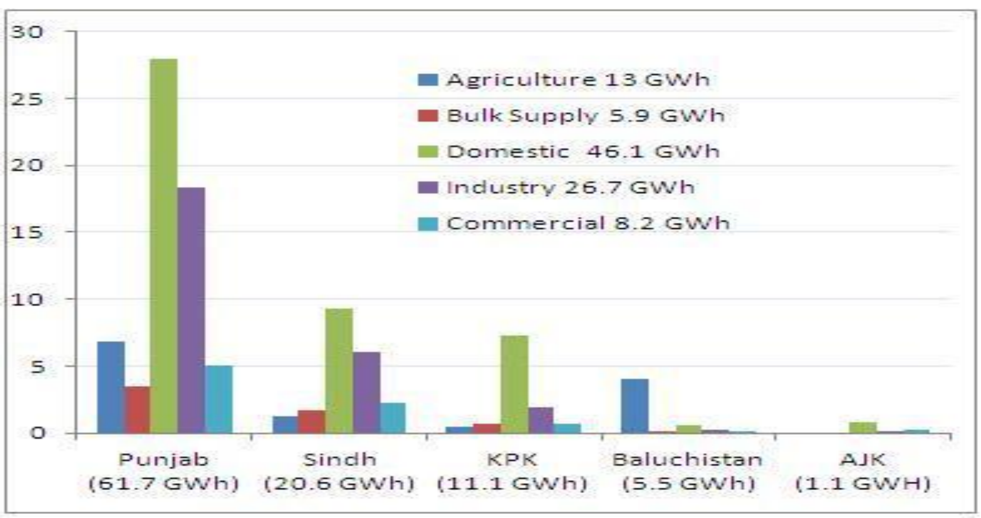

Figure1: Provincial and sector wise consumption of energy

During the two decades, electricity consumption has increased while the electricity provision is insufficient to meet the required demand. Due to these circumstances, the supply and demand widened with the increase in population. Figure 1 shows the demand for energy in different sectors of an economy. WAPDA (Water and Power Development Authority) is the main institution for the power sector management. The hydropower sector's capacity is 20921 megawatts (MG) by WAPDA. In addition, 481 megawatts (MG) are contributed by General commodities warehouse and distribution company (GENCO), while 7123 megawatts (MG) and 462 megawatts (MG) have been contributed by Independent power producer (IPP) and Nuclear plants in the national grid. However, the demand for electricity in summer's peak duration was 18,511 megawatts (MG) in 2012, while the electricity production was 14,468 megawatts (MG) in 2012. The short-fall of electricity in 2013 was 3800 megawatts (MG). Urban areas experienced load shedding of 8-12 hours per day, while rural areas experienced load shedding of 12-18 hours per day in 2012. Moreover, the transmission losses were around 13% to 37% of net total energy generation due to the transmission and distribution companies' poor performance. Furthermore, 70% of electricity production comes from the thermal sector, which is a major contributor of electricity in the national grid. Electricity production by incorporating long-term projects has been squeezed for the past few years. Production of electricity under Independent power producers (IPP) has increased dramatically. A major portion of thermal generation is comprised of imported oil. 57% of thermal production is comprised of oil and diesel and this trend is kept on increasing due to poor situation of natural gases. An increase in short-fall of electricity production and production of electricity dependent on oil has severely affected the policy of "Least cost generation expansion" (Abbasi , Mahmood, Kamal, & Baig, 2015; Pakistan Economic Survey, 2015).

