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Energy Consumption, Economic Growth and CO_2 Emission Nexus in Pakistan

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ABSTRACT

The basic objective of this study is to empirically examine the relationship among energy consumption, economic growth and Carbon Dioxide (CO_2) emission in Pakistan. The study utilized annual time series data during the period ranging from 1975-2013. The Augmented Dickey Fuller (ADF) unit root test was employed to check the stationarity and results found are non-stationary at level and become stationary at first difference. The Johansen cointegration and vector error correction model techniques have been applied for empirical investigation purpose. The results of vector error correction model verify the long run relationship among energy consumption, economic growth and CO_2 emission. The finding of the study suggests that although on one hand increase in energy consumption boost economic growth while, on the other hand, it also reason to escalate CO_2 emission which trigger environmental problems in Pakistan. The increase in use of green and renewable energy is good option to reduce the effect of CO_2 on environment and sustainable growth and development in Pakistan.

Key words: Energy consumption, growth, CO_2, environment, Pakistan, JEL classification, O40, O53, Q43, Q50

INTRODUCTION

The present issues in energy consumption are escalate, consequently these issues attracting economist and policy makers to solve these problems. The economic growth performance of South Asian countries is rapidly increasing with the annual growth rate 5-7%. The energy consumption also increasing and raise the numerous issues in South Asia. There are various economic policy have been implemented by these countries to make sure sustainable economic problem. Nevertheless, it is difficult to achieve ultimate goal of sustainable development in the presence of environmental issues arise by energy consumption.

There are several studies (Liang, 2011; Cao *et al*., 2011; Zachariadis, 2007) discussed the issue of energy consumption and economic growth. Energy consumption is essential and back bone in the production sector and production is back bone of economic development. Numerous studies (Francis *et al*., 2010; Squalli, 2006) investigated that there is significant correlation between energy consumption and economic growth. Jumbe (2004) explored the relationship between energy consumption and economic growth. The results of causality witness the causality between energy use and economic growth. Thus, short fall in energy may threaten economic growth. In addition, Belke *et al*. (2011) explained that before formulate energy protection policies it is necessary to

examined energy consumption influence on economic growth. The clear result of relationship between energy consumption and economic growth is helpful in designed energy conservation policies. Nevertheless, policies will not be sufficient if the effect of energy consumption in the environment is not considered.

Increase in energy consumption cause environmental issues by produces CO_2 emission. Studies (Sathiendrakumar, 2003; Fong *et al*., 2007; Menyah and Wolde-Rufael, 2010; Peng and Sun, 2010; Apergis and Payne, 2009; Hamit-Haggar, 2011) founded that energy consumption critically affect the environment and environmental issues hurdle in economic development. Sathiendrakumar (2003) explored some policies to protect environment while enhancing economic growth. He supports the greenhouse gas emission which causes friendly environment and healthy ecosystem. Similarly, Jalil and Mahmud (2009) argued that increase in energy consumption simultaneously boost economic growth and hazard environment, hence hamper economic development. In the recent years it is now more difficult to simultaneously reduce energy consumption and enhance economic development (Islam *et al*., 2009). Furthermore, Menyah and Wolde-Rufael (2010) suggested that South Africa have to reduce energy consumption to decrease the CO_2 emission. He argued that increase energy consumption cause more environmental issues as compare to benefits of increase economic growth. However, Peng and Sun (2010) founded that it not possible to reduce energy consumption to encounter CO_2 because energy consumption strongly associated with economic growth. These results show that economic development of highly energy consumption countries may affect by unfavorable policies. With the background of these findings, the present study have objective to explore the relationship among energy consumption, economic growth and CO_2 emission in case of Pakistan.

The perpetual increase in energy consumption and the continuous increase in CO_2 emission in Pakistan motivate to investigate the relationship among energy consumption, economic growth and CO_2 emission in Pakistan.

Table 1 reported the trends of energy consumption, CO_2 emission and economic growth in Pakistan from 1980 to 2012. Energy consumption was increased significantly from 1980-2012 and there is no decrease in this period. Energy consumption in Pakistan was 24,759.68 kt in 1980 and increased 30.32% in 1985 and increased up to 242.67% in 2012. CO_2 emission also show significant increasing trend from 1980-2012. CO_2 emission recorded 32,067 kt in 1980 and only after five years increased 47.11% in 1985 and increased 403.30% after 32 years in 2012. This significant increasing trend in CO_2 emission is alarm for environmental issues in Pakistan. In 1980 economic growth in Pakistan recorded 10.22% which decrease 34.65% in 1985. In case of economic growth of Pakistan it does not show constancy during the period of 1980-2012. In addition, economic growth in Pakistan does not increase as increased energy consumption because of the supply shortfall in the energy.

