Finding the Optimal Way of Electricity Production in Pakistan

Zeshan, Muhammad

School of Economics, Quaid-e-Azam University, Islamabad, Pakistan

1 April 2012

Finding the Optimal Way of Electricity Production in Pakistan

Muhammad Zeshan

School of Economics, Quaid-i-Azam University, Islamabad, Pakistan

zeshanqau.isb@gmail.com

Abstract

Present study reveals the impact of electricity production on economic growth in Pakistan. It covers the period of 1975-2010 and assumes a log-linear relationship between the variables. Both the bounds test and Johansen test for cointegration indicate a unique long-run relationship between the variables. However; higher tariff rates, associated with thermal power plants, are eroding the private business investment in short-run. Based on these facts, this study advocates the promotion of hydropower plants that are beneficial for two reasons. First, it would produce clean power in the country. Second, cost of production would also drop resulting in lower tariff rates. Finally; it finds bi-directional causal relationship between the variables in long-run, whereas no causal relationship has been found in short-run.

JEL Codes: E22, Q41, Q42

Keywords: Hydropower, Cointegration, Causality

I-Introduction

Sustainable supply of electricity is crucial for balanced economic growth. Contemporaneous literature specifies that it is the deriving force behind the development in many countries, the so called growth hypothesis. This arena is important for policy relevance and is also central to conservation policies, the so called conservation hypothesis (Ghosh, 2002). One can support the conservation policies if the electricity supplies bring no economic growth in long-run. In such a scenario, it would be better to utilize other available options for satiating energy needs. Nonetheless, if electricity supplies induce significant macroeconomic developments in an economy then conservation policies might be detrimental to the economic health of society. Any negative shock such as load-shedding, or higher electricity tariffs, or a combination of both would be damaging to country (Narayan and Singh, 2007). Electricity supply has remained subject to frequent disruptions in Pakistan as well. Following lines are going to discuss the basic reasons for the failure of electricity system in Pakistan.

Generation, transmission and distribution of electricity are conducted by Water and Power Development Authority (WAPDA), and Karachi Electric Supply Corporation (KESC). The former institution is liable to cater the electricity essentials of the whole country, with the exception of Karachi, while the later one provides its services to Karachi (Jamil and Ahmad, 2010). Unfortunately, both of these institutions are unable to fulfill electricity demand in country. To overcome the electricity deficit, government of Pakistan has committed two agreements with private power producers. First formal agreement was initiated in a1994 (Power Policy 1994), and 15 IPPs registered themselves as private power producers in this initial phase. There was no further development in this program for a long period of time, but persistent electricity deficit reinitiated this program. In results, many IPPs were accessed for the production of 2,500 MWs electricity (Power Policy 2002). This was the second phase of private electricity production which was completed with incumbent players and some new ones.

An effective tariff rate is the most important thing for optimal production and consumption of electricity. In this regard, power purchase agreement (PPA) between the government of Pakistan and private power producers preserves great prominence. There are two types of PPAs, formally known as the first generation PPA and second generation PPA, signed under Power Policy 1994 and 2002 respectively. Nonetheless, there is significant difference between the two PPAs. The first PPA calculates tariff in real US dollar terms, while the second PPA deals in Pakistani Rupee. This makes average tariff rates higher in the first PPA as compared to second PPA. In short, there are two reasons for costly production of electricity Pakistan. First, as majority of the private power producers are operating under first PPA, it makes every additional unit of electricity more expensive than the previous one[1]. Second, these IPPs are operating under thermal power plants which are much costly as compared to hydropower plants. For these reasons, IPPs charge higher tariff rates from their buyers. Owing to stagnant public sector electricity production in Pakistan, any rise in the electricity consumption is supposed to encounter by IPPs. These private power producers generate almost 30 percent of the total electricity production in country.

In past, natural disasters such as earthquakes and floods have also caused huge damaged to power sector infrastructure. Jinnha hydropower plant faced the most

---

[1] [The Pakistan Credit Rating Agency Limited (2009), http://www.pacra.com/RMethodology/IPP%20rating%20Methodology.pdf].

devastated destruction, most of its machines were damaged severely and it was unable to operate at its potential level. Moreover, many other electricity generating plants were closed as a result of these disasters. All these problems reared electricity deficit and it is projected that, up to the year 2020, per day electricity deficit would rise to 13,651 MW (see Table-1 for details). Khan and Ahmad (2009) claimed that per day electricity production was 11,500 MW in year 2008 while its demand was 20,000 MW. Provision of sustained electricity at compatible rates plays the essential role in economic development but this is not the case in most of the developing countries. Incompatible electricity prices and underdeveloped electricity infrastructure is also curbing the economic growth in Pakistan. People experience the longest power outages that is making difficult to run the daily business.

Table-1 Electricity Demand and Supply Position in Pakistan 2011-2020 (In MW)

Year	2011	2020	Growth Rate
Existing Generation	15,903	15,903	0.00
Proposed Generation	10,115	18,448	45.17
Total Existing Generation	26,018	34,351	24.26
Available Generation	20,814	27,481	24.26
Summer Peak Demand	20,874	41,132	49.25
Deficit	60	13,651	99.56

Source: Private Power and Infrastructure Board - Government of Pakistan

Literature provides the information about residential demand of electricity (Nasir *et al.,* 2008), and impact of electricity consumption on economic growth (Aqeel and

Butt,2001; Zahid, 2008; Jamil and Ahmad, 2010) in Pakistan. Two points are notable here. First, all these empirical studies have focused on electricity demand or consumption while the role of electricity production in growth is missing. Second, all of them take GDP as the indicator of economic growth, whereas GDP entails consumption which has very little to do with the long-term growth. Nonetheless, it is the investment, especially private business investment, which contributes to long-term growth. As compared to the stable GDP, owing to stable consumption, private business investment is much volatile and needs individual attention. Up to this time, no attention has been paid to the private business investment that is vital for long-term growth. These facts provide the motivation for discovering the influence of electricity production on private business investment in Pakistan.

