The nexus of electricity access, population growth, economic growth in Pakistan and projection through 2040

An ARDL to co-integration approach

Received 19 April 2018
Revised 13 October 2018
22 November 2018
Accepted 27 November 2018

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Abstract

Purpose – The purpose of this study was to investigate the relationship between electricity access, population growth and economic growth in Pakistan.

Design/methodology/approach – Phillips–Perron unit root test was applied to check the stationarity of the variables and an Autoregressive Distributed Lag (ARDL) bounds testing approach to co-integration was used to investigate the causality link between the study variables. Finally, a projection method was applied to check the future trend of the variables.

Findings – The study results show the long-term connections among the variables; further, the results illustrate that the electricity access to the urban population and the urban population growth has a significant impact on the economic growth, while the electricity access to the rural population and the rural population growth has a negative impact on the economic growth in Pakistan.

Research limitations/implications – The electricity sector needs further attention from the Government of Pakistan to boost the production from different energy sources, such as oil, gas, solar, nuclear and hydropower to be able to fulfill the country's growing demand.

Originality/value – By using the ARDL bounds testing approach to co-integration, this study addressed the literature gap regarding electricity access, population growth and economic growth in Pakistan.

Keywords Co-integration, Distribution, Econometric, Autoregressive, Electricity

Paper type Research paper

Introduction

The energy sector plays a vital role in boosting the economy and supporting the development of all countries. Electricity is considered a useful form of energy that helps to enhance the performance of every sector of the economy. The failures in the energy policies of Pakistan over the past few decades have caused this country to face severe power shortages, undermining its economic growth. Occasionally, the eastern region faces several energy challenges, affecting the national electricity system. Power supply in Pakistan has not developed parallel to the rising demand for it, causing long-term disruptions and numerous unexpected outages. These circumstances have complicated the conditions for families and businesses, hindering investments for new businesses in the economy (World Bank, 2014). About 60-70 per cent of the population in Pakistan has access to electricity,

The authors are grateful to the Research Center of Agricultural-Rural-Peasants, Anhui University Hefei, China for its financial and moral support.

International Journal of Energy Sector Management
Vol. 13 No. 3, 2019
pp. 747-763

1750-6220
DOI 10.1108/IJESM-04-2018-0009

with an increasing ratio between those with access and those without, mainly because of energy crisis. From 1958 to 2008, the number of electrified villages increased from about 609 to 125,495. In the 2008s, the ratio of electrified villages in Punjab was 71,979; in Khyber Pakhtunkhwa, this number was 24,416, while this figure in Sindh reached 21,799, in Balochistan only 7,301 villages had access to electricity (Power Wing Development Projects, 2015).

In the last decade energy demand in Pakistan has reached 17,000 megawatts, while deficiency has remained between 4,000 and 5,000 megawatts. In the next decade, electricity demand will increase from 4 to 5 per cent, with a production proportion of 1,500 megawatts. The thermal power plants constitute a latent environmental risk, which must be taken seriously. The major sources that generate energy in Pakistan are oil, hydropower, natural gas and nuclear power (KazmiZ, 2014). Oil is the dominant source of energy, followed by natural gas; thermal power plants also use oil to generate electricity, which is imported into Pakistan. The energy generated from the imported oil is costly solution and cannot be afforded by a developing country such as Pakistan. Another energy-generating source includes the nuclear power plants, although their capacity is small (Chaudhry *et al.*, 2009; Sheikh, 2010; Khalid and Begum, 2013).

Pakistan continues to face energy crisis, mainly because of insufficient production. In the urban areas, the electricity load-shedding duration is normally 12 hours, while in the rural areas, the length of load-shedding reaches 18 hours a day. The major cause for the widening gap between supply and demand is the rising need for electricity, energy consumption and financial constraints (Valasai *et al.*, 2017). In 2014, the population of Pakistan was 185 million, and it is expected to increase every year, causing a rise in demand for electricity. Because of poor planning and governance, rapid urbanization in the past two years has given rise to severe energy shortages. Therefore, the per capita electricity consumption in Pakistan is only about 452 kWh, which is ¼ of the world's average. Recently, the variations in power supply have caused the country to face load shedding (NTDC, 2015; World Bank, 2015).

Demand for energy is increasing every year, and the Government should take the necessary steps to fill the gap by using alternative energy sources, such as solar power and wind energy. Many studies have illustrated the issues surrounding energy, and these include: energy production, energy security, electricity crisis, future energy consumption, policy implications, energy production from alternative sources, energy production and its linkage with economic growth, renewable and non-renewable energy sources, and the institutional infrastructure in Pakistan for boosting the energy and economic sectors (Rauf *et al.*, 2015; Shaikh *et al.*, 2015; Shakeel *et al.*, 2016; Mirjat *et al.*, 2017; Rafique and Rehman, 2017; Rehman and Deyuan, 2018; Kamran, 2018; Aized *et al.*, 2018). New policies should be implemented by the Government of Pakistan to address the energy shortage.

