Causal Relationship between Electricity Consumption and GDP in Pakistan

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Abstract

The prime focus of the study was to find out causal relationship between per capita GDP and per capita electricity consumption for Pakistan using cointegration and granger causality analyses. This study covers time series data from 1971 to 2010 for both of variables. Unit root analyses reveals that both variables are stationary of same order. Cointegration analyses confirm long run associationship between per capita electricity consumption and per capita GDP. Causal relationship was confirmed using Granger causality test which reveals unidirectional causality flowing from electricity consumption to economic growth. Variance decomposition test confirms that in duration of 10 years up to 14 % variations in GDP are brought by electricity consumption. The result reveals that for developing countries like Pakistan important policies should be adopted and applied for enhancing electricity sector especially by focusing on hydroelectricity. So if electricity sector improves it will further stimulate the economic growth of Pakistan.

Keywords: Electricity Consumption, Cointegration, Granger Causality, Economic Growth.

Introduction

Over the past 3 decades energy consumption is considered to be a key factor of enhancing economic growth and that's why also become a main issue of debate for policy makers and economist to explore the associationship between economic growth and energy consumption (Chandran et al, 2010). Energy is considered to be as a building block of economic growth of a country (Ghosh, 2002). According to (Hondroyiannis et al, 2002) energy consumption can play a key role in determination of economic growth of any economy. They also argued that the enhancement in economic growth in past few years for Greece was due to adoption and adjustment of suitable policies for industrial sector in 1990s. (Aqeel & Butt, 2001) also suggested that for enhancing employment opportunities and economic growth various policies should be made for increasing the energy sector of gas and electricity consumption of Pakistan. (Shiu and lam, 2004) provide empirical evidence of importance of electricity usage in economic growth of china that increase in economic growth of China has also led it to the 2nd largest consumer of electricity which confirms that as economic growth increases the demand and use of energy also increases. (jumbe, 2004) also confirmed that rise in economic growth can lead to increase in electricity consumption. He said that energy particularly electricity up to greater extent is a source of enhancing economic development. (Yoo, 2006) also suggested that for enhancement in economic growth efforts should be made to improve the electricity sector of country. Literature reveals that energy can lead to enhance in economic growth so policy makers should made policies that can enhance energy and an economy can get benefit from it.

Electricity Sector of Pakistan

Due to the increase in demand for electricity it led the policy makers to make policies for Pakistan to enhance its electricity sector and enrich its economic growth. As having no

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resources for further investment in electricity sector of Pakistan there was need of some alternative source of energy which was to invite the private sector to contribute in power generation. The 1st ever policy made for improving power sector was in 1994 which invited the private sector to contribute in the production of electricity. Private sector successfully managed 29 independent plants and their capacity reached to about 8657 MW till 2014. Alternative electricity is also obtained from wind and solar energy. In December 2012 the 1st wind power plant was build which provided electricity of about 50 MW. Pakistan electricity sector consist of hydroelectric, fossil fuels and nuclear power plants. Hydroelectric power plants are main source of electricity in Pakistan as they are less costly from all other sources of electricity generation. Currently the installed power plants capacity is of about 21000 MW till 2011. Which comprises of 13637 MW from fossil fuels, 6654 MW from hydro while 812 MW from nuclear power plants. But due to some defects only 14000 to 16000 MW of electricity is produced. The maximum electricity demand till 2012 reached to the peak level of 17861 MW while the maximum shortfall was 3544 and maximum production was about 14317 MW (Pakistan electric power company). As due to high demand of electricity high prices are charged for electricity consumption. Developing countries like Pakistan need huge amount of electricity for its development. The recent shortfall damaged the industrial sector highly especially the Textile industry of Pakistan. The high prices of electricity also affected the industrial sector as their internal cost is high and they are unable to compete with the world market. Also many of the multinational companies have closed their businesses in Pakistan due to high cost of electricity which is a major issue for Pakistan.

In Pakistan demand for electricity is increasing at rate of 8 % annually. And according to the (International Energy Agency) the total demand for electricity will reached to about 49048 MW till 2025. As if the demand for electricity rises at that rate so it will be a big problem for Pakistan.

