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Causal relationship between energy consumption and economic growth: evidence from Pakistan

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ABSTRACT

This paper examines the causal relationship between energy consumption, economic growth and prices evidence from Pakistan by using the annual time series data from 1980 to 2011. Co-integration, Engle Granger test and Error correction techniques are used to achieve the objective. The empirical results of co-integration test shows that energy consumption and economic growth are cointegrated. In addition, causality test results reveal that there is a short-run and long-run Granger causality running from economic growth to energy consumption for Pakistan. The empirical results of this study provide policy makers a better understanding of energy consumption-economic growth relationship to formulate energy policies in Pakistan. In this study, economic growth cause energy consumption, it suggests that the implementation of energy conservation policies may be implemented with little or no adverse effect on economic growth. Therefore, there is relatively more scope for energy conservation measures as a feasible policy in Pakistan.

Introduction

The energy sector plays an important role in the development and growth of any country and satisfactory supply of energy is must to produce economic activities. The main objectives of energy sector are ensure enough, and gainful supplies utilizing the resources competently and minimize it loses, because of its central significance to economic growth and development. Today energy is considered as a fourth major sector of the economy. The world is facing the growing an energy demand with a double digits. The demand for energy put pressure on people around the world to explore new vistas for energy and think beyond the available sources of energy. Exploring new renewable energy sources has become more important to lead the world towards a more secure, reliable and sustainable energy path. Energy is the key determinant of economic development and prosperity of society. It also provides an impetus for keeping sustainability in economic growth.

Pakistan is among those developing countries where facing an unprecedented energy crisis for past few years as the demand and supply gap widens. Its current energy demand exceeds its indigenous supplies fostering dependency on the imported oil that put substantial burdens on the economy. Energy availability and consumption play a key and crucial role in the process of economic growth. The consumptions of energy are associated with growth and the expansion of industrial sector. Therefore, energy consumption is a key to industrialization and the development of industrial infrastructural facilities. Moreover, the usage of energy is necessary input for the economic growth and is also function of growth.

The aim of this paper is to explore causal relationship between the energy consumption and economic growth in term of real GDP for Pakistan.

Literature Review

Masih (1996) used the cointegration techniques to study the causal relationship between energy consumption and economic growth in a panel of six Asian countries and found cointegrated relationship between these energy consumption and economic growth in India, Pakistan and Indonesia but no integration is found in Malaysia, Singapore and Philippines. He found the direction of causality from energy consumption to GDP in India, and from GDP to energy consumption in Pakistan and Philippines.

Medlock and Soligo (2001) examined economic development and end-use energy demand using panel data consisting of 28 countries. They constructed a “map” of energy use by sector during the course of economic development. They used development map to project possible future growth in energy demand by end-use sector, and determined the composition of final energy consumption as a function of the level of development. They found that industrial energy demand increases most rapidly in the initial stages of economic development, but growth slows steadily throughout the industrialization process.

Oh and Lee (2004a) used four variables (energy consumption, GDP, capital, and labor) from the supply side and three variables (energy consumption, GDP, and price) from the demand side in their multivariate Granger causality analysis to investigate the relationship between energy consumption and GDP in South Korea during the period of 1981:1–2004:4. They also employed the VEC model to distinguish between a long run and short run relationship among the variables and to identify the source of causation. In the short run, no causality was detected; however, GDP led energy consumption in the long run. Therefore, the government in South Korea can pursue conservation energy policy in the long run without compromising economic growth.

Siddiqui (2004) estimated the standard production function for Pakistan and included different proxies for energy from different energy sources applying Granger Causality and ARDL test. She found that the energy consumption cause economic growth.

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Alinsato, A., S (2008) studied the Electricity consumption and GDP for the electricity community of Togo and Benin by using the bound testing cointegration and Granger-causality tests. They explored long- and short-run Granger causality running from GDP to electricity consumption for Benin and short-run Granger causality running from GDP to electricity consumption for Togo. They found the Benin and Togo economies that are less dependent on electricity. They conclude that the causality is not running from the electricity to GDP because the wastage of electricity would not affect the future economic growth in community.