The major purpose of this study was to examine the relationship between electricity access, population growth, and economic growth in Pakistan. For the stationarity of the variables, Phillips–Perron unit root test was applied, while Autoregressive Distributed Lag (ARDL) bounds testing approach to co-integration was employed to investigate the causality link among the aforementioned variables, with the analysis of long-run and short-run implications. Finally, a projection method was applied to check the future trend of all the variables. Time span data were collected and used from the World Development Indicators (WDI). Apart from this introduction section, the rest of the paper is organized as follows: The "Existing Review of Literature" section discusses the empirical findings and results concerning electricity and energy production. The "Methodology" section presents the data sources and the model specification. The "Empirical Estimation Strategy" section explains the unit root test for stationarity and co-integration with the ARDL model. The "Results and Discussion" section discusses the results of the descriptive statistics, unit root test, results of the co-integration test, covariance test results and short-run and long-run analysis results. Finally, the "Conclusion" section ends this paper by offering several policy recommendations.

Existing review of literature

Energy constitutes an important sector for any country, mainly because it is associated with economic development, energy security and social stability. Factors such as population growth, climate change, expanding economic activities and population movement from rural areas to cities are increasing demand for electricity in Pakistan. However, the burning issues in the country are electricity transformation, power shortage, corruption and abuse of political power, which are damaging the economic growth (Government of Pakistan, 2013). The rural population is growing more rapidly than the urban population. The agriculture sector is contributing about 25 per cent of the country's gross domestic product and creates employment for about 40 per cent of the labor force (GOP, 2014; Rehman *et al.*, 2015). With the growing population, the economy of Pakistan is growing too, leading to an increasing demand for electricity in both the transportation and industrial sectors. In 2011, the capacity of power generation was 21,036 megawatts. Every year, demand for electricity increases about 9 per cent, while supply is only about 7 per cent. The chief energy production sources in Pakistan are thermal energy, hydropower, and nuclear power, which contribute tremendously to the production of electricity. The coal and other renewable energy sources play a secondary role; however, with the anticipated future economic boost, key renewable sources such as wind, biomass and solar energy have been identified, with some contribution in recent times (Pakistan Energy Yearbook, 2013; Sahir and Qureshi, 2008; Shah *et al.*, 2011). The world energy council estimates that until 2025, about 60 per cent of the world's electricity will be generated from renewable energy sources, with only 30 per cent coming from oil sources (Koh and Hoi, 2003; Mirza *et al.*, 2009).

Half of the world's population in the developing countries lives in the rural areas, causing the depletion of huge biomass in these areas. It is predicted that biomass will supply about 13 per cent of China's and Pakistan's energy needs and 47 per cent of those of India (Chaudhry *et al.*, 2009). In the developing countries, the rapid economic growth and industrial revolution have led to the use of fossil fuel as an energy supply, causing a reduction in the total share of biomass. Biomass energy resources may exceed the annual growth rate for about 2 per cent. About 97 million people live in the rural areas in Pakistan, which constitutes about 62 per cent of the total population. However, only about 46 per cent of this population has access to electricity (Butt *et al.*, 2013; IEA, 2011). These areas lack electrified infrastructure, and given that poverty is on the increase in the rural and urban areas, people have to rely on alternative energy sources for their consumption (Rahman and Paatero, 2012). Such problems undermine the overall performance of the electricity sector and tend to disrupt the economic growth (Qazi *et al.*, 2017).

Electricity is a versatile form of energy, with great potential for boosting the overall economic growth of a country and its institutions. The sustainable production of electricity can enhance a country's economy and social structure (Maxim, 2014). In the rural communities, the supply of electricity contributes to the growth of agriculture, economy, education, health and other related developments (Palit and Bandyopadhyay, 2016; Danish *et al.*, 2015). Demand for electricity in the future will surpass the capacity of the total energy consumption (Wu, 2013). The total capacity of electricity generation in Pakistan in 2014 was 24,375 megawatts, with 7,116 megawatts coming from hydraulic sources, 787 megawatts from nuclear power plants and about 106 megawatts from the wind; the total power generation during 2014-2015 was about 109,059 GWh (NEPRA, 2014, 2015).

At present, the country is facing energy crisis, while economic and social progress depends on energy flows. Despite the renewable energy sources, traditional energy generation methods are still being used in Pakistan. While energy efficiency has expanded, energy generation systems have not developed in tandem to meet the country's energy demand (Nisar *et al.*, 2017). The establishment of new lines and substations will not be sufficient to attain the goal of overcoming energy shortages, especially knowing that power infrastructures take time to meet the growing power demand. An increase in the renewable energy generation helps to achieve an intelligent, autonomous system by changing the recent power management structure (Irfan *et al.*, 2017).

