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Energy Consumption and Economic Growth: A Disaggregate Approach

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Abstract

This paper attempts to examine the long run as well as short run relationship between Pakistan's real GDP and energy consumption at sectoral level. The analysis is based on the time series data from 1977 to 2010. We estimate the DOLS cointegration to check the long run relationship. The results indicate the long run relationship between energy consumption and real GDP on aggregate level as well as in industry and services sector but no evidence is found in agriculture sector. This paper also examines the direction of causality by employing Granger causality test and found bidirectional causality between variables under study and unidirectional causality runs from real GDP to energy consumption for industrial and services sectors but result is reverse for agriculture sector.

Keywords: Energy Consumption, Economic Growth, Granger Causality, DOLS

Introduction

In economic literature, the causality between economic growth and energy consumption is a controversial debate; the major problem is to define the role of the variable which effect to other. Energy plays an important role in the economic development as well as the prosperity of economy. Business and financial economists pay a significant importance to the impact of oil and other energy prices on economic activities, but the main stream theory of economic growth pays little or no importance to the role of energy or other natural resources in enhancing or enabling economic growth (Stern 2003). Among various views regarding energy consumption and economic growth, one is that energy cause to economic growth. It enhances the productivity of factors of production, like capital and labour. It is also recognized that economic development and energy consumption are interdependent (Burnney 1995). The other considers energy as neutral to growth which is known as "neutrality hypothesis".

Pakistan is among those countries, relying heavily on imported fuel to meet the demand of its energy consumption. On the other hand over the last few years Pakistan is switching over to domestically available cheaper resources of energy from relatively expensive imported fuel.

Total energy consumption during 2009-10, was 38.8 million. The energy consumption by sector was as commercial 3.9%, domestic 21.6%, industrial 40.3%, agriculture 2.2%, transport 30.1% and other Govt 2.0 %(Pakistan Energy Yearbook 2010).

Table-1 Primary Energy Supplies by Source

Sources	2003-04	2008-09
Oil	38.5	29
LPG	1.3	1.5
Gas	34.7	43.7
Coal	9.3	10.4
Electricity	16.2	15.3

Source: Hydrocarbon Development Institute of Pakistan

In 2009-10 primary energy supply were 63.1 million TOE[1]. Primary energy supplies by source were, Oil 31.4%, Hydro, Nuclear & Imported 11.8%, LPG0.6% and Coal 7.3%
The purpose of this study is to examine the Cointegration and Granger Causality; between output and energy consumption on aggregate level as well as sectors level.
The paper is organized in the following manner. Section 2 discusses the methodology and model. Subsequent section reports the empirical results, empirical analysis and policy implications.

Fig1: Energy consumption by sources (2003-04)

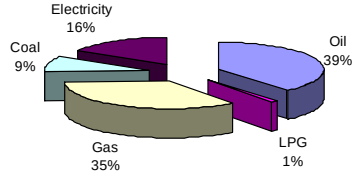
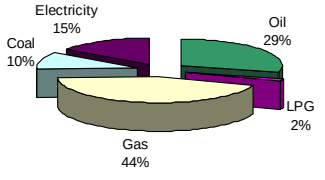


Fig2: Energy consumption by Source (2008-09)



Source: Hydrocarbon Development Institute of Pakistan

[1] Total of Oil Equivalent

Literature Review

Most of the studies used Granger causality and cointegration analysis to investigate the relationship between energy consumption and economic growth.

Masih and Masih (1996) investigated the relationship between energy consumption and the real income for seven Asian countries. Their results show a cointegrated relationship between variables for India, Indonesia and Pakistan. Moreover, they found a unidirectional causality from energy to income and from income to energy for India and Indonesia respectively. Stern (2000) used the static and dynamic cointegration analysis and found a cointegration relationship between GDP, capital, labour, and energy consumption for US economy. Hondroyiannis et al (2002) analyzed data for Greece from 1960-1996 and found the evidence of long run relationship between the real GDP, energy consumption and consumer price index. Glasure (2002) tested the data from 1961 to 1990 for Korea, by employing VECMs and found that bidirectional causality exist between energy consumption and real income. Cheng and Lai (1997) used the data from 1959-1993 for South Korea and concluded bidirectional causality exist between national income and government expenditure. Yang (2000) found bi directional causality between total energy consumption and GDP by using the Taiwan data for the period 1954 to 1997.This study indicates that different directions of causality exist between GDP and various kinds of energy consumption. Ghali and Sakka (2004) used the data of real GDP, capital, labor and energy consumption, for Canada during the period 1961-1997. The study shows a multivariate cointegration between output, capital, labour and energy consumption. Authors also found the evidence of bidirectional causality between output growth and energy consumption.