A concrete analysis is pre-requisite for better policy implications, it would be important to have the knowledge of both the short-run and the long-run scenarios in the model. The ultimate objective of the present study would be to analyze the impact of electricity production on the private business investment in short-run and long-run. For this purpose, in the first stage, it establishes a log linear model to identify the long-run relationship between the private business investment and electricity production. In the second stage, it analyzes the stationarity of all the variables to be employed in regression. Unit root tests do not provide enough information so that it could choose between the Bounds test and Johansen test for the analysis of cointegration. For the sake of efficiency and a comprehensive analysis and without losing the long-run information in data, present study employs both of these estimation techniques to find a stable long-run relationship between the two variables and this is conducted in third stage. In the fourth stage, it discusses long-run and short-run relationships and their causal linkages.

Remaining study has been organized as follows. Section-II reviews the literature, for a compact analysis it presents the tabulated review of literature. Section-III presents data, sources of data and econometric methodology for empirical analysis. Section-IV describes the long-run and short-run results along with the causal linkage between the variables. Finally, Section-V concludes the study and also provides some policy implications.

II- Literature Review

On the basis of direction of causality, literature is classified under four hypotheses which are discussed one by one. If causality runs from electricity to economic growth, and the opposite is not true, this unidirectional causality specifies the presence of Growth hypothesis. On the other hand, it there is unidirectional causal relationship between the electricity and economic growth, while causality is running from economic growth to electricity, it is known as Conservation hypothesis. In some cases, there is also the evidence of an interdependent relationship between electricity and economic growth, it is known as Feedback hypothesis. Finally, Neutrality hypothesis assumes no causal relationship between the variable. Review of literature has been enclosed in the following Table-2. Although it covers both types of cases (country specific and multi-county cases) but owing to the nature of study, it emphasizes more on former category.

Table-2 A Compact form of Literature Review

S. No.	Author(s)	Period	Country Name	Methodology	Direction of Causality
Panel-I: Country-Specific Empirical Studies					
1	Yang (2000)	1954-1997	Taiwan	Engle-Granger Cointegration	$E \rightarrow Y$
2	Aqeel (2001)	1956–1996	Pakistan	Cointegration, Hsiao's Granger Causality	$E \rightarrow Y$
3	Ghosh (2002)	1950-1997	India	Johansen-Juselius Cointegration	$Y \rightarrow E$
4	Wolde-Rufael (2004)	1952-1999	Shanghai	Toda and Yamamoto Causality Test	$E \rightarrow Y$
5	Jumbe (2004)	1970-1999	Malawi	Engle-Granger Cointegration	$E \leftrightarrow Y$
6	Morimoto and Hope (2004)	1960-1998	Sri Lanka	Engle-Granger Cointegration	$EP \rightarrow Y$
7	Shiu and Lam (2004)	1971-2000	China	Johansen-Juselius Cointegration	$E \rightarrow Y$
8	Altinay and	1950-2000	Turkey	Dolado-Lutkepohl Causality	$E \rightarrow Y$

	Karagol (2005)				
9	Lee and Chang (2005)	1954-2003	Taiwan	Johansen-Juselius Cointegration	$E \rightarrow Y$
10	Narayan and Smyth (2005)	1966-1999	Australia	ARDL bounds Test to Cointegration	$Y \rightarrow E$
11	Yoo (2005)	1970-2002	Korea	Johansen-Juselius Cointegration	$E \rightarrow Y$
12	Yoo and Kim (2006)	1971-2002	Indonesia	Engle-Granger Cointegration	$Y \rightarrow EP$
13	Ho and Siu (2007)	1966-2002	Hong Kong	Johansen-Juselius Cointegration	$E \rightarrow Y$
14	Mozumdr And Marathe (2007)	1971-1999	Bangladesh	Johansen-Juselius Cointegration	$Y \rightarrow E$
15	Narayan and Singh (2007)	1971-2002	Fiji Islands	ARDL bounds test to Cointegration	$E \rightarrow Y$

16	Yuan *et al.* (2007)	1978-2004	China	Johansen-Juselius, Hodrick-Prescott filter; VDC	$E \rightarrow Y$
17	Zamani (2007)	1967-2003	Iran	Engle-Granger Cointegration	$Y \rightarrow E$
18	Yuan *et al.* (2008)	1963-2005	China	Johansen-Juselius Cointegration, IRF	$E \leftrightarrow Y$
19	Ziramba (2009)	1980-2005	South Africa	ARDL Cointegration, Toda and Yamamoto Causality	$Y \rightarrow E$
20	Jamil and Ahmad (2010)	1960-2008	Pakistan	Johansen Cointegration, VECM	$Y \rightarrow E$
21	Shahbaz *et al.* (2011)	1971-2009	Portugal	Bounds Test to Cointegration, VECM	$E \leftrightarrow Y$
	Panel-II: Multi-Country Empirical Studies				
22	Fatai *et al.* (2004)	1960-1999	6 countries panel	Granger-Causality, Toda Yamamoto causality Tests, ARDL Bounds Test, Johansen	Australia: $Y \rightarrow E$ New Zealand:

				and Juselius Cointegration	$E \rightarrow Y$ India: $E \rightarrow Y$ Indonesia: $E \rightarrow Y$ Thailand: $E \leftrightarrow Y$ Philippines: $E \leftrightarrow Y$
23	Yoo (2006)	1971-20024	4 countries panel	Johansen-Juselius	Indonesia: $Y \rightarrow E$ Malaysia: $E \rightarrow Y$ Singapore: $E \rightarrow Y$ Thailand: $Y \rightarrow E$
24	Akinlo (2008)	1980-2004	11 countries	ARDL Bounds Test	Cameroon: $Y \rightarrow E$ Cote d'Ivoire: $Y \neq E$ Congo: $E \rightarrow Y$ Gambia: $E \rightarrow Y$ Ghana:

