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Energy Resources, Foreign Exchange Reserves and Economic Growth: Empirical Evidence from Pakistan

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Abstract: The objective of this study is to investigate the impact of energy components such as, oil, electricity, natural gas and coal consumption and financial variable; foreign exchange reserves altogether on economic growth in Pakistan utilized the annual time series data from 1972 to 2013. Augmented Dickey Fuller (ADF) test has been employed for stationarity of the variables and error correction model (ECM) to obtain the short-run and long-run elasticities results in the case of Pakistan. Empirical investigations indicate that credit to all; energy components (oil, electricity, natural gas and coal consumption) and financial variable (foreign exchange reserves) that correlate positively with economic growth in the long run and short run. Furthermore, in the short-run and long-run the average elasticities of economic growth for foreign exchange reserves and oil consumption (in absolute terms) are greater than that of electricity, natural gas and coal consumption. The differences in elasticities of each component of energy have significant policy implications for economic growth in Pakistan.

Key words: Energy · Economic growth · Foreign exchange reserves · Error correction model · Pakistan

INTRODUCTION

Economic growth is measured in terms of gross domestic product (GPD) and it is basically dependent upon the energy and financial factors that's why it is taken as backbone of entire economic system. GDP is essential for socioeconomic growth of the country [1]. Energy is certainly the basic requirement of an economy [2]. Every nation depends upon its economic growth which can be only obtained through efficient utilization of energy resources, plus sustaining their reserves.

Most of the classical theories and practices focus on the financial and monetary indicators like capital, labor etc and usually associates them with production and utilization of energy resources but give least importance to foreign exchange reserves [3]. While, neoclassical theory says that increase in foreign exchange reserves has a positive effect on economic growth and actually makes the growth process stable. Many researchers and practitioners focus on the concept that both financial and energy indicators together playing an important part, apart from others factors in the process of economic stability [4].

Energy consumption, foreign exchange reserves and economic growth are obviously associated and are significantly endeavored toward country's prosperity. They altogether play crucial role at theoretical, numerical and policy making level. Number of studies vested their focus on consumption and production of energy but the outcome of those researches are different and conflicting, some conclude positive relation while others negate existence of any relationship. The association among GDP oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves expose fluctuating results since past decades in several studies.

Effect of energy variables like oil and electricity can be evidently assessed through gross domestic product of a country [5]. Knowledge about demand of energy and foreign reserves is critically vital for the fulfillment and assurance of sustained economic growth. This is why it is essential to identify the nature of relationship between the economic growth and its major determinants in a country; these may include some of existing energy and financial resources.

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From the conclusions of the empirical researches in the energy and financial sectors, it can be extracted that variables like energy consumption and foreign exchange reserves implies a great impact on economic growth which can never be denied.

Background of Study: Energy requirement in the country are expected to grow in coming years and financial sustainability is intensely required. Current research is an advance step in recognizing the relation between economic growth & its major determinants covering financial and energy indicators in Pakistan, so that core determinants of economic growth can be analysed and entertained.

At the moment, Pakistan is confronting with the worse energy and financial crisis of its history, if these crises are resolved effectively and efficiently then GDP is expected to grow exponentially. This will enable energy production and foreign reserves to rise and in surplus they can be used by industries and businesses which can further result into improved economic growth in the country.

There is another concept which indicates that employment is another source that is extending the use of energy. As being employed, living standard of employees are raised which directly affects the energy consumption with increasing ratio. In context of Pakistan due to less energy producing infrastructures and limited resources, foreign reserves are badly affected causing an abrupt decline in GDP of Pakistan.

Hence, analysis of relationship between energy consumption (electricity, oil, coal and natural gas), foreign exchange reserves and GDP is of prime importance in a developing country like Pakistan. It will not only enable the policy makers in the countries, but also the foreign and domestic investors to thoroughly evaluate the energy situation for their business strategies. Importance of this study is directed to follow previous studies and implying them in context of Pakistan by evaluating the association of GDP with its major indicators (oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves) in Pakistan, with in time frame of 1972 to 2013.