It is believed that energy is the helping hand of every economy because it an essential input to support commercial, domestic and industrial activities. While, unfortunately, energy shortfall and

Table 1: Energy consumption, CO_2 emission and economic growth in Pakistan

Variables	1980	1985	1990	2000	2012
Energy consumption*	24,759.68	32,266.92	42,857.23	64,066.69	84,844.56
CO_2 emission (kt)	32,067.92	47,175.96	68,565.57	106,449.34	161,395.67
Economic growth (%)	10.22	7.59	4.46	4.26	4.02

*Kt of oil equivalent

deficiencies is continuously going on from almost a decade in Pakistan. The Government of Pakistan Economic Survey (GoP., 2014) also notes that energy interruptions and energy scarcities not merely result in damage of economic growth, development and employment but undesirably distress social condition of the society. The survey has further shown that since 2007 energy crisis in Pakistan had been appearing and expanded in 2012 which vastly destructively affected the economic growth and development, where consequently unemployment increased. The government of Pakistan though understood the energy problems faced by the country and making some efforts to solve the energy problems. Apparently, on one hand, energy consumption in Pakistan is absolutely more because the total population of Pakistan is nearly 190 million. While, on the other hand, the current energy production shortfalls and remained unable to fulfill country's demand. Therefore, based on the significance of energy, the aim of this study is to quantitatively examine the relationship among energy consumption, economic growth and CO_2 emission in of Pakistan. We use time series annual data during the period ranging from 1975-2013. Hope, this is the fresh study on the subject topic under the study. Further, this study will not only contribute to the energy and economic growth literature but also will guide the policy makers to chalk out right, effective and appropriate policy in order to improve energy system in Pakistan.

The prior studies used different econometric techniques to investigate the relationship among energy consumption, CO_2 emission and economic growth. Numerous researchers (El-Din, 2004; Squalli, 2006; Zachariadis, 2007; Ighodaro, 2010; Hong, 2010; Shahiduzzaman and Alam, 2012) explored the relationship between energy consumption and economic growth.

El-Din (2004) studied the long run elasticity of total energy consumption from 1980-1999 in Jordan. The results claim that income elasticity of demand for total energy consumption is 1.16, which show that economic growth associated with energy consumption. Furthermore, Squalli (2006) studied consumption of electricity and growth in OPEC member's countries. The results of Bound test indicate that increase in consumption of electricity cause economic growth in five countries, dependent in three countries, less dependent in four countries and independent in two countries from 1980 to 2003. Similarly, Zachariadis (2007) studied G-7 member's countries in energy consumption perspective. The study applied Autoregressive Distributed Lag (ARDL) model during 1960-2004 and found long run relationship between energy consumption and economic growth in G-7 countries. In addition, Ighodaro (2010) utilize time series data from 1975 to 2005 in case of Nigeria. The results of Johansen cointegration claim that there is long run relationship between health expenditure, energy consumption and economic growth. Further results of Granger causality prove the unidirectional causality between energy consumption, oil production and economic growth in case of Nigeria. However, Hong (2010) explored the long run and short run equilibrium between energy consumption and economic growth during the period 1953-2007. The result of cointegration test indicates that there is long run equilibrium between energy consumption and economic growth. The results of Granger causality witness that energy production and energy consumption cause economic growth. Shahiduzzaman and Alam (2012) used time series data from 1960-2010 in case of Australia and found that there is causal relationship and bidirectional causality between energy consumption and economic growth.

Numerous studies (Enevoldsen *et al*., 2007; Wolde-Rufael, 2004; Liu and Liu, 2011; Huang and Lu, 2011; Hussain *et al*., 2012; Hamit-Haggar, 2011) explored the causality among energy consumption, CO_2 emission and economic growth. Enevoldsen *et al*. (2007) explored the effect of energy price and tax on the energy efficiency and CO_2 emission of 10 industrial sectors in the three

Scandinavian countries. The study utilizes trans log factor demand estimation for a cross-industry pooled model and fixed effects. The results show that higher long term elasticity is more effective for industries. The results also indicated that energy tax is an important instrument for decoupling economic growth and CO_2 emission. The application of the own and cross elasticity to individual fuels contribute to the alleviation of CO_2 intensity.