The demand for electricity is increasing in Pakistan, mainly because of population growth, rising electricity bills and bad weather conditions. Furthermore, power shortage is another issue caused by theft of electricity and excessive usage in the domestic and industrial sectors (GOP, 2015). Price fluctuations in the international oil markets increase the costs of electricity generation, creating serious issues for the Government and forcing the power sector into a vicious financial crisis. The supply-demand gap in 2015 reached the range of 4,800-7,000 megawatts (Kessides, 2013; Imran and Amir, 2015; Qudrat-Ullah, 2015), with the major cause of shortage being a lack of investment and political instability, hindering the development of massive coal or hydropower projects in the country (Ali and Anjum Shah, 2012; HDIP, 2016).

Using an ARDL approach to co-integration, several studies have explored electricity consumption, exports and gross domestic product (GDP), employment and real income and energy consumption and economic growth (Narayan and Smyth, 2005, 2009; Ozturk and Acaravci, 2011; Shahbaz *et al.*, 2011). In this study, however, we employed an ARDL bounds testing approach to co-integration to investigate the relationship between electricity access, population growth and economic growth in Pakistan. To meet the country's demand for energy, the Government of Pakistan should start focusing on renewable energies, such as solar, wind, biomass and hydropower. Figures 1-3 illustrate the electricity access to rural and urban populations, rural and urban population growths and economic growth from 1990-2016, and data was originate from the World Development Indicators (WDI).

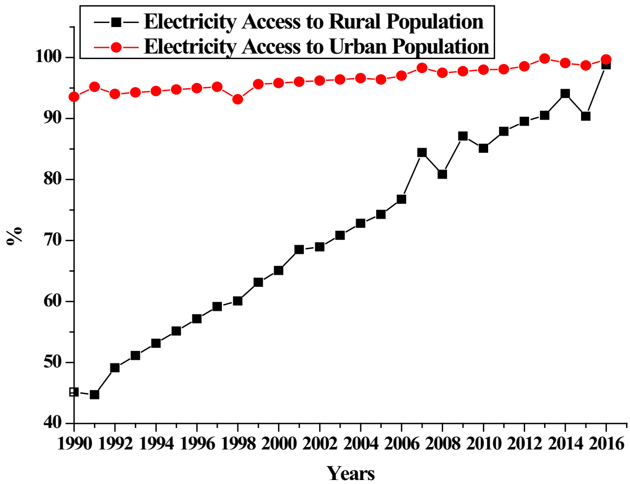

Figure 1.
Electricity access to rural and urban population

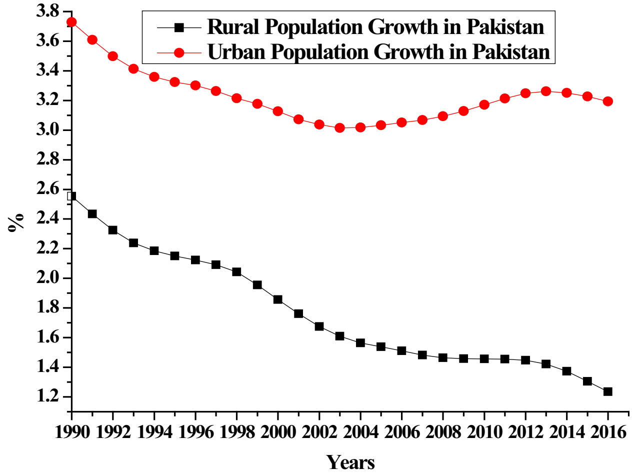

Figure 2. Rural and urban population growth in Pakistan

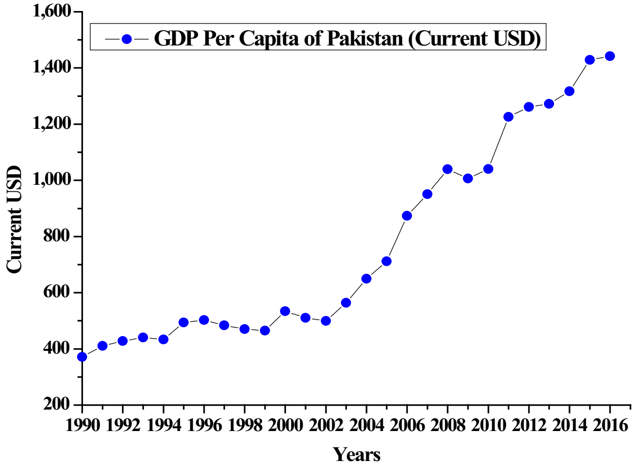

Figure 3. GDP per capita of Pakistan

Figures 1-3 trends show the electricity access to rural and urban population, rural and urban population growth and GDP per capita of Pakistan from 1990 to 2016.

