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Causality between Energy Consumption and Economic Growth in Pakistan

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Abstract
The objective of this study is to examine the causality between energy consumption and economic growth in Pakistan over the period of 1991 to 2006. Pakistan has been facing severe energy crises in the current period and the condition is deteriorating day by day. By applying technique of Granger causality and unit root test, the results infer that electric power consumption is granger causing GDP growth. The implications of the study are that energy conservation policy regarding consumption of energy would not lead to any side-effects on economic growth in Pakistan. The country needs a quantum jump in electricity generation in medium-term scenario to revert the possibilities of load shedding in future due to shrinking gap between demand and supply of electricity.

Keywords: Granger test, GDP, energy consumption.

1. Introduction

Energy systems have been key drivers of social and economic development. The importance of energy cannot be denied as one of the basic inputs to economic growth process. The consumption of energy has been among the critical indicators of the level of development of any country. It is observed that usually the developed countries use more energy per unit of economic output and far more energy per capita than developing countries. This reflects the adoption of increasingly more efficient technologies for energy production and utilization as well as changes in the composition of economic activities. This, largely, needs a shift in energy use [Cheng and Lai (1997)]. When this shift in the composition of final energy use is taken into account energy use and the level of economic activity are found to be tightly coupled. The prospect of large reduction in the energy use intensity of economic activity seems limited. So, the accelerated demand results in the scarcity of energy and increasing cost have severe implications for economic growth. This ever increasing role of energy in the present day scenario underlines the need to increase the supply of energy and to find some new alternative energy sources and energy conservation techniques.

In order to meet the expected growth momentum of the economy (average 4 percent over the past few years and projected to be more in the coming years), Pakistan needs a comprehensive National Energy Plan to meet her future needs [Economic Survey of Pakistan (2012)]. It is also clear that energy is one of the important inputs for production, conversion, processing and commercialization activities. Like other developing countries, Pakistan is also an energy intensive economy and as in most other non-petroleum producing countries its energy needs met by imports. The consumption of petroleum products has been increasing by an average rate of 2.5 percent per annum from 1990-91 to 2003-04. While the consumption of gas and electricity has increased at an average rate of 4.9 and 5.1 percent per annum respectively.

2. Literature Review

Productivity is closely associated with direct and indirect use of energy as an input. The relationship between energy consumption and economic growth is now well established in the literature, but the direction of causation of this relationship remains controversial. That is, whether economic growth leads to energy consumption or that energy consumption is the engine of economic growth. The direction of causality has significant policy implications. Empirically it has been tried to find the direction of causality between energy consumption and economic activities for the developing as well as for the developed countries employing the Granger or Sims techniques. However, results are mixed. The research work between the two by Kraft and Kraft (1978) supported the unidirectional causality from GNP growth to energy consumption in the case of the United States of America for the period 1947-1974. Erol, and Yu, (1987), tested data for six industrialized countries, and found no significant causal relationship between energy consumption and GDP growth. Yu, et. al. (1988), found no relationship between energy and GNP in the case of the United States. When they used the Granger method Yu,

and Chai, (1985), also found causality from energy to GDP in the Philippines, but this causality is reversed in the case of the Republic of Korea. A bi-directional causality between growth of energy consumption and GNP growth was observed in Taiwan Province of China by Hwong, et. al. (1991), while Cheng, and Lai, (1997), found causality from economic growth to energy consumption without feedback in Taiwan Province of China. A similar study would be beneficial in the case of Pakistan to design an economic policy framework for the energy and other sectors.

Like other developing countries Pakistan is also an energy intensive growing economy, and as in most other non-oil producing countries its energy needs are met by large quantities of imports. The ACGR (annual consumption growth rate) of net consumption of total energy is 6.4 percent. The share of oil, gas and electricity is 48 percent, 30 percent (of which more than half is used for electricity) and 15 percent respectively by Aqeel (2001). The share of imported oil was 92 percent of net consumption of oil in 2004-2005, which is about 44 percent of total net consumption of energy in the country. Thus to meet its growing needs of energy, Pakistan faces both energy constraints from the supply side and demand management policies. (Riaz, 1984, and Chisti and Mahmood, 1980). However, for any such policy making it is essential to determine the causal relationship between energy consumption and general economic activities. The purpose of this study is to determine such a relationship for Pakistan. This is accomplished by examining Granger Causality between growth in energy consumption and GDP growth and unit root test. The paper is organized in the following manner. First is the methodology with interpretation of primary literature, then empirical findings are presented and finally the results will be concluded.