Similarly, Wolde-Rufael (2004) investigated the causality among economic growth, CO_2 emission, energy consumption, capital flow and labour in case of South Africa from 1965-2006. The results reveal that a unidirectional Granger causality exists from CO_2 emission to economic growth. In addition, Liu and Liu (2011) investigated the long run relationship and causality among energy consumption, economic growth and CO_2 emission from 1985-2008. The results of ARDL model confirm the long run positive relationship between energy consumption and CO_2 emission and long run negative relationship between economic growth and CO_2 emission. Further results indicate that there is causality run from energy consumption to CO_2 emission and energy consumption to economic growth. However, Huang and Lu (2011) applied Johansen cointegration and VECM to investigate the causality between economic growth and CO_2 emission. In this study annual time series data from 1953 to 2008 of China was used. Empirical findings show that GDP Granger causes CO_2 emission with no feedback. In both the long and short term, an increase in GDP in China corresponds to an increase in CO_2 emission.

Furthermore, Hussain *et al.* (2012) studied the relationships between environmental pollution, economic growth and energy consumption per capita using the Johansen co-integration VECM and Granger causality. These researchers argued that a unidirectional causality exists between CO_2 emission per capita and GDP per capita. The study also found that the time series data is stationary and that CO_2 emission per capita does not affect economic growth but affects energy consumption per capita. Similarly, Hamit-Haggar (2011) used Fully Modify Ordinary Least Squares (FMOLS) and Vector Error Correction Model (VECM) to explore the long run causal relationship between energy consumption, greenhouse gas emission and economic growth in Canada from 1990-2007. The results of FMOLS confirm the long run relationship among all variables where VECM witness the causality run from energy consumption and economic growth to greenhouse emission.

The forgoing empirical studies indicate that a fresh inclusive study is required in order to further investigate the relationship among energy consumption, CO_2 and economic growth.

METHODOLOGY

Data description and empirical methodology

Data source: The annual time series data of Pakistan for energy consumption, CO_2 emission and economic growth from 1975 to 2013 were collected from World Bank database 2014. The CO_2 emission and energy consumption is calculated in kilo Tones (kt) where economic growth was measure in percentage.

Model specification: Support with prior literature and theoretical framework the long run relationship between CO_2, energy consumption emission and economic growth is shown in following Eq. 1:

$$CO_2 = f(EC, Y) \quad (1)$$

Where:
CO_2 = Carbon dioxide
EC = Energy consumption
Y = Economic growth

According to Eq. 1, CO_2 is the function of EC emission and Y. After taking natural log (ln), Eq. 1 has been transformed into Eq. 2:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln EC_t + \beta_2 \ln Y_t + \varepsilon_t \quad (2)$$

where, β_0 is intercept, β_1 (i = 1, 2) are coefficients and ε_t is an error term.

Method: This study applied ADF unit root test to check the stationarity of each variable. Further cointegration approach used to explore the long run relationship among all variables. This study utilized cointegration approach to confirm the long run relationship among CO_2 emission, energy consumption and economic growth. Furthermore, Granger causality applied to explore the causality among all variables. Before apply cointegration test and Granger causality it is necessary to confirm the stationarity of each variable.

Stationary test: The ADF unit root test was applied to determine the stationarity and level of integration I (0) or I (1). Each of the series tested at level and first difference. Consider the Eq. 3 below:

$$\Delta Y_t = \alpha_1 + \alpha_2 t + \gamma Y_{t-1} + \beta \sum_{i=1}^{N} \Delta Y_{t-1} + \varepsilon_t \quad (3)$$

where, Y is dependent variable, Δ is indicate difference, t is time trend, N is number of lagged term and ε is error term, α_1 α_2... are parameters have to be estimated. The H_0 of no unit root test is rejected and H_1 of unit root is accepted if the stationarity test is significant. However, null hypothesis of no unit root test is accepted and alternative hypothesis rejected if the stationarity test is not significant.