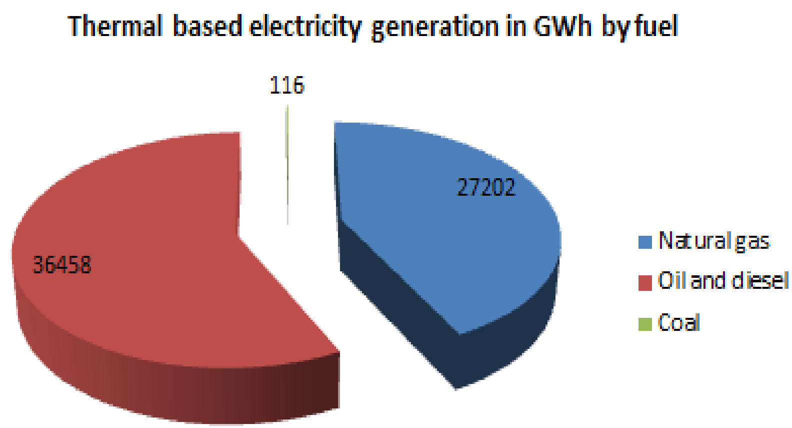

Figure 2: Thermal generation from different sources in 2013

Pakistan lost 4.8 billion$ due to short-fall in electricity consumption in 2012-12. Furthermore, circular debt is also an important issue for Pakistan, which increased from 111.26Rs billion to 872.6Rs billion from 2006 to 2013. The problem of circular debt arises when one entity faces the problem of cash payments from its customers and is thus unable to make payments to its suppliers (S. S. Ali & Badar, 2010; Pakistan Economic Survey, 2015). Transmission and distribution companies; unable to collect electricity bills from several institutions of Pakistan and consumer. This will cause a delay in payments of electricity generation companies, which further creates hurdle to make payments to oil exporting countries. This will create a problem of circular debt and short-fall in electricity consumption, which further create unemployment and shutdown of industries. Less supply of electricity is not the only reason for the compilation of circular debt but also the electricity use, which is not targeted to achieve economic stability. The domestic segment consumes more electricity than the industrial sector, which least adds to economic progress. There is an increasing tendency in the consumption of electricity in domestic segment during 2014-15.This is because of adopting more energy-saving techniques in industries and using energy devices (refrigerators, air conditioners etc.) at homes. Knowing the fact that domestic segment is unproductive for economic growth, it is given more subsidies than the industrial sector. When demand increases more than supply, it leads to less economic growth (Abbasi et al., 2015).

The main aim of the current study is to examine circular debt, energy demand and economic progress relationship by using quarterly data of Pakistan from 2006-2015. The motive behind estimating the relationship of discussed variable is that major sector of an economy is heavily electricity dependent like household, industrial, commercial and agriculture sector are profoundly dependent on electricity. However, household consumption accounts the major consumption of electricity due to growth in population and modernization from 1994 to 2012. Consumption of electricity has been reduced among household sector due to increase in tariff after 2012. However, it is assumed that electricity demand will be increased in future due to the increase in population in Pakistan (Tariq et al., 2011). 58% of people in Pakistan have access to electricity in 1990 but after some years the access to electricity has been increase to 75% in

2005. The consumption of electricity has been increased due to usage of latest and cheap electricity appliances at home and this will increase the electricity demand-supply gap in case of Pakistan. This will create a shortfall in electricity production and create a severe economic challenge which further hurts economic growth of Pakistan. It is estimated that economic demand has been declined by 2% to 3% due to shortfall in electricity production. The electricity production by independent power producer (IPP) are heavily dependent on oil due to which an increase in oil prices increases electricity shortfall (Shahbaz & Lean, 2012b). Many studies such as Jumbe (2004); M. A. Khan, Qayyum, and Ahmad (2007); Lee (2005) used time series and panel data for different countries and for various regions of the world and bridge a proper link between electricity demand and economic progress. However, instead of using longitudional the current study uses quarterly data of Pakistan and bridge a proper link among circular debt, energy demand and economic progress.

2. Literature Review

Gbadebo and Okonkwo (2009) found that the demand for energy has a positive effect on the Nigerian economic progress. In contrast, Orhewere and Henry (2011) studied the short-term impact of energy demand on economic progress and discovered a one-way energy demand and economic progress relationship, but a two-way relationship between gas demand and economic progress in the long run. The long-term results also indicated a one-way oil demand and economic expansion causal relationship. Dantama, Abdullahi, and Inuwa (2012) found that power usage has a significant impact on economic progress using the ARDL method. Chen, Shih, Chen, and Chen (2011) used panel data from Asian economies to investigate the bidirectional energy demand and economic progress causality. According to Lee (2005), increased energy demand leads to higher economic growth in developing economies. Huang, Hwang, and Yang (2008) estimated positive correlations among energy demand and economic progress in medium-income countries but negative relationships in high-income nations. (Narayan & Smyth, 2005) demonstrated an economic progress to electricity demand causality in Australia using ARDL, while Sharma (2010) found electricity demand and economic progress bidirectional causality among European and Asian economies.