					$E \leftrightarrow Y$ Kenya: $Y \neq E$ Nigeria: $Y \neq E$ Senegal: $E \leftrightarrow Y$ Sudan: $E \leftrightarrow Y$ Togo: $Y \neq E$ Zimbabwe: $E \leftrightarrow Y$

Definitions of notation: $\rightarrow$, $\leftrightarrow$ and $\neq$ represent unidirectional, bidirectional, and no causality, respectively.

Y, E *and* EP denote GDP, Electricity Consumption and Production respectively.

III- Data and Methodology

Previously, literature has used real Gross Domestic Product (GDP) as development indicator and electricity consumption as the energy indicator. However, given the above mentioned objective of the study, private business investment has been employed as development indicator and electricity production as energy indicators. For the choice of a better functional form, it takes the help of prevailing literature. Log-linear functional form produces robust results as compared to linear specification (Nasir *et al.,* 2008; Noor and Siddiqi, 2010; Shahbaz and Lean, 2012). It is as follows:

$$I_t = \alpha_0 + \alpha_1 E_t + \mu_t \quad (1)$$

Private business investment has been denoted with I_t and is denominated in million rupees, while electricity production has been denoted with E_t and measured in kWh, and μ_t denotes white noised error term. Annual data has been used for the period of 1975 to 2010. Both the variables are taken from World Bank database and are converted in natural logarithms. After specifying the data and variables, it would be important to know the order of integration of the variables. For this purpose, it takes the help of Augmented Ducky Fuller (ADF) test and Phillips–Perron (PP) test. Both of these tests proceed with Equation (2) for their operations. It is as follows:

$$\nabla x_t = \alpha_0 + \alpha_1 x_{t-1} + \sum_{i=1}^{n} \beta_i \nabla x_{t-i} + \mu_t \quad (2)$$

Where $\nabla, x_t\, and\, \mu_t$ denote difference operator, a given variable, and white noised error term respectively (Dickey and Fuller, 1979). Equation (2) is estimated under the null of unit root against the alternative of stationarity. Additional lags of the differenced variable can also be utilized to make the error term white noised.

Standard econometric techniques require stationary data for integrated date might provides spurious estimates. Nonetheless; differencing eliminates the long-run information in the data, it would be misleading if there is a long-run relationship among the variables. Fortunately, contemporaneous econometric literature has made it possible to operate with integrated data. Hence, if all the variables are integrated of the same order, then one must find a unique cointegrating vector among the variables in the level form (Johansen, 1991; Johansen and Juselius, 1990).

Different order of integration among the variables brings a severe shortcoming to this technique. This limitation was tackled by Autoregressive Distributive Lag (ARDL) models. Along with retaining the long-run information, it also provides robust results if the variables have different order of integration (Pesaran and Pesaran, 1997). Furthermore, the inclusion of sufficient lag terms in regression establishes a smooth data generating process (Laurenceson and Chai, 2003). It becomes:

$$\Delta I_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \, \Delta I_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \, \Delta E_{t-i} + \alpha_3 I_{t-1} + \alpha_4 E_{2t-1} + \mu_t \qquad (3)$$

$$\Delta E_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \, \Delta I_{t-i} + \sum_{i=1}^{n} \beta_{2i} \, \Delta E_{t-i} + \beta_3 I_{t-1} + \beta_4 E_{2t-1} + \mu_t \qquad (4)$$

Where Δ symbolizes difference operator and μ_t stands for a white noised error-term. As asymptotic properties of standard F-test would be non-standard under the null of no cointegration, it might result in spurious regression. To overcome this problem, Pesaran and Pesaran (1997) and Pesaran *et al.* (2001) offer two sets of critical values with different significance levels. One of the sets is constructed on the assumption that all variables are I(1) process and other assumes them I(0) process. Comparison of the estimated values of the F-stat(s) with these given critical values provides meaningful implications. There would be a long-run relationship among the variables if the estimated value exceeds the upper bound critical value. If it is smaller than lower bound, null of no cointegrating relationship would be true. Finally, if calculated values are between two bounds, no conclusion can be drawn because it is an inconclusive zone. Null and alternative hypothesis for Equations 3-4 are as follows:

For Equation (3) $\quad H_o : (\alpha_3 = \alpha_4 = 0)$, $H_1 : (a_3 \neq a_4 \neq 0)$

For Equation (4) $H_0 : (b_3 = b_4 = 0)$, $H_1 : (b_3 \neq b_4 \neq 0)$

Finally, long-run and short-run relationships between the variables have been indicated by Equations 5-6 respectively. Error correction terms, ECM_{t-1}, are also added to equations 7-8 which are derived from the corresponding long-run relationships in the equation 5-6, indicating speed of convergence. In short, these terms specify the rate of convergence of the endogenous variables if there is some external shock in the system.