Methodology

Data source

Time span data were used in this study from 1990-2016, and it was collected from the World Development Indicators (WDI). Below Table I indicates the variables used in this study:

Model specification

To check the linkage among the dependent and independent variables, adopting the regression procedure, the multivariate regression model specification in its implicit methods is as follows:

$$GDPPC_t = f(EARP_t, EAUP_t, RPG_t, UPG_t) \tag{1}$$

Where $GDPPC_t$ indicates the gross domestic product per capita, $EARP_t$ indicates the electricity access to rural population, $EAUP_t$ represents the electricity access to urban population, RPG_t represent the rural population growth and UPG_t indicates the urban population growth.

$$GDPPC_t = \phi_0 + \phi_1 EARP_t + \phi_2 EAUP_t + \phi_3 RPG_t + \phi_4 UPG_t + \mu t \tag{2}$$

By using natural logarithm to Equation (2), a log-linear model is as follows:

$$lnGDPPC_t = \phi_0 + \phi_1 lnEARP_t + \phi_2 lnEAUP_t + \phi_3 lnRPG_t + \phi_4 lnUPG_t + \mu t \tag{3}$$

Equation (3) is the log-linear form of the variables. $lnGDPPC_t$ show the natural logarithm of gross domestic product per capita, $lnEARP_t$ show the natural logarithm of electricity access to rural population, $lnEAUP_t$ show the natural logarithm of electricity access to urban population, $lnRPG_t$show the natural logarithm of rural population growth, $lnUPG_t$show the natural logarithm of urban population growth, t is the time dimension, μt is the error term, ϕ_0 is the constant intercept and the coefficients of the model ϕ_1 to ϕ_4 represent the elasticity of the long run.

Empirical estimation strategy

Unit root test for stationarity

The ARDL model requires no pretesting for the inspection of variables stationarity through the unit root test. The Phillips and Perron (1988) unit root test with trend and interception was used to determine that none of the variables were considered and integrated to order *2*, mainly because ARDL bounds testing approach is invalidated in cases where *I(2)* variables are used. Therefore, the Phillips–Perron unit root test was performed using Equation (3):

$$\Delta X_t = \alpha_\circ + \beta_\circ T + \beta_1 X_{t-1} + \sum_{i=1}^{m} \alpha_1 \Delta X_{t-1} + \mu_t \tag{4}$$

Where, X indicates the variables being tested for the unit root, T represents a linear trend, Δ indicates the first difference, t shows the time, μ_t is the error term and m represents to achieve white noise residuals.

Variables	Explanation	Country	Data aources
GDPPC	Gross Domestic Product Per Capita	Pakistan	WDI
EARP	Electricity Access to Rural Population	Pakistan	WDI
EAUP	Electricity Access to Urban Population	Pakistan	WDI
RPG	Rural Population Growth	Pakistan	WDI
UPG	Urban Population Growth	Pakistan	WDI

Note: the units of the variables are in USD and %

Table I.
Variables description

Co-integration with ARDL model

For the analysis of long run and short run among the dependent and independent variables, this study used the ARDL bounds testing approach which is developed by the Pesaran and Shin (1998) and further protracted by Pesaran *et al.* (2001) and Narayan (2004). The co-integration testing approach is applicable regardless of the order of integration with concerned variables, *I(0)* and or *I(1)*, except for the presence of *I(2)*. The long-run and short-run relations examined the ARDL representation of the unrestricted error correction model (UECM) of Equation (2) as depicted in Equation (5):

$$\begin{aligned}\Delta lnGDPPC_t = \partial_0 &+ \sum_{i=1}^{p} \partial_{1i} \Delta lnGDPPC_{t-i} + \sum_{i=1}^{q^1} \partial_{2i} \Delta lnAERP_{t-i} + \sum_{i=1}^{q^2} \partial_{3i} \Delta lnAEUP_{t-i} \\ &+ \sum_{i=1}^{q^3} \partial_{4i} \Delta lnRPG_{t-i} + \sum_{i=1}^{q^4} \partial_{5i} \Delta lnUPG_{t-i} + \phi_1 lnGDPPC_{t-1} \\ &+ \phi_2 lnAERP_{t-1} + \phi_3 lnAEUP_{t-1} + \phi_4 lnRPG_{t-1} + \phi_5 lnUPG_{t-1} + \mu_t \end{aligned} \tag{5}$$

where, Δ indicates the difference operator, ∂_0 is constant intercept, ϕ indicates the coefficients of long-run, while ∂ imprisonments the coefficients of short run. The co-movement of the long-run analysis among the study variables of interest is ascertained on the basis of F-Statistics estimation. Pesaran *et al.* (2001) constitutes two values available for the test of co-integration:

(1) first the critical values of lower bound, where the variables are integrated of order zero *I(0)*, and

(2) second the critical values of upper bound, where the variables are integrated of order one *I(1)*.

The hypothesis of no presence of long-run association is excluded if F-Statistic estimation exceeds the critical values on upper bound.