The hypothesis can be presented as follow:

$$\text{Null hypothesis } (H_0): \gamma = 0 \text{ (unit root/non stationary)} \quad (4)$$

$$\text{Alternative hypothesis H1: } \gamma \neq 0 \text{ (no unit root/stationary)} \quad (5)$$

Cointegration test: Cointegration test was applied to examine the relationship among energy use, CO_2 emission and economic growth. Consider the Eq. 6 the VAR, with X_t defined as the log of proposed variables:

$$X_t = c + \sum_{i=1}^{N} T_i \Delta X_{t-i} + \varepsilon_t \quad (6)$$

The VAR in Eq. 6 is not stationary if X_t is I (1) and if there is no cointegration than it is difficult to test statistical inference by regular test. Consider Eq. 7 below:

$$\Delta X_t = c + \sum_{i=1}^{N} T_i \Delta X_{t-i} + \varepsilon_t \quad (7)$$

Integration vector give rise to the stationary variables. In such condition the VAR mentioned in Eq. 7 can be written as:

$$\Delta X_t = c + \sum_{i=1}^{N} T_i \Delta X_{t-i} + \prod X_{t-1} + \varepsilon_t \quad (8)$$

Following the Johansen procedure, the number of cointegration vector was tested by using the cointegration VAR as in Eq. 8.

Granger causality: Further, this study investigates the direction of causality among energy consumption, CO_2 emission and economic growth. According to a previous study if there are two non-stationary variables are cointegrated, VAR in first difference not be specified. If there is found long-run equilibrium relationship among all variables then study can test Granger Causality with the specified model. The Granger Causality test is based on the following regressions:

Direction of causality of Y can find with the help of following equation. Equation 9 shows that Y causing EC and CO_2 emission:

$$\Delta \ln Y_{it} = C_{1i} + \sum_{p} \phi_{11ip} \Delta \ln EC_{it-p} + \sum_{p} \phi_{12ip} \Delta \ln CO_{2it-p} + \mu_{1i} ECT_{it-1} + \varepsilon_{1t} \quad (9)$$

Direction of causality of EC can find in the following equation. Equation 10 shows that EC causing Y and CO_2 emission:

$$\Delta \ln EC_{it} = C_{2i} + \sum_{p} \phi_{21ip} \Delta \ln Y_{it-p} + \sum_{p} \phi_{22ip} \Delta \ln CO_{2it-p} + \mu_{2i} ECT_{it-1} + \varepsilon_{2t} \quad (10)$$

Direction of causality of CO_2 can find in the following equation. Equation 11 shows that CO_2 causing Y and EC:

$$\Delta \ln CO_{2it} = C_{3i} + \sum_{p} \phi_{31ip} \Delta \ln GDP_{it-p} + \sum_{p} \phi_{32ip} \Delta \ln EC_{it-p} + \mu_{3i} ECT_{it-1} + \varepsilon_{3t} \quad (11)$$

All variables are previously defined but Δ = First difference, ECT = Error correction term, p = Lag length, ECT_{it} = Long-run model estimated residuals from Eq. 4, $\mu_{i,j}$ ECT_{it} = Long-run equilibrium.

RESULTS

Empirical findings: First ADF unit root test was applied to check stationarity and level of integration of each variable (CO_2, EC and Y). After confirm the unit root of each variable Johansen cointegration test was conducted and confirm the long run relationship. Finally, Granger causality was applied for indentify the direction of the causality among all variables.

Table 2: Unit root test result

	Intercept		Intercept+trend	
Variables	Level	First difference	Level	First difference
Y	1.0000	0.0003*	0.8912	0.001*
EC	0.9898	0.004*	0.7171	0.000*
CO_2	1.0000	0.002*	0.7865	0.009*

*Denoted significant at 5% critical value

Table 3: Cointegration test results

Rank	Maximum eigen statistic	Critical value (Eigen) at 5%	Trace statistics	Critical value at 5%
r = 0	28.2109	22.1318	41.2023	28.7971
r≤1	12.9314	13.9867	15.0000	15.2314
r≤2	1.0621	3.8409	1.0621	3.8409

Unit root test: The results of unit root test are reported in Table 2. The results indicate that the all the variable (EC, CO_2 and Y) are non-stationary at level and become stationary at first difference. The null hypothesis (H_0) is rejected while alternative hypothesis (H_1) is accepted. Thus, Johansen cointegration can be applied.