Lee and Chang (2007) applied the CBL (2005) panel data stationary tests to examine the energy consumption and output. They found bidirectional causality running

between energy consumption and GDP for developed countries. Whereas, unidirectional causality running from energy consumption to GDP in case of developing countries. Morimoto and Hope (2004) used the annual data for the period 1960-1998 of real GDP and electricity production in the case of Sri Lanka. The study indicates that the current and past changes in electricity supply have a significant impact on a change in real GDP in Sri Lanka. Dhungel (2008) tested the data of total energy consumption and real GDP for the period of 1980-2004 for Nepal and found that there is unidirectional causality running from coal, oil and commercial energy consumption to per capita real GDP, whereas a unidirectional causality running from per capita real GDP to per capita electricity consumption.

By using the data for the period 1955 to 1996 for Pakistan, Aqeel and Butt (2001) concluded that economic growth causes total energy consumption. The study further investigated that economic growth leads to growth in petroleum consumption. On the other hand, in the case of gas sector, neither economic growth nor gas consumption affects each other. In power sector, electricity consumption leads to economic growth. Lee (2005) tested the cross sectional and time series data of 18 developing countries to find the relationship between energy consumption and GDP. He concluded that energy consumption Granger causes GDP. Asafu (2000) found a unidirectional Granger causality from energy to income in India and Indonesia while bi directional causality between energy an income in the case Thailand and Philippines. By using a data for three SAARC countries, Imran and Masood (2010) found a long run relationship between economic growth and energy consumption and a unidirectional causality from energy consumption to economic growth but no causality found in short run. Jumble (2004) found that the causality running from electricity consumption to the income in the case of Turkey.

Data and Variables

The annual data on (aggregate, industrial, agricultural and service sector) real GDP is used. Energy consumption (aggregate level, industrial, agriculture and services) is used as explanatory variable. The data span the period from 1977 to 2010. Data collected from different volumes of *Economic Survey of Pakistan* and *Energy Year Book*.

Model

The present study used four separate models for aggregate level as well as for industry, agriculture and services sector. The model can be seen below.

$$y_t = \alpha_0 + \alpha_1 EC + \mu_t$$

The variables' notations and definitions are as follow

EC - Energy Consumption

Y - Real GDP

All variables are in natural log.

Methodology

Unit root tests

The variables used in the analysis exhibit trending behavior, or non stationarity in the mean. Unit root tests are used to determine the stationarity of the data. Economic and financial theory often suggests the existence of long run relationship among non stationary time series variables. If the variables are integrated *I* (1), then cointegration technique can be used to find the long run relations. Hence pre testing of unit root is the first step in order to investigate the cointegration.

Two popular tests for unit root like Augmented Dickey Fuller (ADF) and Phillips Perron test are used in the study. The null hypothesis (H_0) that a time series y_t is *I* (1) against the alternative (H_1) that is *I* (0) in both tests.

The ADF test is based on the test regression.

$$y_t = \phi y_{t-1} + \sum_{j-1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t$$

If the calculated ADF and PP statistics are less than the critical values, then the null

hypothesis (H_0) is rejected and the series is stationary.

Cointegration Test

As we have use the time series variables in our analysis which are usually non stationary in nature and integrated of order 1 or higher. Hence we cannot apply Ordinary Least Square (OLS) technique for regression because it is applicable only in the case of stationarity.

Two or more variables are said to be cointegrated, if they have the same or common trend. Different methods are used to test the cointegration between variables. However we employed Stock Watson dynamic OLS (DOLS) which have certain advantages over OLS and Johansen cointegration.

$$y_t = \alpha_o + \alpha_1 EC + \sum_{j=-q}^{p} d\Delta EC_{t-j} + u_t$$

Y_t -dependent variable

EC - energy consumption

α_1 - cointegration vector, long run effect of EC on Y

p - lag length

q - lead length

Granger Test (temporal analysis)

Granger (1969) presented the concept of causality relationship between two variables. According to Granger causality, if a variable X_1 Granger causes a variable X_2, then the past values of X_1 must have information to predict the value of X_2 other then the past values of X_2 alone.