$$I_t = \alpha_0 + \sum_{I=1}^{m} \alpha_{1i} I_{t-1} + \sum_{I=1}^{n} \alpha_{2i} E_{t-1} + \mu_t \quad (5)$$

$$E_t = \beta_0 + \sum_{I=1}^{m} \beta_{1i} I_{t-1} + \sum_{I=1}^{n} \beta_{2i} E_{t-1} + \mu_t \quad (6)$$

It would be important to note the short-run and the long-run causality between the variables. One important advantage of the ECM term is that it provides the information about the long-run causality between the variables. In Vector Error Correction Mechanism (VECM) framework, significant ECM term specifies the long-run causality running form explanatory variable to dependent variable. On the other hand, lagged value of the explanatory variable specifies the short-run causality running form explanatory variable to dependent variable. If more than one lags of an explanatory variables are used in VECM framework, a joint test for the combine significance of all the lagged variables is applied with the help of F-test or Wald test.

$$\nabla I_t = \alpha_0 + \sum_{I=1}^{m} \alpha_{1i} \nabla I_{t-1} + \sum_{I=1}^{n} \alpha_{2i} \nabla E_{t-1} + ECM_{t-1} + \mu_t \quad (7)$$

$$\nabla E_t = \beta_0 + \sum_{I=1}^{m} \beta_{1i} \nabla I_{t-1} + \sum_{I=1}^{n} \beta_{2i} \nabla E_{t-1} + ECM_{t-1} + \mu_t \quad (8)$$

For a concrete analysis, it would be valuable to evaluate the goodness of fit, in ARDL model. In addition, diagnostic analysis scrutinizes normality, serial correlation, heteroscedasticity too. After having satisfactory inspection, it moves forward for analyzing the stability of the system. For this purpose, it takes the help of cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMsq).

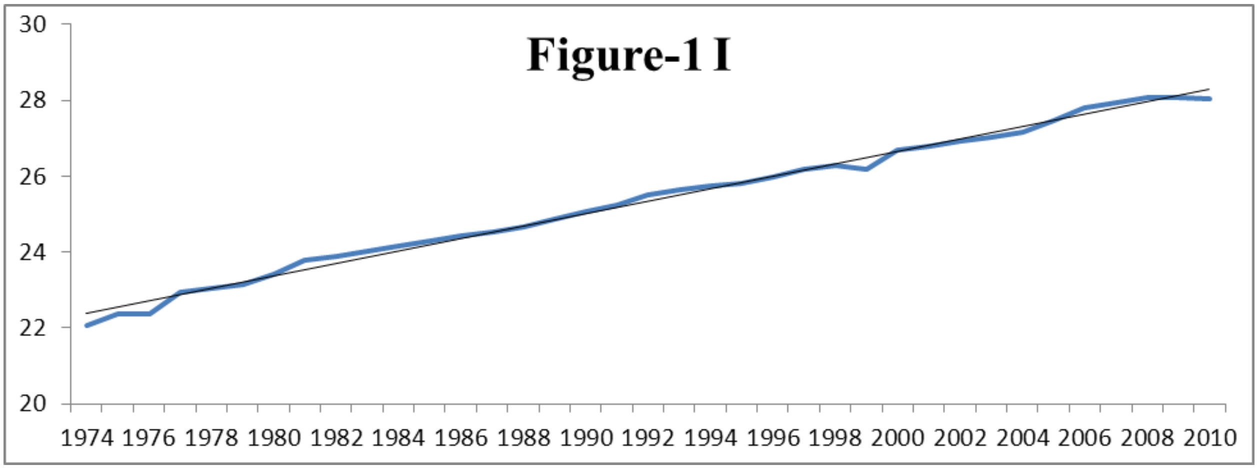
IV- Empirical Results

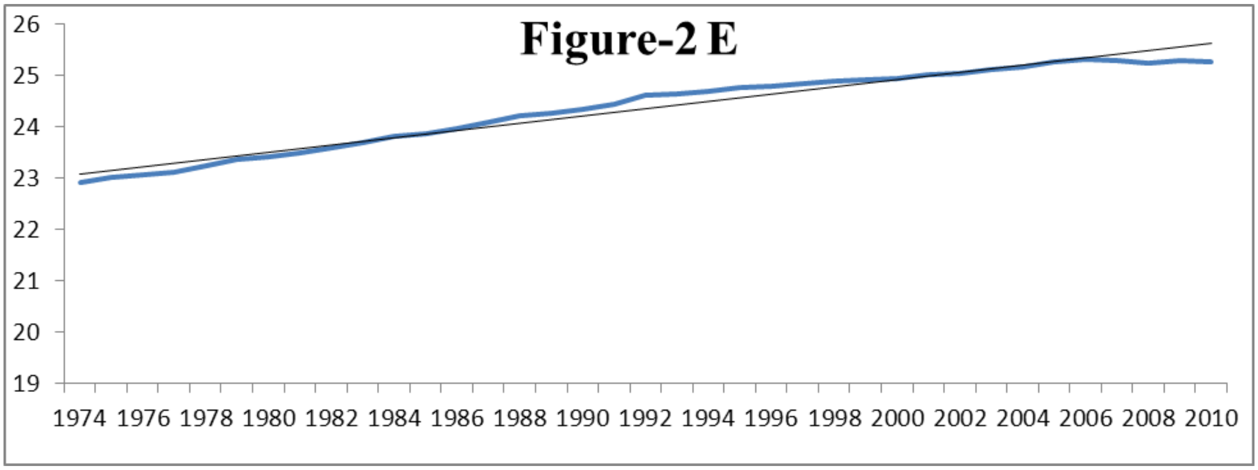
Results of the ADF and PP tests are reported in Table-3, in level and differenced form. It is evident that private business investment is stationary at 10 percent level of significance while electricity production is non-stationary. However, first difference of electricity production makes it also stationary with 1 percent level of significance. It can be concluded that order of integration of the two variables in not same, and the highest order of integration is one.