3. Energy Sector In Pakistan

Pakistan's energy infrastructure is under-developed, insufficient and poorly managed. Presently Pakistan has been facing severe energy crisis. Despite strong economic growth and rising energy demand during the past decade, no serious efforts have been made to install new capacity of generation. Consequently, the demand exceeds supply and hence load-shedding is a common phenomenon through power shutdown (Haq and Hussain, 2008). Pakistan needs around 14000 to 16000 MW electricity per day, and the demand is approximately 21000 MW per day by 2013. Presently, it can produce about 11000 to 12000 MW per day and there is a shortfall of about 3000 to 4000 MW per day. This shortage is badly affecting industry, commerce, daily life and posing risks to the economic growth (Haq and Hussain, 2008). The overall requirement of Pakistan is about 80 MTOE in 2010, up by 50 percent from the 54 MTOE of the 2007.Ten billion TOE of energy is consumed per year worldwide compared with around 500 million TOE in 1860. During the past 25 years energy supply in Pakistan has been increased by about 40 times but still the demand outstrips supply. With the increase in economic activities, per capita energy consumption had also been increased. Industrialization, growth in agriculture and services sectors, urbanization, rising per capita income and rural electrification has resulted in a phenomenal rise in energy demand. Inefficient use of energy and its wastages has further widened the demand-supply gap and exerts strong pressure on the energy resources in the country. The annual growth of primary energy supply increased from 3.17 percent to 4.3 percent during 1997-98 to 2006-07. The share of natural gas reached to 48.5 percent, followed by oil 30.0 percent, hydroelectricity 12.6 percent, coal 7.3 percent, nuclear electricity 0.9 percent, LPG 0.5 percent and imported electricity by 0.1 percent during the year 2006-07.

The energy sector of Pakistan is poorly managed, service quality is low, theft of power and gas is rampant and most utilities are still receiving subsidies. All possible measures need to be adopted, i.e., to conserve energy at all levels, and use all available sources to enhance production of energy. It seems that the government is considering importing energy from Iran and Central Asian Republics and using indigenous sources, such as, hydel, coal, waste, wind, and solar power, as well as other alternate and renewable energy sources, besides nuclear power plants for production of energy. Needless to say that if the country wishes to continue its economic development and improve the quality of life of its people, it has to make serious efforts towards framing a coherent energy policy.

3.1 Share of Primary Energy Supply

Table 1 shows the percentage share of primary energy supply in Pakistan. It can be clear from Table 1 that energy supply in Pakistan is highly dependent on Oil and Gas, which together contributes more than 77 percent of the total primary energy supplied. Figure 1 showing pie chart of the same. The average share of gas and oil are respectively 44.36 percent and 32.58 percent during the period 1997-98 to 2006-07. The remaining sources of energy supply consist of hydro- electricity and coal and their shares in total energy supply are around 12 percent and 6 percent respectively during the corresponding period. It is now globally recognized that energy plays an important role in the production process. In Pakistan, agriculture, industry, trade and services sectors have been growing rapidly over the past few years. Given the pace of economic growth, energy demand is expected to increase. At present Pakistan meets 75 percent of its energy needs by domestic resources including gas, oil and hydroelectricity production. Only 25 percent energy needs were managed through imports and Oil taken major share alone and imported oil may likely maintain important share in the future energy mix. Natural gas has

emerged as the most important fuel in the recent past and the trends indicate its dominant share in the future energy mix (Sahir and Qureshi, 2007). To increase the pace of economic growth rate Pakistan needs to expand its energy resource base.

3.2 Commercial Energy Consumption

Table 2 highlights the percentage share of the current commercial energy consumption in Pakistan. Table 2 is showing the pie chart of commercial energy consumption. It suggests that the average percentage share of industrial sector in energy consumption is 36 percent, followed by transport sector with 33 percent, domestic with 23 percent, agriculture and commercial with 3 percent each while all others with 2 percent. Significant changes took place among the inter-sectoral patterns of energy consumption.