Similarly, numerous studies have been conducted to investigate electricity demand, circular debt and economic progress relationship. Few studies conclude that circular debt has negatively and significantly affect the per capita income. Because, circular debts reduced the per capita income. Similarly, empirical studies also explain that provision of electricity with the help of new technology helps to attain economic growth (Aftab et al., 2021; S. Ali, Zhang, Azeem, & Mahmood, 2020; Bento & Moutinho, 2016). However, few study shows the contradictory results of electricity demand on economic progress (Hirsh & Koomey, 2015; Stern, Burke, & Bruns, 2019).

The main cause of circular debt in Pakistan is electricity sector because electricity sector is over subsidized. Hence, these outstanding subsidies in electric sector will create the circular debt and this circular debt ultimately deteriorates the market-framework (Samad, Faraz, & Awan, 2023). The existing literature on the circular debt and economic progress also helps to provide the picture of the circular debt issues and its linkages and impact on economic progress Bacon (2019); A. J. Khan (2014); Samad et al. (2023) and Trimble, Yoshida, and Saqib (2011). Moreover, some studies also contradict the existing literature. The developing countries always has a potential and natural resources. Liaquat and Mahmood (2017) reveal that circular debt is a blessing or curse is totally depending upon the good or bad governance. Hence, wise allocation and effective utilization of resources will be the blessing of the nation.

Energy play a vital role for the production process, however, source of energy augmentation is costly and complex (Aftab et al., 2021; S. Ali et al., 2020). Hence, due to the need and role of electricity demand, researchers urge to conduct the studies to found the role of energy demand on economic progress. Although, energy consumption and energy demand positively associated with economic progress, however, the cost of economic growth is negatively affect the natural environments (Aftab et al., 2021; Farooq, Gillani, Subhani, & Shafiq, 2022; Nazir, Gillani, & Shafiq, 2023). Because, in developing economies like Pakistan, the major source of energy demand is accomplished from non-renewable energy source (Bento & Moutinho, 2016; Fazal, Gillani, Amjad, & Haider, 2020; Shafiq, ur Raheem, & Ahmed, 2020). S. Ali et al. (2020) used the ANN (Artificial Neural Networks) to forecast the electricity demand for future with a high degree of accuracy. The finding suggested that government should fulfill the electricity demand because electricity consumption has the positive impact on economic progress. These results are also in-line with the Talbi, Jebli, Bashir, and Shahzad (2022), which further explain that, energy scarcity negatively affect the economic progress of the country. Additionally, few researchers also explain the presence of bidirectional economic growth and energy demand causality (Balcilar, Bekun, & Uzuner, 2019). However, the continuous increase in electricity demand will create a severe crises and it may threaten the industrial production. Furthermore, (Hye & Riaz, 2008) examined energy impact on economic growth. Later on, Jamil (2022) used data of seven countries and examine the energy impact on economic progress. They found that effective utilization of energy can play an important role in economic progress of a country.

3. Data Sources and Estimation Technique

For empirical estimations, the study uses quarterly data of Pakistan from 2006-2020. Data of majority variables has been extracted from "National Transmission and Dispatch Company", "Pakistan planning commission" and "Pakistan economic survey" and has been converted in quarterly data to observe electricity consumption in each quarter, because its consumption significantly varies over quarters. The fundamental functional form for the economic progress and electricity demand relationship can be modeled as follows

$$y = f(cd, ec, inf, pd, gcf) \tag{1}$$

Due to linear specification of the model, we convert all the specified variables into a natural log, which generates more robust and comparative estimates (Shahbaz & Lean, 2012a; Shahbaz, Sarwar, Chen, & Malik, 2017; Waheed, Chang, Sarwar, & Chen, 2018). Furthermore, applying a natural log to the model provides the opportunity to discuss the estimated parameters in terms of elasticities, which further provides a smooth way to compare the parameters. The empirical equation can be written as:

$$ly = \beta_0 + \beta_1 lcd + \beta_2 lec + \beta_3 inf + \beta_4 lpd + \beta_5 lgcf + \varepsilon_i \tag{2}$$