Results and discussions

Descriptive statistics and Phillips–Perron unit root test results

The results of the descriptive statistics are reported in Table II. Table III reports the Phillips-Perron unit root test results.

Phillips–Perron unit root test results show that none of the variables was integrated with the order of I(2) and then ARDL model used.

Co-integration test

The co-integration test was used when F or W statistics applies the upper bound of the selected significant level. Table IV reports the results of the co-integration.

The table shows the bounds test and summarizes the existence of a co-integration linkage among the variables at the level of 1, 5 and 10 per cent. Furthermore, the Johansen and Juselius (1990) co-integration test results with trace statistics and maximum eigenvalue are presented in Table V.

Covariance analysis

The results of the covariance analysis are interpreted in Table VI, with showing correlation among the dependent and independent variables.

Table VI reports the correlation association between the electricity access to the rural and urban population, rural and urban population growth and economic growth in Pakistan.

Table II.
Descriptive statistics

	LNGDPPC	LNEARP	LNEAUP	LNRPG	LNUPG
Mean	6.545188	4.239864	4.569133	0.547510	1.169750
Median	6.334335	4.260662	4.568481	0.475891	1.167486
Maximum	7.273985	4.593175	4.603168	0.937553	1.316260
Minimum	5.917744	3.799974	4.534104	0.210858	1.103620
SD	0.457467	0.237229	0.019615	0.210950	0.053922
Skewness	0.327005	−0.320701	0.047087	0.306283	0.998951
Kurtosis	1.515710	1.929109	1.983000	1.762606	3.669353
Jarque–Bera	2.959701	1.752979	1.173551	2.144680	4.994605
Probability	0.227672	0.416242	0.556118	0.342207	0.082307
Sum	176.7201	114.4763	123.3666	14.78277	31.58326
Sum Sq. Dev	5.441181	1.463224	0.010004	1.156992	0.075597
Observations	27	27	27	27	27

Table III.
Phillips–Perron unit root test results

	Phillips–Perron unit root test			
	At level		First difference	
Variables	*t*-statistic	Critical values	*t*-statistic	Critical values
LnEARP	−2.602248 (0.2822)	1% − 4.356068	−13.37829 (0.0000)	1% − 4.374307
		5% − 3.595026		5% − 3.603202
		10% − 3.233456		10% − 3.238054
LnEAUP	−4.972231 (0.0025)	1% − 4.356068	−21.59359 (0.0000)	1% − 4.374307
		5% − 3.595026		5% − 3.603202
		10% − 3.233456		10% − 3.238054
LnGDPPC	−1.575934 (0.7747)	1% − 4.356068	−4.318162 (0.0113)	1% − 4.374307
		5% − 3.595026		5% − 3.603202
		10% − 3.233456		10% − 3.238054
LnRPG	−1.851566 (0.6501)	1% − 4.356068	−3.908624 (0.0232)	1% − 4.356068
		5% − 3.595026		5% − 3.595026
		10% − 3.233456		10% − 3.233456
LnUPG	−2.422004 (0.3606)	1% − 4.356068	−4.281174 (0.0245)	1% − 4.356068
		5% − 3.595026		5% − 3.595026
		10% − 3.233456		10% − 3.233456

Table IV.
ARDL bounds test for co-integration results

ARDL Bounds Test for Co-integration Results				
F-Statistic	Significance level (%)	Lower bound	Upper bound	Decision
5.355108	10	2.03	3.13	Co-integrated
	5	2.32	3.5	
	1	2.96	4.26	

Table V. Results of the Johansen co-integration test using trace statistic and maximum eigenvalue

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Probability**
Trace statistic				
None*	0.993717	396.7264	143.6691	0.0000
At most 1*	0.976870	269.9806	111.7805	0.0000
At most 2*	0.944234	175.8151	83.93712	0.0000
At most 3*	0.816141	103.6505	60.06141	0.0000
At most 4*	0.738330	61.31087	40.17493	0.0001
Maximum Eigenvalue Statistic				
None*	0.993717	126.7458	48.87720	0.0000
At most 1*	0.976870	94.16546	42.77219	0.0000
At most 2*	0.944234	72.16461	36.63019	0.0000
At most 3*	0.816141	42.33964	30.43961	0.0011
At most 4*	0.738330	33.51680	24.15921	0.0020

Notes: *Denotes rejection of the hypothesis at the 0.05 level; **MacKinnon–Haug–Michelis (1999) p-values

Table VI. Covariance analysis

Correlation T-statistic probability	LNEARP	LNEAUP	LNGDPPC	LNRPG	LNUPG
LNEARP	1.000000				
	–				
	–				
LNEARP	0.929619	1.000000			
	12.61276	–			
	0.0000	–			
LNGDPPC	0.937864	0.940450	1.000000		
	13.51378	13.83296	–		
	0.0000	0.0000	–		
LNRPG	−0.985057	−0.924430	−0.922226	1.000000	
	−28.59753	−12.12042	−11.92582	–	
	0.0000	0.0000	0.0000	–	
LNRPG	−0.644678	−0.450613	−0.382482	0.679004	1.000000
	−4.216589	−2.523822	−2.069792	4.624523	–
	0.0003	0.0183	0.0490	0.0001	–

Results of long-run analysis

Results of the long-run analysis are reported in Table VII.