For every country their main objective is to enhance their economic growth especially in developed countries like Pakistan. There are many things that are considered to be as a source of enhancing economic growth but the main source that is considered as a key to enhance economic growth is Electricity. For many developed countries it is found that they are largest consumers of electricity. Keeping in mind the importance of electricity in enhancing economic growth this particular study is carried out for Pakistan. The main focus here of the study is to whether electricity consumption can play a vital role in enhancing economic growth. This paper is carried out by focusing on the specific form of energy i.e. electricity. As electricity is a form of energy majorly used as compare to any other form of energy and is considered worthy and inexpensive as other sources of energy. Also electricity is considered to be as mostly efficient form of energy to enhance economic growth. For this purpose this study will explore the long run relationship between electricity consumption and economic growth. If there is any long run relationship so policy should be made regarding enhancing electricity consumption as to also enhance economic growth. Also this study will explore the direction of causality between two selected variables of study which will provide additional information about the flow of causality between electricity consumption and economic growth which would be efficient regarding policy implications.

Research Questions

1) Is there exist any long run relationship between electricity consumption and economic growth
2) Is there causal relationship between electricity consumption and economic growth

Research Objectives

1) To identify long run association ship between electricity consumption and economic growth.
2) To identify the direction of causality unidirectional or bidirectional

Literature review

Many researchers have worked a lot on causality and exploring relationship between energy consumption and economic growth. But the bulk of literature provides inconsistent and irregular results b/w energy consumption and economic growth. Also the inconsistent results may be due to various statistical tools and methodology used by many researchers in different countries. Few studies reveal unidirectional relationships while many of the studies explored bidirectional relationships between electricity consumption and Economic Growth. The literature can be divided into 3 categories (1) bidirectional (2) unidirectional (3) and no causality between electricity consumption and economic growth. Unidirectional is also divided into 2 parts (1) causality from electricity consumption to economic growth (2) and from economic growth to electricity consumption. But however literature reveals that electricity is also considered to be an essential part of enhancing economic growth.

Few of the contributions from researchers are following (Adjaye, 2000) while studying Indonesia, Philippines, India, and Thailand using cointegration and error correction technique explored unidirectional causality flowing to income from energy for Indonesia and India while bidirectional between energy and income for Philippines and Thailand. (Aqeel and Butt, 2001) used time series data from 1956-1996 for Pakistan and empirically found that both energy and petroleum consumption is caused by GDP growth while there exists unidirectional causal flow to economic growth from electricity consumption. They further concluded that there exists no causal flow between gas consumption and GDP.

Hondroyiannis et al, (2002) empirically provided evidence of causality between energy consumption and GNP for Greece for period 1960 to 1996. (Ghosh, 2002) provided evidence of unidirectional causal flow to electricity consumption from economic growth for India. (Shiu & Lam, 2004) empirically explored unidirectional causality flowing from electricity consumption to real GDP for China and later on (Yuan et al, 2007) also confirmed unidirectional flow to economic growth from electricity consumption. While studying Korea for period 1970-1999 (Oh and lee, 2004) found bilateral flow in long run with energy consumption and growth while they concluded unidirectional causal flow in short run in GDP and energy consumption. (Jumbe, 2004) used agricultural and non agricultural GDP and empirically found bidirectional causal flow with GDP and electricity consumption. He also concluded that NAGDP also causes electricity consumption. Furthermore (Yoo, 2006; Odhiambo, 2009; Chen et al, 2006 and Lang et al, 2010) empirically concluded bidirectional associationship between economic growth and electricity consumption.

Few of the other contributions from researchers and the methodology used, their findings and the direction of causalities are given in table A.