Lee (2005) explored the panel estimation techniques to 18 developing countries, including sub- Saharan African Kenya and Ghana, and finds evidence of causality running from energy consumption to GDP.

Zou and Chau (2006) found no cointegration between oil consumption GDP and prices, in China for the period of 1953-2002. Due to liberalization of China's economy in 1984; they separate these periods into 1953-1984 and 1985-2002. They found relationship between oil consumption, GDP and prices. In 1953-1984 periods, they found no causality between oil consumption and GDP in the short run; conversely, they found bidirectional causality in the long run. In 1985-2002 period; in short run they found unidirectional causality from oil consumption to GDP, however, in long run there is bidirectional causality as 1953-1984 period.

Erdal, G et al (2008) investigated energy consumption economic growth relation disaggregates using oil and electricity consumption for energy consumption for 1970-2003 periods in Turkey. They employed Bounds test approach by Pesaran *at, al* (2001) for cointegration relationship. Co-integration test results found that in short run both oil consumption and electricity consumption has positive and statistically significant effect on economic growth, in long run oil consumption has also positively effect on economic growth while electricity consumption has negative effect.

Lee *et, al* (2008) used a panel error correction model to examine the short run and long-run causality between energy consumption and economic growth for a panel of 22 OECD countries. They found a bidirectional relationship between energy consumption, capital stock, and GDP.

Wolde Rufael (2009) examined the relationship between energy consumption and economic growth in African countries. He also found evidence of causality running from economic growth to energy consumption in Egypt, Ivory Coast, Morocco, Nigeria, Senegal, Sudan, Tunisia and Zambia.

Chali Nond *et al* (2010) investigated the long-run relationship between energy consumption and GDP by using panel data techniques for a panel of 19 African countries (COMESA) based on annual data for the period 1980-2005. They examined the degree of integration between GDP and energy consumption and found long-run relationship between energy consumption and GDP; Further, they concluded that the reveal that causation runs from energy consumption to GDP for low income COMESA countries.

Apergis and Payne (2009, 2010) examined the causal relationship between energy consumption and economic growth for a panel of 11 countries of the Commonwealth. They found unidirectional causation from energy consumption to economic growth in the short-run, and a bi-directional relationship between energy consumption and growth of real output in the long-run.

Odhiambo (2010) examined the relationship between energy consumption and economic growth in three sub-Saharan African countries, namely South Africa, Kenya and Congo (DRC). He found evidence of unidirectional causality running from economic growth to energy consumption in Congo (DRC). He therefore suggested that the energy conservation policy is feasible to be implemented in this country because the economy in this country is not energy dependent.

Ozturk.I and Kalyoncu.H (2010) studied the energy consumption and economic growth relationship. They used the panel data of energy consumption and economic growth for 51 countries from the period 1971-2005. They divided the countries into different groups like low income group, high income group and upper middle income group countries. First they investigated the relationship between energy consumption and economic growth by employing the Pedroni (1999) panel cointegration method. Secondly, they test panel causality between the energy consumption and economic growth. The found that energy consumption and GDP are cointegrated for all three income group countries. And long-run Granger causality running from GDP to EC for low income countries and there is bidirectional causality between EC and GDP for middle income countries. Finally they concluded that there is no strong relation found between energy consumption and economic growth for all income groups' countries.

Phung Thanh Binh (2011) investigated the energy Consumption and Economic Growth for Vietnam. He used the per capita energy consumption and the per capita GDP for the 1976-2010 by using the threshold cointegration and vector error for causal relationship. He found that there is a strong unidirectional causality running from LPCGDP to LPCEC, but not vice versa. It is also found that the effect of LPCGDP on LPCEC in Vietnam is time-varying before and after the structural breakpoint, 1992. He concluded that the results are strongly support the neoclassical point of view that energy consumption is not a limiting factor to economic growth in Vietnam.

Lau. E et al (2011) investigated the impact of energy consumption on economic growth. They re-examine the direction of causality by using the panel data, between energy consumption (EC) and the gross-domestic product (GDP) for seventeen selected Asian countries. They found that long-run stable equilibriums in these countries and the EC positive impact on GDP. Causality runs from EC to GDP in the short-run, while the long-run causal linkage exists from GDP to EC. They concluded that energy is a force for economic growth in the short-run, but in the long-run, the EC is fundamentally driven by economic growth. And efficient coordination and cooperation towards the implementation of energy conservation policies to support sustainable economic development should be in the regional agenda.