3.3 Per Capita Household Energy Consumption

It is clear from the Table 3 that per capita consumption of oil during 1997-98 to 2003-04 fell from 4.0 kg to 1.6 kg, whereas per capita consumption of natural gas stood constant at 1.0 (MMBtu). The per capita consumption of LPG and electricity shows an increasing trend. However, the excess demand for energy has been increasing year-by-year and creating alarming situation for the country (Looney, 2007). It is clear from the Figure 4 that of the excess demand for energy has increased overtime. The average excess demand for energy is equal to 0.48 QBtu for the period 1980-2005. According to Pakistan's Energy Security Plan (2005-2030), the total primary energy consumption in Pakistan is expected to increase seven-fold from 55 MTOE to 360 MTOE and over eight-fold increase in the requirement of power by 2030 (ISSI "The Institute of Strategic Studies", Islamabad., 2007b). Thus the country would be facing the shortage of more than 31 percent of energy in the future. In Pakistan the current energy crisis stems from the decline in hydro sources of energy and over reliance on the expansive source of electricity. Presently, oil-based thermal plants accounts for 68 percent of generating capacity, hydroelectric plants for 30 percent and nuclear plants for only 2 percent (Looney, 2007). This has led to a huge generation costs, which in turn adversely affect the economy over the past eight years. Rise in the oil prices pushing electricity tariff very high. As a result, manufacturing costs and inflation are at the rising trend, export competitiveness is eroded and the pressure on the balance of payments is increasing. These factors adversely affect the present growth trajectory of the economy (Loonely, 2007 and NBP, 2008).

3.4 Growing Demand In Pakistan

The growing demand of electricity and the forecasted generation till 2017 is estimated in table 4. The demand of electricity is growing day by day and it is expected that that the current existing generation of 15903 kWh with shortage of 849 kWh will reach to a deficit of 8023 kWh in 2017. The generation in 2010 is 18503 kWh which will be 27481 kWh in 2017. The increasing trend in demand is slower compared to the expected rising demand in summer that is currently at 19352 kWh and estimated value of 2017 is 35504 kWh. There are many factors of increasing gap in electricity in Pakistan which include different technological, managerial, economic and structural causes.

3.5 ENERGY POLICY OF PAKISTAN

The government of Pakistan has initiated an energy policy to decrease the gap between demand and supply of electricity by increasing exploration and development of indigenous oil, gas and coal production and reduction of reliance on imported energy, substitute oil with natural resources, promotion of energy sector's efficiency and a judicial balance between affordability of prices and cost of providing services. But different measures taken by previous governments are not working well because of many reasons including lack of resources for investment in rehabilitation of existing plants, lack of resource conservation, non awareness of waste minimization and volatility of international prices also influence economies.

4. Methodology

Traditionally to test for the causal relationship between two variables, the Standard Granger (1969) test has been employed in the relevant literature. This test states that, if past values of a variable Y significantly contribute to forecast the value of another variable Xt+1 then Y is said to Granger cause X and vice versa. The test is based on the following regressions.

$$Yt = \beta 0 + \beta k\ Yt{-}k + \alpha l Xt{-}1 + Ut$$
$$Xt = \gamma 0 + \gamma k\ Xt{-}k + \delta l Yt{-}1 + V\,t$$

Where Yt and Xt are the variables to be tested, and Ut and Vt are mutually uncorrelated white noise errors, and t denotes the time period and lags. The null hypothesis is $\alpha 1 = \delta i = 0$ versus the alternative hypothesis that $\alpha i \neq 0$

and $\delta i \neq 0$. If the coefficient αi's are statistically significant but δi's are not, then X causes Y and vice versa. But if both αi and δi are significant then causality runs both ways. Data on electricity production (kWh), GDP growth in percentage, electric power consumption (kWh per capita) and fuel imports (percentage of merchandize imports) has been taken from IFS (2008).

The function is given below:

EPC = f (EP, GDP, FI)
Where
EPC = Electric Power Consumption (kWh per capita)
EP = Electricity Production (kWh)
GDP = GDP growth (percent)
FI = Fuel Imports (percent of merchandize imports)

Table 5 shows the data of the discussed variables from 1991 to 2006 (IFS 2008) and figure 1 shows the multiple graphs of it.

4.1 Test for Unit Root

The degree of integration of each variable involved has been determined in our analysis, for both DF and the ADF test statistics. The results are reported in table 5. In the level form, both the DF and ADF class of unit root tests are rejected for all the variables except that for DGP. However, both the tests reject the null hypothesis of non-stationary for all the variables when they are used in the first difference. This shows that, except for GDP, all the series are stationary in the first difference, and integrated of order I (1).

Table 5. Unit root tests

	LEVEL		FIRST DIFFERENCE	
	DF	ADF	DF	ADF
EP	0.503056	0.884474	-3.11537	-3.49272
GDP	-2.37666	-2.29499	-0.82596	-0.55019
EPC	0.224919	0.458099	-3.07836	-3.48714
FI	-1.63086	-1.58483	-3.43693	-3.28849

The unit root test for stationary with DF(Dickey Fuller) and ADF(Augmented Dickey Fuller)shows that only GDP growth is stationary at level while all the other three variables are non stationary at level and can be made stationary at first level.