Table A

Authors	Country/period	Variables	Methodology	Conclusions
Adjaye (2000)	Philippine (1971-1995)	Energy consumption, Income and price	Granger causality & error correction	Energy causes income in both uni and bidirectional
Aqeel & Butt (2001)	Pakistan (1956-1996)	GDP per capita, energy, electricity, Gas & petroleum consumption	Cointegration & Hasio's Granger causality	GDP causes EC & Petroleum consumption EC causes GDP.
Hondroyiannis et al (2002)	Greece (1960-1996)	energy consumption, GNP economic growth & price level.	cointegration & error correction model	energy consumption causes
Ghosh (2002)	India (1950-1997)	electricity consumption & GDP per capita	cointegration & Granger causality	GDP causes EC
Shiu & Lam (2004)	China (1971-2000)	real GDP & electricity consumption	error correction & granger causality	EC cause real GDP
Oh & Lee (2004)	Korea (1971-1999)	real GDP, labor & energy consumption	VECM	In short run energy consumption causes GDP
Jumbe (2004)	Malawi (1970-1999)	EC, GDP, agricultural & non agricultural GDP	error correction model	Bilateral B/w EC and GDP NGDP causes EC
Narayan & Smyth(2005)	Australia (1966-1999)	EC, employment & real Income	ARDL bound testing	In long run, employment & real income cause EC. In short run Income causes employment.
Yoo(2006)	ASEAN Countries (1971-2002)	EC & economic growth	cointegration & Granger causality	both unidirectional & bidirectional b/w EC & economic Growth
Ho & Sui (2006)	Hong Kong (1966-2002)	EC & real GDP	granger causality	EC causes real GDP
Chen et al (2006)	ASIAN (1971-2001)	EC & real GDP	error correction & granger causality	bidirectional in long run b/w EC & economic growth
Mozumder et al (2007)	Bangladesh (1971-1999)	per capita EC & per capita GDP	Cointegration & VECM	GDP causes EC
Yuan et al (2007)	China (1978-2004)	real GDP & EC	Error correction Granger causality	EC causes real GDP
Halicioglu (2007)	Turkey (1968-2005)	income & residential energy	ARDL bound testing	income causes energy Consumption

Odhiambo (2009)	South Africa (1971-2006)	EC, real/capita GDP employment level	cointegration & granger causality	bidirectional b/w EC & GDP employment cause economic growth
Lean et al (2010)	Malaysia (1970-2008)	GDP, exports, prices electricity generation	granger causality ARDL bound test	GDP causes electricity generation no causality b/w GDP & prices
Chandran et al (2010)	Malaysia (1971-2003)	real GDP, EC & price	ARDL bound test	EC causes real GDP
Lang et al (2010)	Taiwan (1982-2008)	Total EC & real GDP	Granger causality	bidirectional b/w EC & real GDP
Masuduzaman (2012)	Bangladesh (1981-2011)	Investment, GDP & EC	granger causality cointegration	EC causes investment & GDP investment causes GDP
Dantama et al (2012)	Nigeria (1980-2010)	energy consumption & GDP	ARDL bound test	long run relationship exist b/w GDP & energy consumption
Javid et al (2013)	Pakistan (1971-2008)	EC & real GDP per capita	granger causality	EC cause Real GDP
Onakoya et al (2013)	Nigeria (1975-2010)	energy consumption & GDP	cointegration	long run relationship b/w energy consumption & economic growth
Aslan (2013)	Turkey (1968-2008)	GDP per capita & EC	ARDL bound test	long run relationship b/w EC & economic growth

EC denotes electricity consumption

Methodology

Data and variables

Following Shiu and Lam (2004), Yoo (2006), Ho and Shiu (2006) and many other studies which includes variables i.e. electricity consumption and GDP I have also used the same variables for the particular study. The time series data for the variables GDP and electricity consumption is taken from World Development Indicator. The data for GDP is in current US $ per capita and for electricity consumption is of kilowatt hours (kwh) per capita. The time series data consist of over the period 1971 to 2010. To analyze data logarithm transformation is made.

Unit root test

For checking the cointegration between variables it is necessary that the variables are stationary of same order. For this purpose two test are used i.e. Augmented Dickey-Fuller (1979) and Philips-Perron (1988). Both of tests will be applied for checking stationarity of data.

Johansen and juselius cointegration

For evaluating the long run relationship between the two variables johansen and juselius (1990) cointegration test is applied. This test follows the maximum likelihood procedure which is based on two test (1) Trace test (2) Maximum Eigen value test. Also for checking the causality between variables it is necessary that the variables are cointegrated.