Ozturk, I et al (2011) examined the causal relationship between energy consumption and economic growth for Turkey during 1971–2006. They employed two multivariate models, demand and production model, based on vector error correction model. Then, they tested Granger causality after finding cointegration among variables for the both models. They found that energy consumption and economic growth are cointegrated and there is bidirectional causality running from energy consumption to economic growth and vice versa. This means that an increase in energy consumption directly affects economic growth and that economic growth also stimulates further energy consumption. They concluded that energy is a limiting factor to economic growth in Turkey and, hence, shocks to energy supply will have a negative impact on economic growth and vice versa.

Abid, M. and Sebri, M. (2012) studied the energy Consumption-Economic Growth Nexus at aggregate Level in the economy as well as for industry, transport, and residential sectors for Tunisia for the period 1980-2007. They investigated causal relationship between energy consumption and economic performance for the total economy as well as for the different sectors. They used the application of Vector error correction model (VECM) for non-stationary. They empirical results suggest that causality directions at aggregated and disaggregated levels are mixed. However, the findings have important policy implications. While at the level of the total economy, energy plays an important role in development of Tunisian economy, it seems not to have an impact on economic performance at sectoral level.

Farhani, S and Ben Rejeb J. (2012) investigated the Energy Consumption, Economic Growth and CO2 Emissions for fifteen MENA countries by using the Panel Data from 1973 to 2008. They investigated the causal relationship between economic growth energy consumption, (GDP) and CO2 emissions we propose to pass firstly by the identification of the data and the descriptive statistics and secondly by four analysis such as the panel unit root analysis, the panel cointegration analysis, the panel causality analysis and the use of the methods FMOLS (Fully Modified OLS) and DOLS (Dynamic OLS). They found that there is no causal link between GDP and EC; and between CO2 emissions and EC in the short run. However, in the long run, there is a unidirectional causality running from GDP and CO2 emissions to EC.

From above studies it is finding that the availability of energy for economic agent, able to produce some things and it play an important role in economic growth and development. The previous studies suggest that the energy crisis breakdown the economic activities. Energy services such as lighting, heating, cooking, motive power, mechanical power, transport and telecommunication are essential for economic growth and development. Most of the developing countries obtain the poor energy services large amount of financial resources need to mobilize for expanding energy investment. The role of energy and cost of energy services should be factored into overall national income and social development, including the poverty reduction. From the above analysis it is concluded that there is causal relationship between the energy consumption and economic growth and vice versa.

Data and Methodology

In order to exams the causal relationship between energy consumption, economic growth and prices we used the time series econometrics procedure, whether energy consumption will affect the economic growth and prices or is it economic growth drive the more demand for the more energy consumption in the economy. The modeling strategy adopted in this paper is based on the following steps.

The first steps involved stationery process whether check the order of integration in all variables by using the augmented Dickey Fuller (ADF, 1981), and Phillips Perron (PP, 1988) tests.

The second step involved the existences of long run relationship between energy consumption energy prices and the economic growth by using the Johansen (1988) and Juselius (1990) test to investigate the existences of long run relationship between the variables. The Johannes con integration test has desirable properties that include the all test variables are treated as endogenous variables. The third step involved if the co integration is conform then the residual are saved from the regression and can be used to estimate the Vector error correction model (VECM). The VECM will access to direction of causality between the energy consumption, economic growth and prices.

Data and Source of Data

The annual data covering the period 1980 to 2011 were used in this study. All the data are obtained from the International Financial Statistics (IFS CD) and World Bank, and economic surveys of Pakistan. Yearly data on energy is represented by energy use in thousand tons of oil equivalents (ktoe). Data on real gross domestic product (GDP) are based on Purchasing power parity (constant 2000 LUC). The consumer price index is used as a proxy for energy price (2001 as base year). All these variables are transformed into the logarithm before the analysis.