Furthermore, ly, lcd, led, lpd, and $lgcf$shows the natural logarithm of discussed variables such as GDP per capita, circular debt, electricity consumption, population density and investment. GDP per capita, circular debt and investment is in Rs billion, later converted into log form. Population density variable has been taken from the website of WDI in the form of number of people per square kilometer. On the other hand consumption of electricity data is also taken from the website of WDI in the form of gigawatt per hour GWh, while data of inflation is in percentage form based on consumer price index.

4. Statistical Techniques

The time series econometrics assume stationary data means no auto-correlation in the given data. If the given time series data is not stationary, then one cannot apply usual regression estimation technique such that ordinary least square OLS. In this case, OLS will provide spurious estimates with high R^2.

4.1 Unit root test

Given series does not contain the unit root problem if it fulfills all the condition in the definition as a data series is stationary if its mean, variance and covariance is time invariant[1].

Several approaches are used for testing stationarity in a given time series. However, Dickey Fuller (DF) is the most appropriate technique among these approaches. Ordinary least square method is used to test the given equation by Dickey and Fuller (1979):

$$V_t = \phi_1 V_{t-1} + e_t \tag{3}$$

However, error term is represented by e_t, which is presumed to be white noise with zero mean and constant variance (o, σ^2). In addition, H_o assumed that series contains the unit root problem such that ($\phi_1 = 1$) while H_a assumed that series does not contain the problem of unit such that ($\phi_1 < 1$). The rejection of H_o believes that series is stationary and vice versa.

Estimating equation (3) using the method of ordinary least square (OLS) creates two major problems. The ordinary least square (OLS) method is only applicable if the series does not contain the unit root problem. From equation (3) the first lag of dependent variable is treated as explanatory variable. These two problems create the problem of biasness, keeping in view the conventional t statistics. This shows that ϕ_1 is biased. Dickey and Fuller (1979) resolves above discussed problem by taking difference with V_{t-1} on both side of equation:

$$\Delta V_t = (\phi_1 - 1)V_{t-1} + e_t \tag{4}$$

Dickey and Fuller (1979) estimate the above equation by using ordinary least square (OLS). Now by using equation (4), null hypothesis is represented by $\{(\phi_1 - 1) = 0\}$ while alternative hypothesis is shown as $\{(\phi_1 - 1) < 1\}$. This shows that the time series is free of unit root problem if null hypothesis is rejected, vice versa.

The first order autoregressive process is represented by equation (4) with absence of deterministic component and zero mean. However, ($V_0 = 0$) represents zero time period. For a model without deterministic component under the H_a of non-stationary series, the mean of a series is dependent on initial observation, therefore, equation (3) is only valid when long run mean of the series is zero. So, there is difficulty in regulating whether ($V_0 = 0$). That's why drift is incorporate, represented by δ in equation (4):

$$\Delta V_t = \delta + (\phi_1 - 1)V_{t-1} + e_t \tag{5}$$

In addition, the H_o of equation (5) is represented by $\{(\phi_1 - 1) = 0\}$ while alternative hypothesis is represented as $\{(\phi_1 - 1) < 1\}$. The H_o of non-stationary is rejected when the calculated value of e_t is greater than critical value of e_t and vice versa. "V_t is stationary with no trend. Using (3.12) to test for a unit root is not appropriate because it does not test both null and alternative hypothesis. So, including trend t, (5) becomes:

$$\Delta V_t = \delta + \chi t + (\phi_1 - 1)V_{t-1} + e_t \tag{6}$$

[1] Confirmed by Gujrati (2009)

Equation (6) has both deterministic and stochastic trend in a series of V_t. However, equation (6) is used to test the problem of non-stationary hypothesis. The acceptance or rejection of H_o relay on the value of t-statistics. The time-series is considered stationary if estimated value of t-statistics is higher than that of t-statistics critical value.