Table-3

Variables	ADF Test		PP Test	
	Level	**First Difference**	**Level**	**First Difference**
I	-3.44*	-7.55***	-3.22*	-7.49***
E	0.94	-5.14***	0.85	-5.12***

Given values report the t-statistic for both of the variable. *** and * show 1% and 10% significance respectively.





In addition, some stylized facts also give some evidence of cointegrating relationship between the variables, (see Figures 1-2). Figure-1 portrays private business investment while Figure-2 displays electricity production, the thin black line in both of the figures is trend line. It is clear from the figures that there is some evidence of a cointegrating relationship between the two variables. Nonetheless; a more comprehensive and sophisticated analysis, for an in-depth knowledge of the situation, has been conducted in the next section.

Results of the ADF and PP tests, reported in Table-1, and the above portrayed graphs provide the motivation for bounds test to cointegration because both of the variables have different order of integration. This test compares the calculated F-statistics with the given tabulated values, whereas each set of tabulated value has been generated for a given sample size. Primarily, these values are associated to Pesaran and Pesaran (1997) and Pesaran *et al.* (2001). Critical values in these studies are generated for large sample size, for 500-1000 observations. In contrast, Narayan (2004a; 2004b; 2005) asserts these critical values are meaningless for the small sample size. This problem was solved by Narayan (2005), which provided the critical values for the small sample size ranging from 30 to 80 observations. As present study is also dealing with small data size of 36 observations, it takes the tabulated valued from Narayan (2005). Bounds test to cointegration takes each variable in Equation (1) as dependent variable and calculates two F-statistics, one by one. However, present study finds that only one of the two F-stats, for the investment as dependent variable[2], gives the evidence of a stable long-run relationship between the two variables, (see Table-4, Panel A).

Table-4 Results of Bounds Test to Cointegration

Panel:-A Test Equation	$F_I = (I / E)$	$F_E = (E / I)$
Calculated F-statistics	43.78	0.41
Asymptotic critical values (T = 36) for the level of significance:		
	I(0)	**I(1)**
1 percent	6.14	7.60
5 percent	4.18	5.33
10 percent	3.33	4.41
Panel:-B Diagnostic Tests for F_I		
Durbin-Watson	2.11	

[2] SBC specifies (0, 1) optimal lag length for the model F_I .

J-B Normality	3.08(0.214)
Serial Correlation	0.77(0.37)
Heteroscedasticity	1.97(0.16)

Parentheses include p-values.

The calculated F-statistic is 43.78, which is greater than the given upper bound critical value (7.06) at 1 significance level. Hence, it implies that the null of no cointegration cannot be accepted. In short, it gives evidence of a unique cointegrating vector if private business investment is employed as a dependent variable. Results of diagnostic tests, for F_I, also ascertains the significance of the estimated regression, (see Table-4, Panel B). In addition, it also plots Cumulative Sum of Recursive Residuals and Cumulative Sum of Square of Recursive Residuals for the model based on F_I. Both of the tests specify that the estimated system is stable overtime, (see Figures 3-4).

Figure- 3

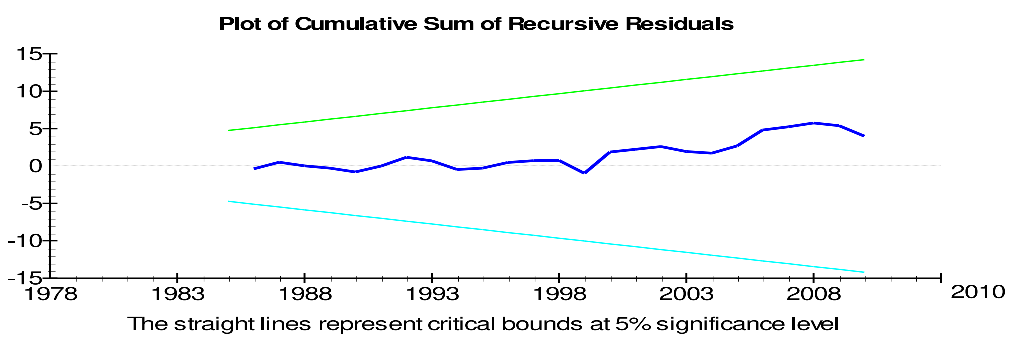
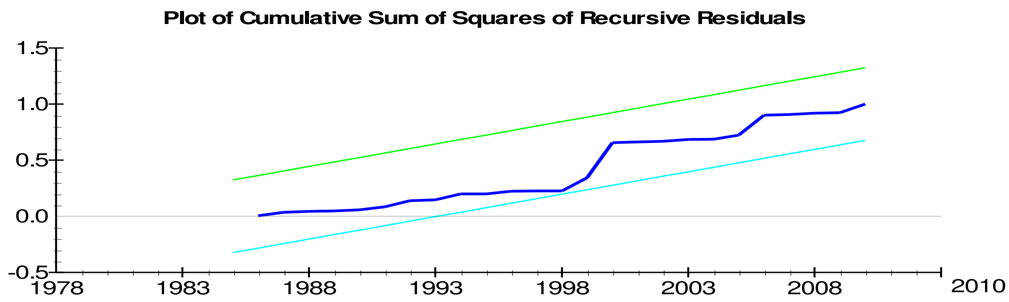


Figure-4



The straight lines represent critical bounds at 5% significance level

Previous section finds a unique cointegrating relationship between the private business investment and electricity production in Pakistan. This section sorts out the long-run as well as the short-run elasticities, as both of the variables are in their natural logarithms[3]. It asserts a strong correlation between the private business investment and the electricity production, (see Table-5, Panel A). Results state that one percent rise in the electricity production results in 1.58 percent acceleration in private business investment in long-run. It would be important to have the knowledge of the short-run results also before reaching to a final conclusion.