Model specification

Simple multivariate framework, as following

$$E = f(Y, P) \dots\dots\dots\dots (1)$$

Where E, is the energy consumption, Y is the Real GDP and P is the energy price which is the proxy by the consumer price index.

The following VECM model is used to investigate the causal relationships between energy consumption and economic growth.

$$\Delta LnEC_t = \beta_1 \Delta LnEC_{t-1} + \beta_2 \Delta LnY_t + \beta_3 \Delta LnY_{t-1} + \beta_4 \Delta LnP_t + \beta_5 \Delta LnP_{t-1} \varphi ECM_t + \epsilon_t \dots\dots\dots\dots\dots (2)$$

$$\Delta LnY_t = \beta_1 \Delta LnY_{t-1} + \beta_2 \Delta LnEC_t + \beta_3 \Delta LnEC_{t-1} + \beta_4 \Delta LnP_t + \beta_5 \Delta LnP_{t-1} \varphi ECM_t + \epsilon_t \dots\dots\dots\dots\dots (3)$$

$$\Delta LnP_t = \beta_1 \Delta LnP_{t-1} + \beta_2 \Delta LnEC_t + \beta_3 \Delta LnEC_{t-1} + \beta_4 \Delta LnY_t + \beta_5 \Delta LnY_{t-1} + \varphi ECM_t + \epsilon_t \dots\dots (4)$$

Here,

$LnEC_t =$ Log of Energy Consumption (commercial energy use in kilograms of oil equivalent in local currency unit) per capita estimated by World Bank.

$LnY_t =$Log of Real Gross Product (GDP) (real income, defined as GDP in constant 2000 prices

$LnP_t =$ Log of Price energy price were not available so the variable is proxy by the consumer Price index CPI (the consumer price index CPI. 2000s100)

ϵ_t Error term and Δ The differences operator, the ECM is lagged error correction term derived from the long run co integrating relation and error term assume to be uncorrelated and random with mean zero. The coefficient of ECM measures the speed of adjustment and derived from the long run co integrating relation i.e.

$$LnE_t = \lambda_1 lnY_t + \lambda_2 lnP_t + \mu \dots (5)$$

Where, μ is the stationary residual. In the VECM the right hand side variables are regressed against the past value of itself and past value of others variables. The equation no (2) will be used to test causation from the income and price to energy consumption. The equation (3) will be used to test the causality from energy consumption and price to income, where equation (4) will test causality from the income and energy consumption to price. The vector error correction model captures both short run and long run relationship.

Empirical Results

The degree of integration of each variable involved has been determined in our analysis, based on equations 2, 3 and 4 for both PP and the ADF test statistics respectively. The results are reported in table 1. In the level form and differences, both the PP and ADF class of unit root tests are rejected for all the variables. 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, that all the series are stationary in the first difference, and integrated of order I(1).

Table 1. Results of Unit Root Tests

	Augmented Dickey Fuller Test (ADF)		Phillips Perron Test (PP)	
Level				
Variables	Intercept	Intercept & Trend	Intercept	Intercept & Trend
EC	-1.9803	-1.9815	-2.0576	-1.9929
	(-0.293)	(0.586)	(-0.262)	(-0.507)
GDP	0.49592	-2.4922	0.66135	-2.6718
	(-0.986)	(0.322)	(-0.989)	(-0.245)
P	-2.1481	-2.0838	-2.2282	-2.1143
	(-0.225)	(0.538)	(-0.202)	(-0.517)
First Difference				
ΔEC	-4.7249	-4.8979	-4.7249	-4.8873
	(-0.08)*	(0.012)*	(-0.08)*	(-0.07)*
ΔGDP	-4.8117	-4.7848	-4.7495	-4.7452
	(-0.06)*	(-0.04)*	(-0.07)*	(-0.08)*
ΔP	-5.4445	-5.5614	-5.4449	-5.5664
	(-0.01)*	(-0.05)*	(-0.01)*	(-0.05)*

Notes: Figures in the parentheses are p- value. (*) indicate 1%, and (**) 5% level of significance, respectively.