Null hypothesis in equation (6) is represented by $\{(\phi_1 - 1) = \chi = 0\}$ while alternative hypothesis is represented as $\{(\phi_1 - 1) \neq \chi \neq 0\}$. In addition, V_t series contain the problem of unit root if estimated value of ϕ_1 is smaller than tabulated critical value, vice versa.

In addition, e_t is presumed to be white noise in stationarity test of (Dickey & Fuller, 1979). The non white noise property of residuals confirm the residual autocorrelation of OLS regression in (5) – (8). This property rules out the DF statistic for unit root test. Two DF variants have been developed for this situation. First is the testing equations (5) – (8) can be generalized.

Secondly, the DF statistic can be adjusted to the augmented Dickey-Fuller test (ADF). So, to make μ_t white noise, lags of dependent variable are included on right hand side of Dickey fuller equations (5) – (8) which become:

$$\Delta V_t = (\phi_1 - 1)V_{t-1} + \sum_{i=1}^{k} \Omega_i \Delta V_{t-1} + e_t \quad (7)$$

$$\Delta V_t = \delta + (\phi_1 - 1)V_{t-1} + \sum_{i=1}^{k} \Omega_i \Delta V_{t-1} + e_t \quad (8)$$

$$\Delta V_t = \delta + \chi t + (\phi_1 - 1)V_{t-1} + \sum_{i=1}^{k} \Omega_i \Delta V_{t-1} + e_t \quad (9)$$

Additionally, only one unit root is assumed in case of DF and ADF test (Dickey & Fuller, 1979). To test the unit root in the level of series, standard hypothesis testing procedure is used If Ha of unit root is not rejected, then first difference form is tested for second unit root and so on. This procedure continues until the H_0 is rejected.

4.2 Autoregressive Distributed Lag Model

We incorporate the different statistical technique in order to test the effect on dependent variable due to change in an independent variable in model. ARDL model is presented by Pesaran, Shin, and Smith (2001) is used for long- and short-run dynamics. The benefits of ARDL is that it can be applicable whether the regressors are 1(0), 1(1) or mutually cointegrated. It can also be applicable on small finite sample and ARDL approach uses a sufficient lags to capture the data generating process (DGP) in general to specific modelling frame work "The test is based on the estimation of the basic VAR model and re-parameterized of Error Correction Model (ECM):

$$c_t = d + bt + \sum_{i=1}^{P} \Phi_i c_{t-1} + \varepsilon_t \quad (10)$$

"C" represents variable vector with assumption of individual elements of "C" are at most 1(1) without explosive roots, Equation "10" can be written as a simple VECM.

$$\Delta c_t = d + bt + \prod C_{t-1} + \sum_{i=1}^{P} \Gamma' \Delta c_{t-1} + \varepsilon_t \quad (11)$$

Where $\prod = -(I_{k+1} - \sum_{i=1}^{P} \Phi_i)$ and $\Gamma'_i = -\sum_{i=1}^{P} \Phi_j, i = 1,2, \dots \dots, p$are the $(k+1) \times (k+1)$ matrices of short-run and long-run estimated parameters. With assumption of one long run relation Pesaran et al. (2001) focus on the first equation in (11) and partition z_t into a dependant variable y_t and a set of forcing variables x. This is one of the key assumptions of the model. Under such conditions, the matrices d, b Γ and, most importantly,Π, the long-run multiplier matrix can also be partitioned conformably with the partitioning of C:

$$\Pi = \begin{bmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{bmatrix} \quad d = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} \quad b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} \quad \Gamma_1 = \begin{bmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \end{bmatrix}$$

"Z" is long run forcing variable for "X" is key assumption, which infers that vector λ_{21} = 0, "which shows that there is no feedback from the level of y on (ΔX)". Consequences of that the conditional model for ΔZ and ΔX can be written as:

$$\Delta X_t = d_1 + b_1 t + \Omega_{11} Y_{t-1} + \sum_{i=0}^{P-1} \lambda_{12} \Delta Z_{t-1} + \varepsilon_{1t} \quad (12)$$

$$\Delta Z_t = d_2 + b_2 t + \Omega_{22} Z_{t-1} + \sum_{i=0}^{P-1} \lambda_{22} \Delta Z_{t-1} + \varepsilon_{2t} \quad (13)$$