Econometric model of Granger causality is:

$$x_{1t} = \sum_{j=1}^{p} A_{11,j} x_{1,(t-j)} + \sum_{j=2}^{p} A_{j=2} x_{12,j} x_{2,(t-j)} + \varepsilon_t$$

$$x_{2t} = \sum_{j=1}^{p} A_{21,j} x_{1,(t-j)} + \sum_{j=2}^{p} A_{22,j} x_{2,(t-j)} + \varepsilon_t$$

The null an alternative hypothesis in Granger test is as follow:

Null hypothesis: X_1 does not Granger Cause X_2

Alternative hypothesis: X_1 Granger Cause X_2

Empirical Findings

Results for unit root tests

To investigate the stationarity of the variables, this study uses the augmented Dickey- Fuller (ADF) and the Phillips Perron (PP) test. The null hypothesis, that each variable has unit root is tested against alternative hypothesis that it does not.

Table 1 reports the results of unit root of variables on level as well as on their first difference. ADF and PP tests indicate that energy consumption and real GDP are stationary at first difference even at 1 % level of significance.

Table-1 Results Unit Root Test

Sector	Variable	ADF		PP	
		level	1st Diff	level	1st Diff
Aggregate	**EC**	-2.398	-5.332*	-2.425	-5.331**
	Y	-1.634	-3.537**	-2.330	-3.537**
Industry	**EC**	-2.188	-5.573*	-2.268	-5.574*
	Y	-0.847	-7.571*	-1.148	-9.276*
Agriculture	**EC**	-3.335	-5.566*	-3.662	-5.837*
	Y	-1.578	-3.487**	-2.388	-3.548**
Services	**EC**	-3.335	-5.566*	-3.662	-5.837*
	Y	-3.081	-3.114*	-2.556	-3.140

*, ** and *** are statistically significant at 1, 5 and 10 percent respectively.

Results of cointegration

Table 2 represents the DOLS estimation results. Analysis separately conducted for aggregate level as well as for agriculture, industry and services sectors. Estimation results show that the parameter of energy consumption is statistically significant for aggregate level, industry and services sectors but not in the case of agriculture sector.

On aggregate level 1 percent increase in output will yield 1.162 percent increase in energy consumption. Similarly, 1 percent increase in output of industrial sector leads to increase 1.176 percent increase in energy consumption.

Table- 2 DOLS Estimation Results

Sector	Co-efficient	t-value
Aggregate	1.162*	34.370
Industry	1.176*	-11.390
Agriculture	-0.418	-1.434
Services	1.267*	20.947

Significant at 1 % level of significance
Dependent variable is energy consumption

Table -4 Granger test results

Null Hypothesis	Aggregate	Industry	Agriculture	Services
	F-Stat	F-Stat	F-Stat	F-Stat
EC does not Granger Cause Y	2.886***	0.928	3.114***	1.313
Y does not Granger Cause EC	2.481***	2.316***	0.2674	4.677**

** and *** are statistically significant at 5 and 10 percent respectively.

The results reported in table 4 indicate that there is bidirectional causality between real output (Y) and energy consumption (EC), on aggregate level. In the industrial and services sectors unidirectional causality runs from output to energy consumption. However the result is reverse for agriculture sector.

Summary and Conclusion

In this study we have investigated the long run and short run relationship between energy consumption and economic growth on aggregate and sectoral level. We employed the Stock Watson dynamic OLS (DOLS) technique to find long run relationship. To find the nature of time series variables, we used ADF and PP. The results show that the variables are I (1). The DOLS results show that there is long run relationship between energy consumption and economic growth on aggregate as well as on services and industrial sector. However no evidence of cointegration is found in agriculture sector. Our results support the study by Masih and Masih

Table 3- Results of Unit Root test on Residual from DOLS

Sector	ADF		PP	
	level	1st Diff	level	1st Diff
Aggregate	-2.44	-5.21*	-2.49	-5.21*
Industry	-1.50	-10.84*	-3.76*	-11.75*
Services	-1.85	-3.81*	-0.64	-3.83*
Agriculture	-0.94	-6.23*	-0.94	-6.21*

Note: dependent variable is residual

In table 3 reported results of ADF and PP unit root test conclude that residual from cointegration regressions are stationary. Therefore, cointegration regressions are not spurious.

(1996), Stern (2000) and Imran and Masood (2010). In order to find the short run relationship, we employed the Granger (1969) technique. Reported results indicate bidirectional causality runs from GDP to energy consumption on aggregate level. In the industrial and services sector causality runs from GDP to energy consumption. However the results are reverse in the case

of agricultural sector in which causality runs from energy consumption to economic growth. Our results are similar to Yang (2000) and Ghali and Sakka (2004).

Pakistan is a growing economy uses extensive amount of energy. The results of our study show the long run as well as short run relationship between energy consumption and economic growth. We can enhance our production capacity and hence employment by increasing energy supply. It will increase our export and decrease the trade deficit. As a result our currency will be strengthened. The government should take necessary action to install new equipments and machinery in this regard and move to alternative source of energy.

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