The results of the long-run analysis show that electricity access to urban population and urban population growth have a positive and significant impact on Pakistan's economic growth with coefficients 3.079896 and 0.308340, having p-values 0.3127 and 0.8886, respectively. Similarly, the result of the electricity access to rural population and rural population growth has a negative relationship with economic growth, having coefficients −0.891821 and −3.988076 with p-values 0.6426 and 0.0089, respectively. Demand for electricity in Pakistan is increasing in parallel with the population growth. The prospect of electricity production from different sources includes promoting and developing new strategies, which also extend to the development of renewable energy technology.

Table VII.
Long-run analysis

ARDL co-integrating and long-run form				
Variable	Coefficient	Standard error	*t*-statistic	Probability
Co-integrating form				
D(LNEARP)	1.179909	1.159803	1.017336	0.3308
D(LNEAUP)	0.184181	1.907163	0.096573	0.9248
D(LNRPG)	−6.964634	3.127366	−2.226997	0.0478
D(LNUPG)	10.114401	6.157831	1.642527	0.1287
CointEq(−1)	−1.031504	0.233261	−4.422112	0.0010
Long-Run Coefficients				
LNEARP	−0.891821	1.868824	−0.477210	0.6426
LNEAUP	3.079896	2.910661	1.058143	0.3127
LNRPG	−3.988076	1.257097	−3.172450	0.0089
LNUPG	0.308340	2.151163	0.143336	0.8886
C	−27.082991	11.476944	−2.359774	0.0378

Renewable energy sources are encouraged for the future, with a total renewable energy potential of about 167.7 GW, which is sufficient to meet the electricity demand in the country (Rafique and Rehman, 2017).

Results of short-run analysis

Among the linkage of the variables, the presence of the cointegration needs an error correction model (ECM) to capture the short-run dynamics with its coefficient, which calculate the adjusted speed to obtain equilibrium in the event of shocks to the system. Table VIII reports the results of the short-run analysis.

In the table, the R-squared value is 0.996705, with short-term dynamics having variations of about 99 per cent for the economic growth, as indicated in the model by the independent variables. The F-statistic confirms the joint significant at the level of 1 per cent significance,

Table VIII.
Short-run analysis

Short-run analysis				
Variable	Coefficient	Standard error	*t*-statistic	Probability*
LNGDPPC(−1)	−0.031504	0.233261	−0.135061	0.8950
LNEARP	1.179909	1.159803	1.017336	0.3308
LNEARP(−1)	−2.099826	1.266322	−1.658209	0.1255
LNEAUP	0.184181	1.907163	0.096573	0.9248
LNEAUP(−1)	2.992745	1.832034	1.633564	0.1306
LNRPG	−6.964634	3.127366	−2.226997	0.0478
LNRPG(−1)	2.850917	2.873768	0.992048	0.3425
LNUPG	10.11440	6.157831	1.642527	0.1287
LNUPG(−1)	−9.796348	6.585777	−1.487501	0.1650
C	−27.93622	11.64342	−2.399314	0.0353
R-squared	0.996705	Mean dependent variable		6.569321
Adjusted *R*-squared	0.992510	S.D. dependent variable		0.448658
S.E. of regression	0.038828	Akaike info criterion		−3.365683
Sum squared resid.	0.016584	Schwarz criterion		−2.639858
Log likelihood	58.75388	Hannan–Quinn criteria		−3.156672
F-statistic	237.6347	Durbin–Watson stat		2.575936
Prob(*F*-statistic)	0.000000			

and the value of Durbin–Watson statistic is 2.575, which was not found to be equal to the standard value of Durbin–Watson, having non-appearance of any autocorrelation exposed to enough for the goodness of the model.

Diagnostic and stability tests

Diagnostic and stability tests results are presented in Table IX.

The Breusch–Godfrey Serial Correlation LM Test and Heteroskedasticity Test with their p-*values* are 0.1346 and 0.5095, respectively.

Structural stability test

The stability tests using CUSUM and CUSUM Square point to stable the long-run and short-run constraints. The graph of both CUSUM test and CUSUM Square test are mentioned in Figures 4-5 which specify that all values lie within critical boundaries at significance level of 5 per cent. It confirms the long-run and short-run parameters stability.