Table-5 ARDL Long-run and Short-run Elasticities based on F_I

Panel:-A Long-run Elasticity		**Panel:-B Short-run Elasticity**	
Dependent Variable: I_t		Dependent Variable: $D(I_t)$	
E_t	1.58*	$D(E_t)$	0.51
	(0.09)		(0.36)
Constant	-0.20	$D(E_{t-1})$	-1.16**

[3] SBC specifies (0, 2) is the optimal lag length.

	(0.96)		(0.02)
		ECM_{t-1}	-1.00***
			(0.00)
		Constant	-0.20
			(0.96)

***, ** and * show 1%, 5% and 10% level of significance respectively. Parenthesis includes p-value.

For the short-run analysis of system, it estimates VECM for the given ARDL model, (see Table-5, Panel B). It would be interesting to note that the coefficient of error correction mechanism, ECM_{t-1}, is -1 which indicates that private business investment adjusts itself within a period of one year, consistent with Narayan (2005). In other words, private business investment takes one year to converse to the long-run equilibrium. In addition, short-run results depict that one unit rise in electricity production results in 1.16 percent fall in private business investment and this impact reveals after the period of one year. However; the contemporaneous impact of the electricity production on private business investment is positive, but very small (0.51 percent) and insignificant. It might be owing to the fact that investment in process cannot be reallocated, once the agreements are furnished, while its consequences emerge after a period of one year. Hence; it can be concluded that most of the long-term benefits associated with the provision of electricity production are almost balanced with short-term investment losses, and electricity production contributes a very marginal share in growth.

Direction of causality is much important in framing policy implications; this section illustrates the causal relationships in model. Results of the ARDL model disclose the short-run causality running form the electricity production to private business investment because coefficient of the lagged differenced value of electricity production is significant. In addition, error correction term coefficient specifies the long-run causality running from electricity production to private business investment. This section provides a limited discussion of the causal relationships between the two variables; next section emphasizes short-run and long-run causal relationships in a better way[4].

As mentioned previously, both ADF and PP unit root tests specify private business investment stationary with 10 percent significance level. It would be imprecise to say it stationary with 5 percent significance level. In addition, if the criterion of 5 percent significance level is followed then both of the variables would be I (1). In this situation, Johansen Cointegration test provides robust results (Johansen,1988; Johansen and Juselius, 1990). Following these recommendations, present study also applies Johansen test for analyzing a cointegration relationship in model. Before moving forward, it is important to finds the optimal lag length. All the leg selection criteria suggest one lag, (see Table-6). Hence, it is a much parsimonious model; a smaller lag length lowers the uncertainty in model and also results in a smooth data generating process.

[4] Present study uses Microfit 4 to estimate the ARDL model. This software package is unable to estimate the simultaneous estimation of error correction terms of all the variables in the system. Nonetheless, this short-coming will be overcome by the estimation of the long-run equation in E-views with Johansen cointegration test. Along with the estimation of long-run relationship, it also provides simultaneous estimation of long-run causality for all the variables in the system.

Table-6 Lag Selection for Johansen Cointegration Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-42.53	NA	0.05	2.69	2.78	2.72
1	90.66	242.18*	.00*	-5.13*	-4.85*	-5.03*
2	91.30	1.09	0.02	-4.92	-4.47	-4.77
3	93.69	3.75	0.02	-4.82	-4.19	-4.61

Johansen test for cointegration has been performed under two null hypotheses. First null hypothesis assumes no cointegrating vector against the alternative of a unique cointegrating vector between the variables, while second null assumes a cointegrating vector against the alternative of two cointegrating vectors. Results exhibit the rejection of first null; nonetheless, the second null cannot be rejected, (see Table-7). Hence, it can be concluded that there is a unique long-run relationship between the private business investment and electricity production.

Table-7 Results of Johansen Cointegration

Rank	Trace Statistics	Critical Values	Maximum Eigen Value	Critical Values
0	16.28**	15.49	15.49**	14.26
$r \leq 1$	0.79	3.84	0.79	3.84

** indicates 5 percent level of significance.

To be more specific, one percent rise in electricity production results in 1.31 percent increment in private business investment, (see Table-8, Panel-A). However, it would be valuable to note the short-run elasticities as well; VECM has been employed for this purpose, (see Table-8, Panel B). For a stable system, at least one of the two ECM terms must be significant to bring the system back to equilibrium, given some exogenous shock. It is clear from the table that both of the error correction terms are significant in short-run but investment brings a quick convergence in the system. It is fact because investment is much volatile as compared to electricity production. Although the point estimates of this regression differ a little bit from above mentioned ARDL model estimates but it conveys the same message. It indicates that although the impact of electricity production on private business investment is positive in long-run but it influences negatively in short-run.