Granger causality

The granger causality test is used to check the lead lag or causal associationship between variables. The data is converted to return series for analyses. When two series are cointegrated then there exists at least unidirectional causality or bidirectional causality.

Variance decomposition

The variance decomposition implies the decomposition of variance in a data. It shows that the changes in a variable are brought by its own innovation or it is due to some other variable. Variance decomposition is also implied to check decomposition between the variables.

Impulse response Function

Impulse response function is used in terms of standard deviation shocks in the period used. It shows that how the variables respond to the shocks and how it effects the other variables.

Empirical results

The figure 1 shows the historical trends in electricity consumption and GDP for period 1971 to 2010. The figure shows that both the variables are following the same trend for the particular period of study. The data for GDP is in US $ per capita while the Electricity consumption data consist of kilowatt hours per capita.

Figure 1

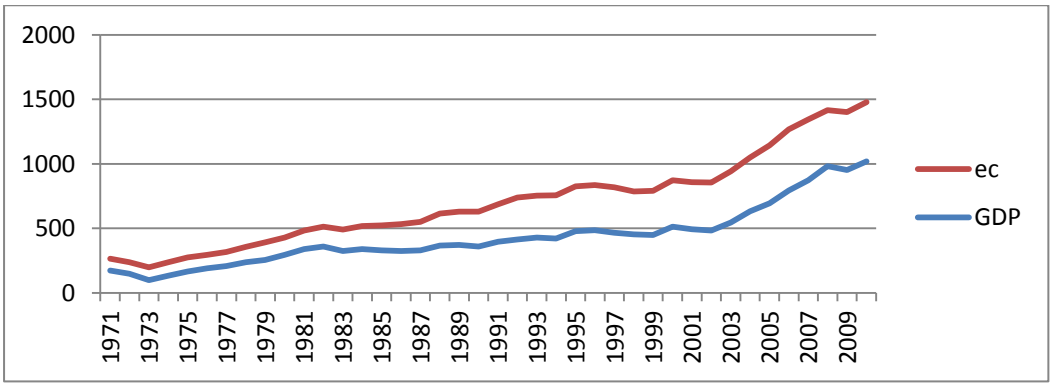

Table 1: Unit Root Tests

Variables	ADF Level	PP Level	ADF First Diff.	PP First Diff.
GDP	-0.158929	-0.158212	-5.454657	-5.474005
EC	-1.771066	-1.725876	-5.303193	-5.303193
Critical Values				
1%	-3.610453	-3.610453	-3.615588	-3.615588
5%	-2.938987	-2.938987	-2.941145	-2.941145
10%	-2.607932	-2.607932	-2.609066	-2.609066

Table 1 shows results of unit root tests. For this purpose both Augmented Dickey fuller and Philip Perron test were employed. In table 1 ADF level shows Augmented Dickey fuller Test which confirms that both the variables are non stationary at level. The PP level shows Unit Root test for both variables which implies that both variables are non stationary at level. Similarly both Dickey Fuller and Phillip Perron test are performed at 1st difference which confirms that both variable i.e. per capital electricity consumption and per capita GDP are found stationary at 1st difference.

Table 2: VAR Statistics

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-13.67987	NA	0.008192	0.871104	0.959077	0.901809
1	105.5716	218.6277*	1.36e-05*	-5.531757*	-5.267837*	-5.439642*
2	109.0267	5.950485	1.40e-05	-5.501486	-5.061619	-5.347961
3	111.9956	4.783088	1.50e-05	-5.444198	-4.828385	-5.229262
4	115.2509	4.882978	1.58e-05	-5.402826	-4.611067	-5.126481

* indicates lag order selected by the criterion

For Cointegration analyses it is needed to provide the suitable lag value that will be used for cointegration. For this purpose VAR statistics is used to check the suitable lag that will be used for cointegration test. In VAR statistics the decision is made on the significance of two type of criteria (1) Akaike Information Criterion (2) Schwarz Criterion. In table 2 both Akaike information criterion and Schwarz criterion confirms to select 1 lag value for cointegration test.