Because of assumption of error term in equation (12) and (13), Pesaran et al. (2001) change the above equation as:

$$\Delta X_t = \beta_0 + \beta_1 t + \varphi X_{t-1} + \gamma Z_{t-1} + \sum_{i=1}^{P-1} v_i \Delta X_{t-i} + \sum_{i=1}^{P-1} \phi Z_{t-i} + W_t \quad (14)$$

If two variables φ and γ are non-zero then equation (14) is a unrestricted error correction model. Hence, one can conclude that a long-run relationship prevail among the level variables:

$$X_t = \frac{\beta_0}{\varphi} - \frac{\beta_1}{\varphi} - \frac{\gamma}{\varphi} Z_t \quad (16)$$

Equation (16) is selected by Pesaran et al. (2001) for testing long-run association among (Z) and (X). They performed it by testing the joint hypothesis: $\varphi = \gamma = 0$. The test developed by Pesaran et al. (2001) is like a bound-test. In test the lower-bound is predicted keeping in mind the value of variable (Z) which is I(0). On the other side, upper-bound of the test is predicated keeping in mind the value of variable (X) which is I(1). Pesaran et al. (2001) had developed critical values in the bounds test from an extensive set of stochastic simulations with differing assumptions regarding the appropriate inclusion of deterministic variables in the model. In the case where estimated test statistic (F-statistics which is used in calculating the null hypothesis that the coefficients γ and φ jointly equal to zero) falls under the lower bound, this suggests that no long-run association exists between the variables and if calculated statistics falls above the upper bound this means long-run relationship exist between the variables. If the calculated statistics falls within the upper and lower bounds than one cannot reach to conclusion about the nature of the relationship.

5. Results and Interpretation

Large sample size data has crucial implications for assessing changes in human behavior (t>20) (Eberhardt, 2011; Pedroni, 2008). In such cases, the mean and variance of variables do not remain fixed over time, violating the assumption of ordinary least squares (OLS), which creates the problem of autocorrelation (Gujrati, 2009). The existence of this problem can be confirmed by using the unit root test developed by Dickey and Fuller (1979) or Phillips and Perron (1988). The results of the unit root test are presented in Table 1. The H_o of the unit root tests the mean and variance of the variables are time invariant, implying that the data is non-stationary.

In contrast, the H_a suggests that the mean and variance are constant, implying that the data is stationary. Table 1 shows that the data for all variables is stationary at first difference I(1), with the exception of inflation, as indicated by the Dickey and Fuller test. The results of the ADF and Phillips-Perron tests suggest that the dependent variable is stationary at I(1), while the explanatory variables are stationary at I(0) and I(1). These results imply the use of the ARDL model for estimation, which provides both short- and long-term relationships for provided specification.

Table 1
Results of Unit Root Test

Tested Variables	ADF without Constant & Trend		Phillip Peron without Constant & Trend	
	Level	**First difference**	**Level**	**First difference**
ly	0.451	-2.101**	5.064	-3.185***
lcd	-1.528	-6.149***	-0.708	-1.762*
lec	-0.918	-2.227**	-0.365	-4.763***
$\inf$	-1.812*	-1.886**	2.741	-4.249***
lpd	2.096	-6.114***	2.172	-6.121***
$\lg cf$	0.451	-7.968***	0.729	-7.870***

* characterizes level of significance at 0.10 (10%), ** embodies level of significance at 0.05(5%) and *** signifies level of significance at 0.01(1%).

The findings of Bound test in Autoregressive distributed lag model (ARDL) elucidates that the calculated value of F-statistics is 30.91 with 5% of statistical significance. Null hypothesis of Bound test indicates long-run and cointegrated relationship for this specification while absence of long-run relationship depicts the H_o. However, the estimated F-statistics value is higher than lower and upper-bounds, which confirm the presence of long-run association among income per capita, circular debt, electricity demand, population density and gross fixed capital formation.