4.2 Granger Causality Test

Granger causality test is used to see whether there is any unidirectional or bidirectional causality between the two variables exists or not. Here are the results of the test.

Table 6 Results of Granger Causality

Null Hypothesis:	Results	F-Statistic	Probability
EPC does not Granger Cause EP	Accept	1.75025	0.22799
EP does not Granger Cause EPC	Accept	0.78538	0.48486
FI does not Granger Cause EP	Accept	0.23051	0.79868
EP does not Granger Cause FI	Accept	1.48034	0.27809
GDPG does not Granger Cause EP	Accept	0.75296	0.49847
EP does not Granger Cause GDPG	Accept	3.2259	0.08784
FI does not Granger Cause EPC	Accept	0.02484	0.97554
EPC does not Granger Cause FI	Accept	0.33814	0.72178
GDPG does not Granger Cause EPC	Accept	1.47377	0.27947
EPC does not Granger Cause GDPG	Reject*	3.9924	0.05739
GDPG does not Granger Cause FI	Accept	0.29835	0.7491
FI does not Granger Cause GDPG	Accept	1.51159	0.27165

* at 10 percent level of significance

All of the above results show that the variables are accepting null hypothesis and are insignificant at 5 percent level of significance and all variables are not granger causing each other while at 10 percent level of significance electric power consumption is granger causing GDP growth.

5. Conclusion

In this paper we attempted to find the direction of the causal relationship between energy consumption and economic activity in Pakistan. More specifically we investigated the causal relationship between growth in energy consumption and growth in GDP while causality between other variables also. The methodology was based on the Granger causality test which has been found appropriate by using the unit root test and finding out that only GDP growth is stationary at level while all the other three variables are non stationary at level and can be made stationary at first level. The estimated results infer that all variables are not granger causing each other at 5 percent level of significance while at 10 percent level of significance electric power consumption is granger causing GDP growth. The paper has important policy implications. Since Pakistan pays high oil import bill, petroleum imports were $1.53 billion in 1999/00 and in the preceding year $1.57 billion. In 2000-01 petroleum imports may be close to $2.5 billion or around 25 percent of total imports (Dawn 18-23 April 2000). Therefore, using oil more efficiently and substituting gas for oil wherever possible could be a good policy measure. The implications of the present study suggest that an energy conservation policy regarding petroleum consumption would not lead to any adverse side-effects on economic growth in Pakistan, whereas energy growth policy in the case of gas and electricity consumption should be adopted in such a way that, growth in these sectors stimulates economic growth.

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APPENDIX

TABLE 1. SHARE OF PRIMARY ENERGY SUPPLY

Primary Energy	Percentage Share
Gas	44.36
Nuclear Electricity	0.77
Hydro Electricity	12.11
Coal	5.8
LPG	0.37
Oil	32.58
Imported Electricity	0.1

Source : Energy Year Book 2009

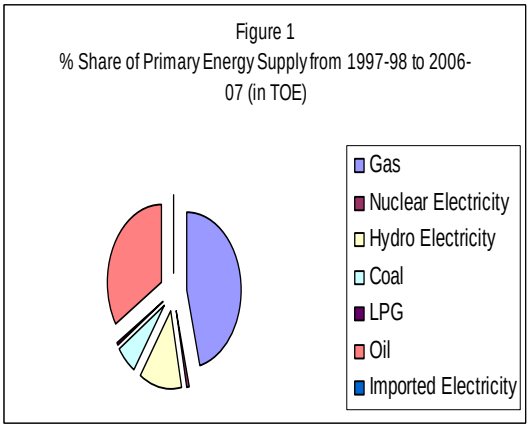

TABLE 2. COMMERCIAL ENERGY CONSUMPTION

Sector	Demand (percent)
Industrial	36
Commercial	3
Agriculture	3
Domestic	23
Transport	33
Other	2