Literature Review: Theoretical and empirical studies on energy consumption and economic growth linkage are widespread partly due to the significant role of energy in sustainable economic development. In the past two decades, various studies have been carried out to examine the relationship between energy consumption and economic growth. The overall findings show that there is a strong relationship between energy consumption and economic growth. However, researchers are unable to arrive at a consensus on the flow of causality between energy consumption and economic growth.

Apart from GDP there is an important impact caused by energy consumption and financial indicators on GNP (Gross National Product) [6]. There exist bidirectional relationship among GDP, energy consumption and capital [7]. Erol and Yu [8] revealed mixed results for different countries by using "Sims and Granger causality tests". While doing a cross country analysis a unidirectional causality among developed nations like Germany and Japan; and bidirectional causality among Italy France and Korea [9]. Log linear regression analysis was employed for examining the relationship between economic growth, energy consumption, energy prices and inflation for Pakistan and no significant relationship between all the applied variables was indicated [10]. Different intake patterns of energy resources may cause different impact economy [11]. For U.S in between the period of 1947-1974 there exists a unidirectional causality from country’s economic growth toward energy consumption pattern [6]. There exists bidirectional association between energy consumption and GDP; and cause a positive impact on energy consumption [9]. In Taiwan there is unidirectional causality running from energy consumption to economic growth [12]. Electricity consumption for developing countries like Japan and Italy against country’s gross domestic product revealed unidirectional relationship from electricity consumption to GDP [8]. ARDL and Granger causality revealed bidirectional association between foreign exchange reserves and the Ghanaian economy in the long run, suggested it favorable and constructive for the country [13]. A study in by China for the period of 1962-1992 was conducted for testing the relationship between country’s economic growth and energy consumption and revealed bidirectional relationship between energy consumption and economic growth [14, 15]. Bidirectional causality was found between energy consumption and real income for set of selected sample countries [16]. In small open economies, it was found that there does not exist any positive impact of foreign exchange reserves on economy [17]. Study conducted for Thailand and Philippines used data series from 1952-1999 and found unidirectional causality running from GDP to energy prices and bidirectional causality between economic growth and energy consumption [18]. In addition to the variables like trade openness and inflation, foreign exchange reserves are also a significant factor that influence the economic growth [19]. There is a significant role of foreign exchange reserves in the accelerating economic growth [20]. In India unidirectional causality was observed running from electricity consumption to GDP for period of 1950-1997 [21]. Foreign exchange reserves are greatly influenced depending upon the economy of a country [22]. In Italy there exist a bidirectional relationship among economic growth and energy consumption [23]. Over the period 1983-2002 no co-integration was found between oil consumption and GDP for China [24]. Similarly bidirectional relationship was found between oil consumption and GDP for Zambia [25]. Foreign exchange reserves and GDP were incorporated concluding foreign exchange reserves as a positive economic measure [26]. In lower and developed countries foreign exchange reserves is not desirable and should be restricted due to impulsive financial markets [27]. Real exchange rate instability inversely effects the economic growth of a country [28].

There exists significant long-term and short-term relationship between economic growth and energy consumption [10]. There exist bidirectional causality between foreign exchange reserves and economic growth in the long run but in the short run there exists unidirectional causality [29]. Bidirectional causality was revealed between foreign exchange reserves and economic growth in Pakistan [30]. A three-gap model was suggested, examined and concluded that increased foreign exchange reserves, real devaluation and capacity utilization are the main determinants of economic growth in Pakistan [31]. Economic growth responds significantly and positively by energy demands. All the energy sources are essential in identifying variability in economic growth, just the way financial indicators define extent of change in economic growth [32]. A significant impact of energy consumption on economic growth was found in Pakistan, total energy consumption is caused due to increase in economic output at aggregate level [33]. A non-uniform impact of economic growth was determined on different available sources of energy [34]. Foreign exchange reserves are positively associated with economic growth in Pakistan while budget deficit and external debt reduce growth of output [35]. There exists a bidirectional relationship between economic growth with energy consumption in Pakistan [36]. For the period of 1972-2007 there exist bidirectional causality between GDP and sectoral energy consumption [37].