Projection of electricity access, Population growth and economic growth in Pakistan upto 2040

The future projection of electricity access to rural population, electricity access to urban population, rural population growth, urban population growth and economic growth in Pakistan can be specified by using following method $x + vy$, where:

Test statistics (LM version)	*F*-statistic	Probability
Breusch–Godfrey serial correlation	2.857881	0.1346
Heteroscedasticity	0.696466	0.5095
CUSUM		Stable
CUSUMSQ		Stable

Table IX. Diagnostic and stability tests

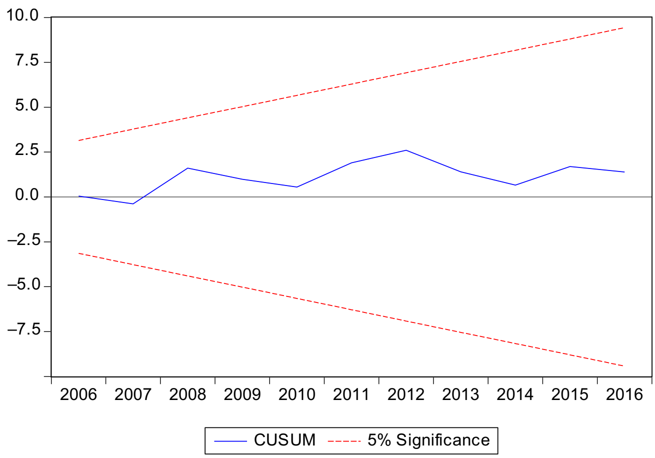

Figure 4. Plot of CUSUM

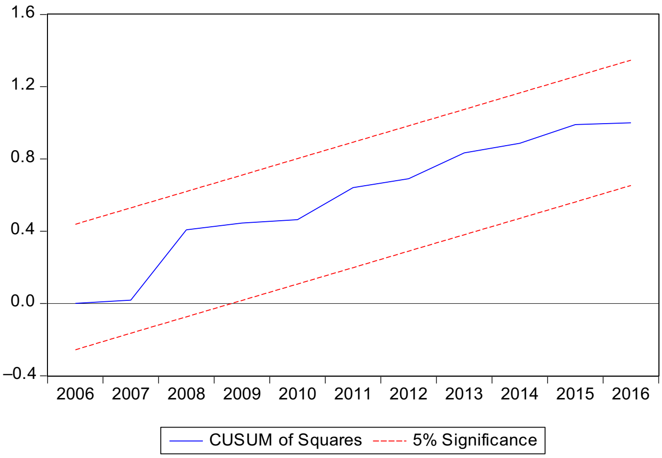

Figure 5.
Plot of CUSUM of square

$$x = \bar{z} - v\bar{y} \tag{6}$$

Equation (6) can also be written as:

$$v = \frac{\sum(y-\bar{y})(z-\bar{z})}{\sum(y-\bar{y})^2} \tag{7}$$

The variables in the equation y and z indicate the sample means average ($known\_y's$) and average ($known\_z's$). Figures 6-10 show the projection of electricity access to rural population, electricity access to urban population, rural population growth, urban population growth and economic growth upto 2040 in Pakistan.

Figures 6-10 show the future projection of electricity access to rural population, electricity access to urban population, rural population growth, urban population growth and GDP per capita upto 2040 in Pakistan.