In above table (1) columns 1 and 2 report the Augmented Dickey Fuller test and Phillips-Perron test, whose null hypothesis is the existence of a unit root test. The results show that the null of a unit root in both tests cannot be rejected in any of the relevant variables in their level. However, upon taking first differences, the null of unit roots is rejected mostly at the 1% significance level. Therefore, it is concluded that all the series are non-stationary and integrated of order one, I(1) over the sample under consideration.

Cointegration Analysis

The variables which have been tested for the order ````of integration and found to have the same order are used to estimate cointegration regression given the small size sample the lag length was chosen to be equal to 2. Table 2 reports the results Johannes cointegration test where find that the some cointegrated order.

Table 2. Results of Johansen Co-integration Tests

Hypothesized no. of CE(s)	r=0	r≤1	r≤2
Trace statistics	36.36	13.14	3.701
Hypothesized no. of CE(s)	r=0	r≤1	r≤2
Maximum eigen value statistics	0.56	0.28	0.12

Note: Trace test indicate that 2 cointegrating equation at the 0.05 level

The results of the co-integration tests for the relevant variables are shown in above Table 2. The empirical results of Johansen trace statistics and Johansen maximum eigenvalue statistics suggest evidence in favor of a long-run relationship between energy consumption, economic growth and energy prices, at the 0.05% level of significance. Therefore, there appears to be clear evidence that there is one cointegrating equation. Since all the variables are I(1) and there is evidence of co-integration, this implies the existence of causality, at least in one direction. However, it does not indicate the direction of causality. Therefore, to identify the direction of the causal relationship, the Granger causality test is performed in the vector error correction model (VECM).

Engle Granger Causality Test

The below output shows that short run and long run relationship between the energy consumption, economic growth and prices. The empirical result suggests that there is exist a long run relationship between the three series. The following estimations are based on equations 2, 3, and 4, are able to reach the results Engle Granger causality test reported in above table 3. Table 3 presents the results of causality test based on the VECM framework. The test, which is referred as the short-run causality test, is conducted using a joint F-statistic. With regards to the long-run causality test, it is supported by the coefficient of the lagged error-correction term.

Table 3. Granger Causality Results

Dependent Variables	Sources of causation (independent variables)			
	Short Run			Long Run
	$\Delta lnEC$	$\Delta lnGDP$	ΔlnP	ECM
$\Delta lnEC$		(-0.04)	-0.05)*	(-0.01)*
		[2.4]	[3.1]	[4.1]
$\Delta lnGDP$	(-0.7)*		(-0.02)	(-0.03)*
	[5.8]		[-3.4]	[-2.9]
ΔlnP	-0.04)*	(-0.04)*		(-0.01)*
	[-2.8]	[3.3]		[2.3]

Notes: Figures in the parentheses ( ) and [ ] are p- value and t-statistic. (*) indicate and 1%, (**) 5% level of significance, respectively.

The results indicate that economic growth causes total energy consumption as shown by the total energy equation and vice versa. However, the table also indicates that energy consumption causes economic growth and vice versa. Therefore, there is evidence that unidirectional causality runs from income to energy consumption, which implies that economic growth stimulates energy consumption in Pakistan. Economic growth and energy consumption also have an impact on energy prices. Moreover, as economic growth is boosting energy consumption the later is also causing generation of employment in the economy as well.

Conclusion

This study examines the link between energy consumption and economic growth for Pakistan from the period 1980 to 2009. In order to avoid biases associated from the bivariate causality analysis, the study incorporates prices as additional variables to be considered in the energy-growth relationship. We employed the time series technique, unit root, cointegration and Granger Causality test based on the VECM framework.

The empirical results of co-integration test show that energy consumption and economic growth are cointegrated. In addition, causality test results reveal that there is a short-run and long-run Granger causality running from economic growth to energy consumption for Pakistan. The empirical results of this study provide policy makers a better understanding of energy consumption-economic growth relationship to formulate energy policies in Pakistan. In this study, economic growth cause energy consumption, it suggests that the implementation of energy conservation policies may be implemented with little or no adverse effect on economic growth. Therefore, there is relatively more scope for energy conservation measures as a feasible policy in Pakistan. The findings of this study have important policy implications and it shows that this issue still deserves further attention in future research.

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