Different studies were conducted to examine relationship between economic growth and energy consumption in Pakistan [33,34,36,38,39,40]. Similarly study was conducted on association between foreign exchange reserves and GDP incorporates limited time period [41]. Many studies incorporated foreign exchange reserves in contrast with other financial variables to determine GDP [8,16,18,32,42,43,44,45].

Although in Pakistan, factors such as energy consumption and foreign exchange reserves appeared as an important determining factor of economic growth function [46]. Whereas, many studies have used foreign exchange reserves as an important financial factor in contrast with inflation, capital, foreign direct investment, circular debt, for determining economic output in developing countries but not with energy consumption [22,47]. A study for Turkey was conducted and variables like energy consumption and foreign exchange reserves were incorporated as determinants of GNP [11].

Along these lines, it might be inferred that GDP is vastly controlled by energy consumption and foreign exchange reserves in Pakistan. Therefore, using variables like oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves can give true picture of the reasons behind fluctuations of economic growth in Pakistan.

Econometric Methodology: This study is based upon annual information of gross domestic product (GDP), oil consumption, electricity consumption, coal consumption, natural gas consumption and foreign exchange reserves coating a period from 1972 to 2013 in Pakistan. In order to avoid seasonal biases, annual datum is used in this study. Two major factors constrained the choice of the starting period, i.e., energy crisis of the 1970s all over the world and the political instability in Pakistan of 1971.

Research Model: This study aims at exploring the impact of oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves on gross domestic product in Pakistan.

Basic model for this research incorporates economic growth as a function of capital and labor.

$$GDP_t = f(CAP_t, LBR_t) \tag{1}$$

For this purpose Cobb-Douglas production function has been applied to investigate relationship between economic growth and it major determinants including capital and labor as additional factors of production. The general form of Cobb-Douglas function is as follow (Equation 2):

$$Y = AE^{\alpha_1}K^{\alpha_2}L^{\alpha_3}e^{u} \quad (2)$$

Here Y is domestic output in real terms; E, K, L denote energy, real capital and Labor respectively. A is for level of technological advancement and *e* is the residual term, assumed to be identically, independently and normally distributed. The empirical equation is to investigate a relationship between economic growth and its major determinants is modeled by keeping technology constant.

It is believed that economists usually consider labor and capital as the main determinants of economy, while they mostly ignore the importance of fuels and other inputs, thus it ignores the fact that developing countries like Pakistan are in dire need of maintaining energy consumption to spur the economic growth in the country [3]. Variables like capital and labor complimentarily already exist in all energy resources and other financial indicators, so there is no need to separately examine them as indicators of economic growth [48].

Solow [49] kept on debating about capital and labor and in their studies and they all criticized [48, 50] for incorporating capital and labor factors for testing growth because for examining economic growth there is a need to use sustainable variables. Similar arguments have been made by other ecological economists and argued that oil being a marginal product is of high importance for measuring economic growth [51-57]. Energy and capital to be complementary [58, 59] while energy and capital substitutable [60]. Energy can be substituted against capital and labor and it will not affect the production or economic growth of the country [61]. Capital and energy are substitutable, the way labor and energy are substitutable [62]. So it has become possible to assume that energy has a direct impact on the decline or increase of country's national income.

Different conclusions are found on the relationship of capital and energy and utilizing them as each other's substitute. Results comprised of time series and cross sectional data are differentiated in studies [43]. Several studies in Pakistan incorporated variables like oil consumption, electricity consumption, natural gas consumption and coal consumption against economic growth [33, 40, 63].