Table 2
Results of ARDL Bound Test

Bound test Critical Decision Criteria			F-statistics
Significance	Lower-Bound I(0)	Upper-Bound I(1)	
10%	2.26	3.35	30.9
5%	2.62	3.79	
2.5%	2.96	4.18	
1%	3.41	4.68	

In this study, we use ARDL estimation technique to find out short- and long-run association among per capita income, circular debt, and electricity demand. The estimated = lag of residuals coefficient is negative and significant. This confirm the presence of co-integration or long-run relationship. This result also shows that any policy shock can converge the model to equilibrium in the long-run at the speed of 87%. Besides, we use Akaike information criteria (AIC) and Bayesian Information criteria (BIC) for finding the optimal lag length for each variable included in the model. In empirical research the researchers used both of these criterion. Both criterion are almost identical but the main difference among the two is the sum of squared residuals (SSR). If differencing factor involved in the data AIC is not provide suitable results, in such a case BIC is better. Conversely, BIC is not suitable when few lags are involved in a model rather AIC must use in such a case (Nkoro & Uko, 2016). On the basis of results of AIC and BIC, we select (1 4 4 4 1 4) optimal lag length for estimating the ARDL model.

The coefficients of long-run estimated discussd in Table 3, which describe the positive and significant effect of electricity demand on per-capita income in case of Pakistan. However, circular debt shows negative and significant relationship with per-capita income. These findings are consistent with (Aqeel & Butt, 2001; Breshin, 2004). In the case of Pakistan, the per-capita income shows a significant positive relationship with inflation, population density and gross fixed capital formation.

Table 3
Long-run Estimates

Variables	Coefficients	Std. Er.	t-ststistics (Prob.)
lcd	-0.061***	0.002	-23.60(0.00)
lec	0.602***	0.085	7.05(0.00)
$\inf$	0.009**	0.004	2.22(0.00)
lpd	1.701***	0.055	30.77(0.00)
$\lg cf$	0.150***	0.013	11.12(0.00)
C	-2.717***	0.852	-3.18(0.00)

* characterizes level of significance at 0.10 (10%), ** embodies level of significance at 0.05(5%) and *** signifies level of significance at 0.01(1%).

Table 4
Vector Error Correction (VEC) Representation

Variables	Coefficients	Std. Er.	t-statistics	Prob.
D(lcd)	-0.0333***	0.0053	-6.20	0.00
D(lcd _1)	0.0013	0.0052	0.26	0.79
D(lcd _2)	0.0004	0.0051	0.08	0.93
D(lcd _3)	0.0190***	0.0046	4.13	0.00
D(lec)	0.1032	0.0686	1.50	0.15
D(lec _1)	-0.0147	0.0652	-0.22	0.82
D(lec _2)	-0.0204	0.0648	-0.31	0.75
D(lec _3)	-0.3911***	0.0851	-4.59	0.00
D($\inf$)	-0.0017***	0.0003	-5.01	0.00
D($\inf$ _1)	-0.0007	0.0004	-0.15	0.87
D($\inf$ _2)	-0.0005	0.0004	-0.11	0.91
D($\inf$ _3)	-0.0022***	0.0005	-4.00	0.00
D(lpd)	1.6841***	0.0759	22.17	0.00
D($\lg cf$)	0.2790***	0.0396	7.04	0.00
D $\lg cf$ _1)	0.0036	0.0274	0.13	0.89
D($\lg cf$ _2)	-0.0017	0.0273	-0.06	0.94
D($\lg cf$ _3)	0.1170***	0.0246	4.74	0.00
Coint Eq(-1)	-0.8660***	0.1290	-6.71	0.00

* represents level of significance at 0.10(10%), ** represents level of significance at 0.05(5%) and *** represents level of significance at 0.01(1%).

Results of ECM have been discussed in Table 4. VECM shows the short-run electricity demand, circular debt, inflation and per-capita income relationship. In short-run circular debt, electricity demand and inflation negatively influence per-capita income. However, population density and gross fixed capital formation positively sway per-capita income in the short-run. Moreover, a significant negative coefficient is observed for ecm_{t-1} which indicates the speed of convergence to long-run equilibrium due to any policy shock. The value of ecm_{t-1} shows that the system is converging at the speed of 87% in the long-run to equilibrium position if any policy shock is observed.