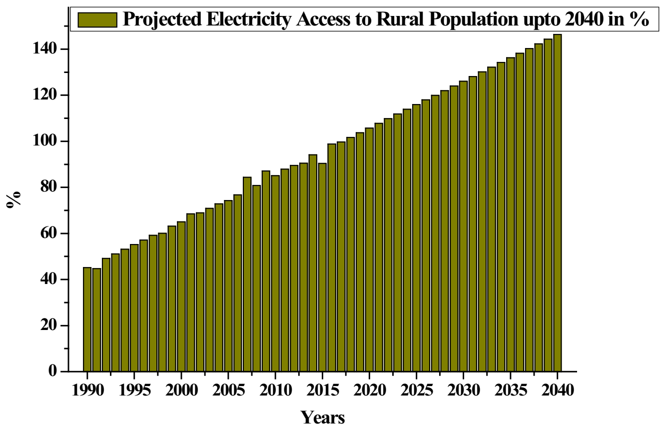

Figure 6.
Projected electricity access to rural population up to 2040

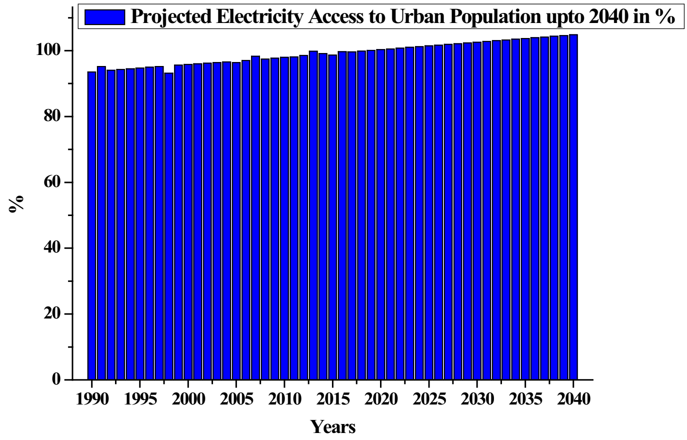

Figure 7. Projected electricity access to urban population up to 2040

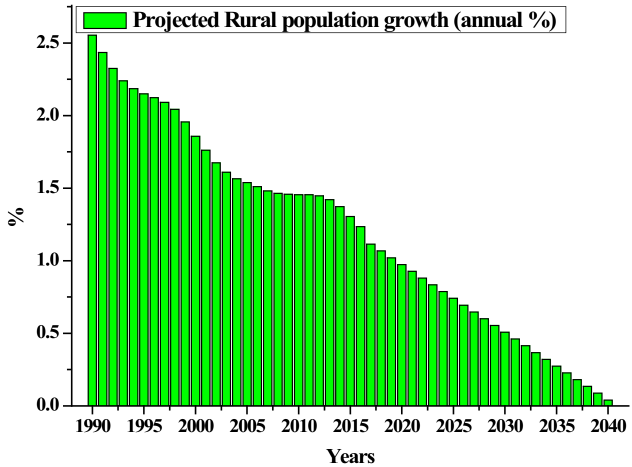

Figure 8. Projected rural population growth up to 2040

Conclusion and recommendations

Energy has a dominant role in a country's economic development, and electricity as a versatile form of energy plays a central role. The major objective of this study was to examine the linkage between the electricity access of rural and urban populations, the growth of rural and urban populations, and economic growth in Pakistan. Phillips–Perron unit root test was used to check the variables stationarity. An ARDL bounds testing approach to co-integration was used to check the dynamic relationship among the study variables with short-run and long-run analysis, and a projection method was applied to check the future trend of the variables. The results show that the electricity access to the urban population and urban population growth has a positive relationship with the economic growth, while the electricity access to the rural population and rural population growth has a negative relationship with the economic growth.

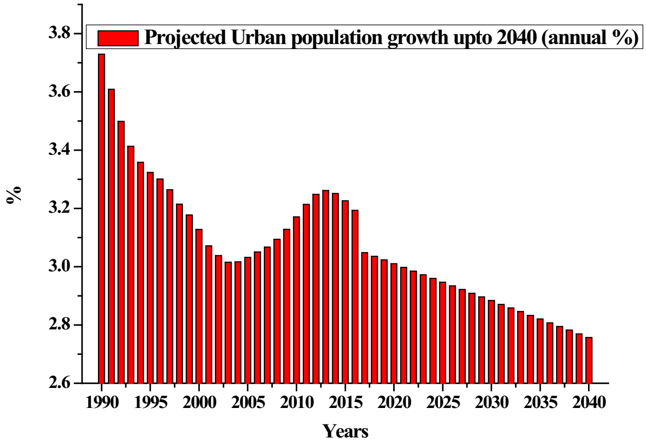

Figure 9.
Projected urban population growth up to 2040

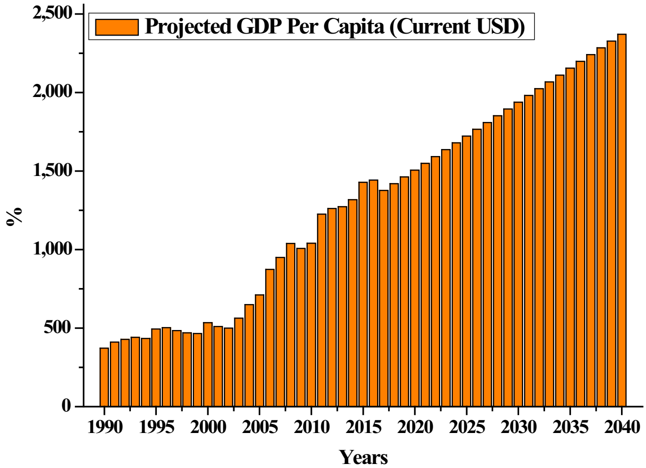

Figure 10.
Projected GDP per capita up to 2040

With the passage of time, the country's population tends to grow, requiring more electricity to fulfill people's basic needs. Hence, this study recommends that the Government of Pakistan should pay more attention to the production of electricity from alternative sources, such as wind, solar power and nuclear power. Natural gas and oil are two dominant sources of energy in the country. Cheap electricity can also be produced from natural gas. In the coming decades, Pakistan will face water crisis; therefore, it is necessary to pay attention to building new dams in the country to store water, which will also play a key role in boosting the agriculture sector. It can also increase the capacity of electricity production coming from hydraulic power. Furthermore, it is important to consider other possible initiatives, including producing electricity from the solar power, although the country lacks modern solar technology. The Government should have short-, medium- and long-term energy production plans to produce cheap energy to fulfill the country's demands.

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