Table 3: Johansen Cointegration Test

Trace Test

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.387066	21.72176	20.26184	0.0313
At most 1	0.078845	3.120821	9.164546	0.5584

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

Maximum Eigen value Test

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.387066	18.60094	15.89210	0.0183
At most 1	0.078845	3.120821	9.164546	0.5584

Max-eigen value test indicates 1 cointegrating eqn(s) at the 0.05 level

Table 3 shows the results of Johansen and juselius cointegration test. It is based on two types of tests (1) Trace test (2) Maximum Eigen value test. Both of the Trace and Maximum Eigen value test confirms that there exists a long run relationship variables i.e per capita GDP and per capita electricity consumption. But johansen cointegration test doesn't tell us about the direction of causality between these variables. For this purpose granger causality test is carried out to know about the direction of causality.

Table 4: Granger Causality

Null Hypothesis:	Obs	F-Statistic	Prob.
R_GDP does not Granger Cause R_EC	38	0.76681	0.3872
R_EC does not Granger Cause R_GDP		5.25990	0.0279

Table 4 shows results of Granger causality test. This test is used to know about the causal flow between variables. The test reveals unidirectional causal flow from per capita electricity consumption to per capita GDP. This implies that economic growth is granger caused by electricity consumption.

Table 5: Variance Decomposition

Variance Decomposition of Electricity consumption

Period	S.E.	EC	GDP
1	0.044900	100.0000	0.000000
2	0.065162	99.76146	0.238539
3	0.077950	99.83047	0.169535
4	0.087799	99.45212	0.547877
5	0.096369	98.46828	1.531722
6	0.104151	97.08160	2.918401
7	0.111307	95.49736	4.502638
8	0.117923	93.85441	6.145586
9	0.124055	92.23929	7.760713
10	0.129747	90.70277	9.297230

Table 6: Variance Decomposition of GDP

Period	S.E.	EC	GDP
1	0.108924	1.620482	98.37952
2	0.161579	2.568255	97.43175
3	0.192704	5.187927	94.81207
4	0.212458	7.223983	92.77602
5	0.226221	8.780435	91.21957
6	0.236502	10.08831	89.91169
7	0.244530	11.25569	88.74431
8	0.251000	12.32228	87.67772
9	0.256346	13.30412	86.69588
10	0.260860	14.21032	85.78968

Table 5 and 6 shows variance decomposition of both the variables. This test is used to know about how much variation in percentage is caused by a variable in itself and whether other variables have contributed in it or not. The variance decomposition of Electricity consumption reveals that the major changes in it is due to its own innovation and negligible contribution is from GDP which is only 9% in duration of 10 years. The variance decomposition of GDP implies that in a 10 years period up to 14% variation are brought by electricity consumption in GDP