Cointegration test: The Johansen cointegration test results are presented in Table 3. The results show that some of the series are correlated in the long run but it does not show any direction of causality. The lag length 1 is selected in this test based on minimum value of AIC. The results presented in Table 3 indicate one cointegration equation at 5% level in case of Pakistan. Further results are also indicating the long run relationship among energy consumption, economic growth and CO_2 emission in Pakistan.

Short run relationship test (VECM): The VECM test was applied to confirm the short run relationship among energy consumption, CO_2 emission and economic growth. The results of VECM test are presented in Table 4. The results indicate negative sign of lagged error-correction term, which is statistically significant at 5% level. The results confirm the short run relationship in the model.

Granger causality test result: The Granger causality test results are reported in Table 5. The results have revealed that there is bidirectional relationship between CO_2 emission and economic growth and causality direction running from energy consumption to CO_2 emission. The results do not indicate any reverse causality from CO_2 to energy consumption.

DISCUSSION

The main aim of this study is to empirically investigate the relationship among CO_2 emission, energy consumption and economic growth in Pakistan over the period; 1975 to 2013. The results of unit root test indicate that all the variables are non-stationary at level and become stationary at first difference. For investigating the cointegration among proposed variables, Johansen cointegration test was employed. The empirical results show that there is one cointegration equation exist, which confirm the long run relationship between energy consumption, CO_2 emission and economic growth during the period under the study. Further, results of Granger causality prove

Table 4: VECM results

Parameters	Coefficient	SD error	t-value
Dependent variable: Ln CO_2 emission			
ECT_{t-1}	-0.6331**	0.2432**	-2.4322
ΔlnGDP(-1)	4.4812*	1.4121*	3.1712
ΔlnEC (-1)	3.1542*	1.1321*	3.1201
C	-0.0567	0.0671	-0.8412
Dependent variable: ln GDP			
ECT_{t-1}	-1.0051***	0.4812***	-2.050***
ΔlnCO_2 (-1)	0.4412*	0.1012*	4.3212*
ΔlnEC (-1)	1.2121*	0.3912*	3.1213*
C	0.0213	0.0212	0.9001
Dependent variable: ln EC			
ECT_{t-1}	0.6612	1.0005	0.6512
ΔlnCO_2 (-1)	0.2612	0.1912	1.3412
ΔlnEC (-1)	1.4412	0.9012	1.5833
C	0.0312	0.0042	0.8123

*,** and ***denoted the significant at 1, 5 and 10% level, respectively

Table 5: Granger causality test results

	X^2-statistics		
Dependent variables	ln GDP	ln CO_2	ln EC
ln Y	-	22.3221	17.0512*
ln CO_2 emission	12.1213**	-	11.3121**
ln EC	4.2123	3.9191	-

*,** and ***denoted the significant at 1, 5 and 10% level, respectively. The optimal lag order (k) is 3 and was determined by using AIC

that energy consumption causes economic growth and these findings are similar with Shahiduzzaman and Alam (2012) and energy consumption also causes CO_2 emission and it is similar with Liu and Liu (2011) results.

The findings of this study reveal that increase in energy consumption causing environmental issues in Pakistan. Whereas, increasing energy consumption to enhance economic growth can cause to increase CO_2 emission. Therefore, alternative should be taken to conserve energy and simultaneously increase in economic growth. Further, the results demonstrate that energy consumption simultaneously cause economic growth and CO_2 emission in Pakistan, so, it is not painless to reduce the energy consumption nevertheless environmental issues can be minimize by using green technology.

Moreover, findings of the study suggest the significance of energy and easing of excessive CO_2 emission in Pakistan. Therefore, apart from the introduction of energy conservation and responsibility culture, the government of Pakistan needs to pursue some short term and long term plans in order to solve energy problems. So, to shape a power generation capacity that can fulfil Pakistan's energy requirement on sustainable basis. In short run, small Dam including in Northern areas needs to be facilitated, while, in long run, big Dam and Hydropower Project needs to be initiated. Some less inexpensive and reasonable electricity for domestic and commercial consumption needs to be generated through domestic available resources like hydel and coal. Though, foreign direct investment in energy sector needs to be accelerated with some appropriate terms and conditions in order to overcome the energy problem in Pakistan.

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