Table-8 Johansen Long-run and Short-run Elasticities

Panel-A Long-run Elasticity		**Panel-B Short-run Elasticity**			
Dependent Variable: I_t		Dependent Variable: $D(I_t)$		Dependent Variable: $D(E_t)$	
E_t	1.31***	$D(I_{t-1})$	-0.24	$D(I_{t-1})$	0.06
	(-5.85)		(-1.49)		(1.3)
Constant	-6.72	$D(E_{t-1})$	-0.64	$D(E_{t-1})$	0.09
			(-1.06)		(0.52)
		ECM_{t-1}	-0.08**	ECM_{t-1}	-0.03***

		(-2.3)		(-3.26)
	Constant	0.25***	Constant	0.048***
		(4.79)		(3.11)

***, ** and * show 1%, 5% and 10% level of significance respectively. Parentheses include t-statistic.

It would be important to know the short-run and long-run causal relationship between the variables. The insignificant coefficients of lagged differenced variable of electricity production, when differenced private business investment is used as dependent variables, specifies the absence of short-run causality running from electricity production to private business investment. On the other hand, the insignificant coefficient of the lagged differenced private business investment, when differenced electricity production is used as dependent variable, states the absence of a causal relation from investment to electricity production. So, it gives the evidence of no causal relationship between the variables in short-run. On the other hand, error correction terms in both of the equations are significant which indicates the presence of bidirectional causality between the two variables in long-run.

V-Conclusion and Policy Implications

V-A Conclusion

Presently, most of the research work is available on electricity consumption whereas no attention has been paid to electricity production. In addition, GDP has remained the focal point of all the empirical studies which is much stable because consumption has most of the share in GDP. In contrast, private business investment is vital to long-term growth and no study is available that could find the impact of electricity production of private business investment. Present study aims to fill these vacuums; it finds short-term, long-term and causal linkages between the two variables.

It employs annual data for the period of 1975 to 2010 which is acquired from World Bank database. Both of the variables are converted in natural logarithms and a log-linear relationship has been established. It takes the help of ADF and PP tests to find the order of integration in variable but results of both of these tests are unable to state the order of integration precisely. For a concrete analysis; it employs prevailing long-run tests, bounds test and Johansen test to cointegration. Bound test specifies a unique long-run relationship between the private business investment and electricity production if private business investment is used as dependent variable. Results of ARDL model state that one present rise in electricity production results in 1.58 increment in private business investment in long-run. In contrast, same acceleration in electricity production results in 1.16 percent fall in private business investment in short-run. Moreover; results of Johansen test for cointegration also communicates the same message with a little change in estimates. Finally, it finds no short-run causal relationship between the two variables where as there is the evidence of long-run bidirectional causal relationship.

Pakistan is in early stage of development, at this stage marginal productivity of electricity must be very high. In contrast, electricity production is adding very marginal benefits to the economy. Most of the long-run benefits are balanced with short-run losses in private business investment. Pakistan needs to reevaluate its long-term policies towards electricity production to make its private business investment more productive in short-run as well as in long-run.

V-B Policy Implications

Effective electricity prices induce business community to expand business which results in employment generation. In contrast, business class in Pakistan bears the highest electricity tariffs as compared to its competitor countries (Weynand, 2007). All the new investment might seek some other avenues, to run a competitive business, because it would not be optimal to run business in Pakistan. This is a worrying state and requires the serious attention of the policy makers.

Electricity deficit must not be encounter just with short-term electricity production by IPPs but some long-term planning is required. Nature has blessed Pakistan generously with water resources, but unfortunately 13 percent of our water flow from rivers can be stored. In addition, rising sedimentation is also reducing the storage capacity in dams. Against the hydropower potential (that is more than 100,000 MW, acknowledged sites of 55,000 MW[5]), Pakistan is just producing 6,599 MW electricity from hydropower (Mirza *et al.*, 2008). Just from the Indus River, 10 million acre feet of water is squandered in sea every year. Many projects are in pipeline, Diamer Basha, Bunji and Kohala are some notable spots which have the capacity of 4,500 MW, 7,100 MW and 1,100 MW respectively. Pakistan is direly in need of consistent policies for the completion of these dams to produce cheap electricity for her people. Rising electricity demand necessitates the completion of these ventures to keep a pace with the world in development.

The pity is that hydel:thermal mix for electricity generation is 34:66 which is against the ideal mix of hydel:thermal. In simple words, for a developing oil importing country like Pakistan, it is not a sustainable policy to generate electricity form imported

---

[5] See Hydro potential in Pakistan (2010).

oil because most of its foreign revenues are consumed for the purchase of crude oil. Thermal power plants, operated by IPPs, can overwhelm the load-shedding for short-term but it also resulting in mounting tariffs. Such high tariff rates are evading the economic growth, and investment is moving to foreign heavens. Competitive electricity can be produced with the help of hydropower which requires just some serious and persistent efforts.

References

Akinlo, A.E., 2008. Energy consumption and economic growth: evidence from 11 Sub-Sahara African countries. Energy Economics 30, 2391-400.

Altinay, G., Karagol, E., 2005. Electricity consumption and economic growth: evidence from Turkey. Energy Economics 27, 849-56.

Aqeel, A., Butt, M.S., 2001. The relationship between energy consumption and economic growth in Pakistan. Asia-Pacific Development Journal 8, 101–110.

Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. Journal of American Statistical Association 74, 427–431.

Fatai, K., Oxley, L., Scrimgeour, F.G., 2004. Modelling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia, the Philippines, and Thailand. Mathematics and Computers in Simulation 64, 431-45.

Ghosh, S., 2002. Electricity consumption and economic growth in India. Energy Policy 30, 125–129.

Ho, C.Y., Siu, K.W., 2007. A dynamic equilibrium of electricity consumption and GDP in Hong Kong: an empirical investigation. Energy Policy 35, 2507-13.