Table 7: Impulse response Function

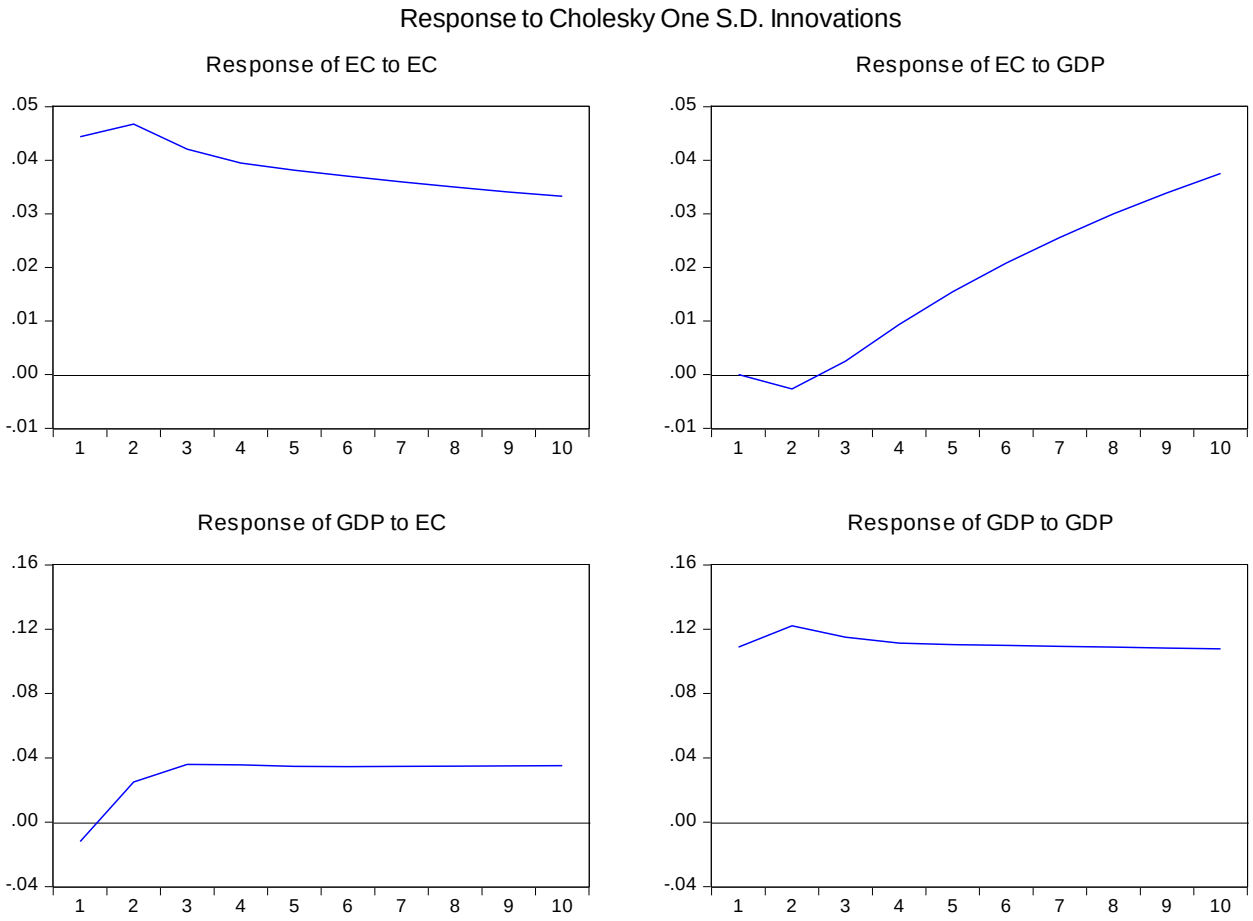

Table 7 shows impulse response analyses of the two variables. It is carried out to know about the various shocks that arise in one variable and whether these shocks are transmitted to other variables or not. The results shows 10 years periods analyses that implies that one standard deviation positive shocks in GDP will change the electricity consumption to rise positively. The result also implies that one standard deviation positive shock to electricity consumption will brought positive changes in GDP.

Discussions and Policy Implications

In this paper the main focus of the study was to find out causal relationship between per capita electricity consumption and per capita GDP for policy makers of Pakistan. The result of johansen cointegration test confirms that there exists long run relationship between electricity consumption and economic growth. The cointegration test guarantees at least unidirectional causality if there exists any long run association ship between variables and if they are cointegrated. The Granger causality test reveals that electricity consumption granger causes economic growth. There is unidirectional causality flowing from electricity consumption to economic growth. The variance decomposition analyses confirm that up to 19 % variations in economic growth are brought by electricity consumption over period of 10 years.

From these analyses it is concluded that increase in electricity can enhance economic growth over long period of time. So as electricity deficient country like Pakistan there should be various policies for improvement of electricity sector. As having production capacity of 21000 MW it hardly produced up to 16000 MW. In Pakistan the most efficient source of electricity is hydroelectricity. Hydro electricity is less costly as compare to electricity produced from other sources like nuclear and thermal. The recent turnover of many multinational companies from Pakistan was due to huge non availability of large amount of electricity and due to high cost by using other sources of energy. So for increasing demand of electricity proper planning should be made regarding enhancing electricity sector as because it will lead to enhance economic growth.

It is noteworthy that developed countries are the largest consumers of electricity. So for developing country like Pakistan it would need huge amount of electricity for its economic development. Hence there is need for improvement of electricity sector of Pakistan. So if the electricity sector improves so it can enhance the economic growth.

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