Source : Energy Year Book 2009

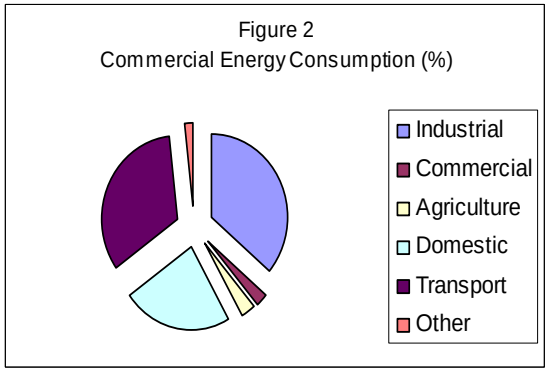

TABLE 3. PER CAPITA HOUSEHOLD ENERGY CONSUMPTION

Parameter	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
Population (in MLN)	113	133	136	140	143	147	150
Oil (kg)	4	3.8	2.6	3.3	2.4	2	1.6
Gas (MMBtu)	1	1	1	1	1	1	1
LPG (kg)	1.2	1.2	1.3	1.4	1.8	1.8	1.9
Electricity(kWh)	114	146	157	163	162	161	172

Source: Household Use of Commercial Energy (Report No. 320/06, World Bank)

TABLE 4. GROWING DEMAND IN PAKISTAN

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Existing generation	15903	15903	15903	15903	15903	15903	15903	15903
Proposed generation	7226	10115	10556	13307	13520	14607	16134	18448
Total existing	23129	26018	26459	29210	29423	30510	32037	34351
Expected generation	18503	20814	21167	23368	23538	24408	25630	27481
Demand in summer	19352	20874	22460	24126	25919	28029	30223	35504
Surplus/Deficit	-849	-60	-1293	-758	-2381	-3621	-4593	-8023

Source Private Power and Infrastructure Board, GOP

FIGURE 3 MULTIPLE GRAPHS

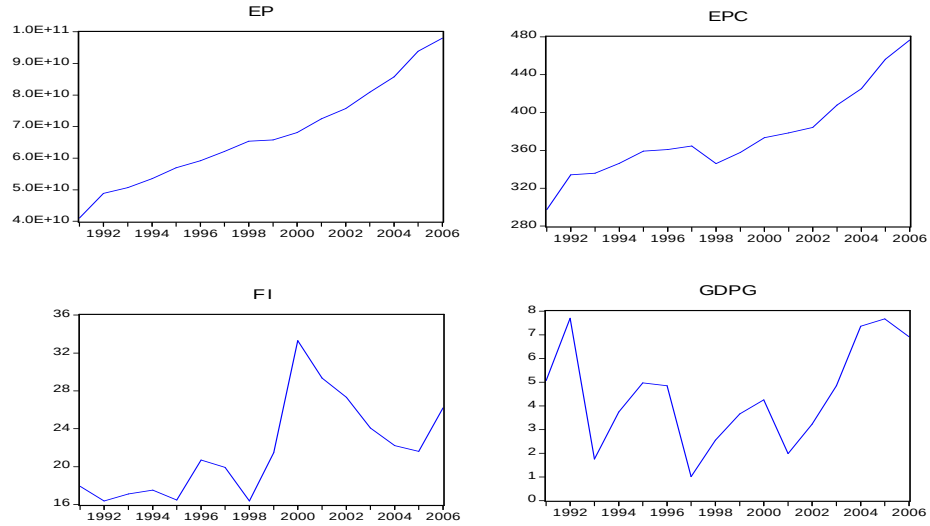

TABLE 7:

Year	EP	GDP Growth	EPC	FI
1991	4.11E+10	5.061568	297.2641	17.93979
1992	4.88E+10	7.705898	334.4254	16.39114
1993	5.06E+10	1.757748	335.7918	17.11533
1994	5.36E+10	3.737416	346.4184	17.52364
1995	5.7E+10	4.962609	359.2484	16.47468
1996	5.91E+10	4.846581	360.9844	20.69994
1997	6.22E+10	1.014396	364.7671	19.90397
1998	6.54E+10	2.550234	346.02	16.38818
1999	6.58E+10	3.660133	357.7862	21.48421
2000	6.81E+10	4.260088	373.5443	33.28765
2001	7.24E+10	1.982484	378.5857	29.34315
2002	7.57E+10	3.22443	384.1413	27.31752
2003	8.08E+10	4.846321	407.7843	24.09195
2004	8.57E+10	7.368571	425.0261	22.20864
2005	9.38E+10	7.667304	456.2245	21.59306
2006	9.80E+10	6.920301	476.5264	26.22385

Where;
EPC = Electric Power Consumption (kWh per capita)
EP = Electricity Production (kWh)
GDP = GDP growth (percent)
FI = Fuel Imports (percent of merchandize imports)