Hydro potential in Pakistan (2010), A report by Pakistan Water and Power Development Authority, [http://wapda.gov.pk/pdf/BrchreHydrpwerPotJuly2010.pdf].

Khan, A. M., Ahmed, U., 2009. Energy demand in Pakistan: a disaggregate analysis. The Pakistan Development Review 47, 347-455.

Jamil, F., Ahmad, E., 2010. The relationship between electricity consumption, electricity prices and GDP in Pakistan. Energy Policy 38, 6016-6025.

Johansen S., 1991. Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Vector Autoregressive Models. Econometrica 59, 1551-80.

Johansen, S., 1988. Statistical and hypothesis testing of cointegration vector. Journal of Economic Dynamics and Control 12, 231–254.

Johansen S., Juselius K., 1990. Maximum Likelihood Estimation and Inference on Cointegratin with Application to the Demand for Money. Oxford Bulletin of Economics and Statistics 52, 169-209.

Jumbe, C.B.L., 2004. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Economics 26, 61-8.

Laurenceson J., Chai J., 2003. Financial Reform and Economic Development in China. Cheltenham, UK, Edward Elgar.

Lee, C.C., Chang, C.P., 2005. Structural breaks, energy consumption, and economic growth revisited: evidence from Taiwan. Energy Economics 27, 857-72.

Mirzaa, U. K., Ahmada, N., Majeeda, T., Harijanb, K. 2008. Hydropower use in Pakistan: Past, present and future. Renewable and Sustainable Energy Reviews 12, 1641–1651.

Morimoto, R., Hope, C., 2004. The impact of electricity supply on economic growth in Sri Lanka. Energy Economics 26, 77-85.

Mozumder, P., Marathe, A., 2007. Causality relationship between electricity consumption and GDP in Bangladesh. Energy Policy 35, 395-402.

Narayan, P. K., 2004a. Reformulating critical values for the bounds F -statictics approach to cointegration: an application to the tourism demand model for Fiji. Department of Economics Discussion Papers No. 02/04, Monash University, Melbourne, Australia.

Narayan, P. K., 2004b. An econometric model of tourism demand and a computable general equilibrium analysis of the impact of tourism: the case of the Fiji Islands. Unpublished PhD thesis, Department of Economics, Monash University, Melbourne, Australia.

Narayan, P. K., 2005. The saving and investment nexus for China: evidence from cointegration tests, Applied Economics 37, 1979-1990.

Narayan, P.K., Smyth, R., 2005. Electricity consumption, employment, and real income in Australia: evidence from multivariate Granger causality tests. Energy Policy, Vol. 33, pp. 1109-16.

Narayan, P.K., Singh, B., 2007. The electricity consumption and GDP nexus for the Fiji Islands. Energy Economics 29, 1141–1150.

Nasir, M., TARIQ, M. S., ARIF, A., 2008. Residential Demand for Electricity in Pakistan. The Pakistan Development Review 47, 457–467.

Noor, S., and Siddiqi, M. W., 2010. Energy Consumption and Economic Growth in South Asian Countries: A Co-integrated Panel Analysis. International Journal of Human and Social Sciences 5, 14 2010.

Pesaran, M.H., Pesaran B., 1997. Working with Microfit 4.0: Interactive Econometric Analysis. Oxford, Oxford University Press.

Pesaran, M.H., Shin Y., Smith, R.J., 2001. Bounds Testing Approaches to the Analysis of Level Relationships. Journal of Applied Econometrics 16, 289-326.

Shahbaz, M., Tang, C. F., Shabbir, M. S., 2011. Electricity consumption and economic growth nexus in Portugal using cointegration and causality approaches. Energy Policy 39, 3529-3536.

Shahbaz, M., Lean, H. H., 2012. Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy Policy 40, 473–479.

Shiu, A., Lam, P.L., 2004. Electricity consumption and economic growth in China. Energy Policy 32, 47-54.

Weynand, G., 2007. Energy Sector Assessment for USAID/Pakisttan. Energy Team Office of Infrastructure & Engineering Bureau for Economic Growth, Agriculture, & Trade United States Agency for International Development.

Wolde-Rufael, Y., 2004. Disaggregated industrial energy consumption and GDP: the case of Shanghai, 1952-1999. Energy Economics 26, 69-75.

Yang, H.Y., 2000. A note on the causal relationship between energy and GDP in Taiwan. Energy Economics 22, 309-17.

Yoo, S.H., 2005. Electricity consumption and economic growth: evidence from Korea. Energy Policy 33, 1627-32.

Yoo, S.H., Kim, Y., 2006. Electricity generation and economic growth in Indonesia. Energy 31, 2890-9.

Yoo, S.H., 2006. The causal relationship between electricity consumption and economic growth in the ASEAN countries. Energy Policy 34, 3573-82.

Yuan, J., Zhao, C., Yu, S., Hu, Z., 2007. Electricity consumption and economic growth in China: cointegration and co-feature analysis. Energy Economics 29, 1179-91.

Yuan, J., Kang, J., Zhao, C., Hu, Z., 2008. Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels", Energy Economics 30, 3077-94.

Zahid, A., 2008. Energy–GDP relationship: A causal analysis for the five countries of South Asia. Applied Econometrics and International Development 1, 167-180.

Zamani, M., 2007. Energy consumption and economic activities in Iran. Energy Economics 29, 1135-40.

Ziramba, E., 2009. Disaggregate energy consumption and industrial production in South Africa. Energy Policy 37, 2214–2220.