Diagnostic test is useful to verify the efficiency of estimates given by ARDL model. The H_o of diagnostic test shows the absence of heteroscedasticity and serial autocorrelation while alternative hypothesis shows the presence of above discussed problem. The probability to accept H_o value is greater than 0.05, which shows the acceptance of H_o. The results indicate that the prescribed model is heteroscedasticity and serial correlation free.

Table 5
Post Regression Diagnostic Test

Test Statistics	P Value	F Version
Serial Correlation	0.5837	F(1,11) 0.7667
Heteroscedasticity	0.6093	F(1,33) 0.6217

In addition, structural stability of the discussed model can be verified by using cumulative sum of square of recursive residual (CUSUMsq) and cumulative sum of recursive residual (CUSUM). The presence of line between the critical bound of 95% for both scenarios. This confirms the absence of any structural instability in a given model.

Empirical investigation of study shows the positive and significant relationship between demand of electricity and per capital income while increase in circular debt will decrease the level of per-capita income in case of Pakistan. Estimated findings are consistent with (Apostolakis, 1990; Aqeel & Butt, 2001; Gurgul & Lach, 2012; Hu & Lin, 2013). Energy is an important factor in attaining high economic progress and development. The constant provision of energy sources backs increase in economic growth in several economies. It acts as important input for the production of any commodity and production's profitability (Soytas & Sari, 2003). However, the study by Yuan, Zhao, Yu, and Hu (2007) assessed causation to examine a potential link between China's economic growth and power usage. According to estimated findings, there is a single line of causality connecting economic growth and power usage. Economic growth was negatively impacted by electricity consumption, but improvements in the supply of electricity will boost it.

In addition, there are two school of thought exist for energy demand and economic progress relationship. First school of thought believes that energy plays an important role in the achievement of high economic, social and technological growth because energy act as input for the production of capital and several commodities for exports. However, the second school of thought believes that energy plays a negligible role for the development of production because portion of energy consumption is very small in production process as compare to capital and labor. That's why the portion of energy demand is very small in the attainment high economic progress (Huang et al., 2008; Jumbe, 2004; Stern, 1999). Numerous studies, including those by Altinay and Karagol (2005); Hatemi-J and Irandoust (2005); Oh and Lee (2004), discovered a substantial and positive correlation between the use of electricity and economic progress. Stakeholders are motivated to build new energy plants because of the link between economic progress and electricity demand. For Taiwan, Lee (2005) examined the reciprocal electricity demand and economic progress causality. Soytas and Sari (2003) discovered unidirectional causality between economic progress and energy demand for Turkey, France, Germany, and Japan, which is the exact opposite of the results stated above. However, Cheng (1995) and Wolde-Rufael (2006) found no connection between the expansion of the economy and the usage of energy.

6. Conclusion of the Study and Policy Implications for Stakeholders

This study intends to empirically analyse the link between per capita income, circular debt, and electricity usage. The study makes use of Pakistan's quarterly statistics from 2006 to 2015 for this aim. Per capita income is our dependent variable in a model, and the study uses the ARDL model and ECM model to estimate the long- and short-run relationships among the discussed variables. The study uses CUSUMsq and CUSUM to examine the stability of the model.

Findings of the long-run relationship shows that electricity consumption exhibits a positive and significant relationship with per-capita income while circular debt shows a negative relationship with per-capita income in Pakistan. However, short-run results indicate that circular debt, electricity demand and inflation negatively affect per-capita income while population density and gross fixed capital formation positively sway on per-capita income in the short-run.

Finally, a significant negative value of the EC term indicates the convergence of the system towards long-run equilibrium due to any possible policy shock.

It is concluded from the above discussion that effective provision of proper and cheap electricity can boost up technological advancement, which will further contribute to high economic progress in Pakistan. Empirical findings suggest the establishing of new and technological advance electricity plants to meet the excess demand of population. However, government should control the transmission and distribution losses as well. In addition, Oil supply, electricity production and distribution companies should settle down there debts. Government should control the further compilation of circular debt among these departments.

Authors Contribution
Awais Anwar: study design and concept, revision
Noman Arshed: manuscript preparation and proofreading
Shabir Ahmad: data collection, methodology and data analysis
Naveed Hayat: literature review, discussion, drafting

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