In reference to Pakistan different studies incorporated factors like foreign direct investment and inflation, but foreign exchange reserves is another important factor that needs to be addressed as an important determinant of Pakistan. The two basic factors are highly affecting the economy of developing countries and these are energy consumption and foreign exchange reserves, therefore economic growth in Pakistan is identified with variables including oil, electricity, gas and coal consumption.

Financial and energy indicators against capital and labor in study for examining the relationship between GDP, energy consumption and some of financial indicators, whereas this study modifies the financial factors by using foreign exchange reserves [39]. Therefore by incorporating energy consumption and foreign exchange reserves in economic growth function can be taken as follow:

$$Y_t = f(EGC_t, FER_t) \quad (3)$$

A study was conducted for Malaysia, which involved sector wise energy consumption against gross domestic product function [64]. This study employed energy function which is further decomposed into oil consumption, electricity consumption, natural gas consumption and coal consumption against economic growth function as below:

$$Y_t = f(OCO_t, ECO_t, GCO_t, CCO_t, FER_t) \quad (4)$$

Log linear model have been preferred over the linear model [65]. Study have performed the procedure and have shown that the log linear transformation are more effective compared to linear transformation [66, 67]. Log linear specification of the model yield elasticities which helps in managing demand, behavior analysis of demand, forecasting electricity demand and policy analysis [68].

Several studies have applied log linear function for log transformation of economic growth and modified them as per their study requirements by using "reduced form model" [46,69-77]. By keeping all these studies in focus energy consumption and foreign exchange reserves are modeled in form of log linear against economic growth and its function is represented as follow:

$$lnGDP_t = \alpha_0 + \alpha_1 lnOCO_t + \alpha_2 lnECO_t + \alpha_3 lnGCO_t + \alpha_3 lnCCO_t + \alpha_4 lnFER_t + \varepsilon_t \quad (5)$$

ln is used to represent natural logarithm in equation 5, $InGDP_t$ shows gross domestic product, $InOCO_t$ represents oil consumption, $InECO_t$ denotes electricity consumption, $InGCO_t$ is natural gas consumption, $InCCO_t$ is coal consumption and $InFER_t$ is foreign exchange reserves. Here, the model demands error term ε_t to be distributed spherically according to white noise distribution. All the employed variables, energy

Table 1: Variable Name, Measurement, Expected Sign and Data Source

Variables	Measurement	Expected Sign	Data Source
Economic Growth (GDP)	Pakistani Rupees	-	Economic Survey of Pakistan (2014)
Oil Consumption (OCO)	Million Tons of Oil Equivalent (MMTOE)	Positive	Energy Year Book (2014)
Electricity Consumption (ECO)	Million Tons of Oil Equivalent (MMTOE)	Positive	NTDC Power Statistics 37th Edition
Coal Consumption (CCO)	Million Tons of Oil Equivalent (MMTOE)	Positive	Energy Year Book (2014)
Natural Gas Consumption (GCO)	Million Tons of Oil Equivalent (MMTOE)	Positive	Energy Year Book (2014)
Foreign Exchange Reserves (FER)	Pakistani Rupees	Positive	Economic Survey of Pakistan (2014)

consumption (oil, electricity, natural gas and coal) and foreign exchange reserves are expected to follow a sequence of $a_1 > 0$, $a_2 > 0$, $a_3 > 0$, $a_4 > 0$, $a_5 > 0$ respectively.

Data Collection: Data for oil consumption, coal consumption and natural gas consumption have been gathered from Energy Year Book (2014), whereas data for electricity consumption have been arranged from different sources like NTDC (National Transmission and Dispatch Company). The time series data for real gross domestic product (GDP) and foreign exchange reserves is gathered from various issues of Economic Survey of Pakistan. All these variables are expressed in natural logarithm. Economic growth, number of electricity customers variables are expected to have significant positive, while electricity price and electricity shortages are predicted to have negative effect on electricity consumption in Pakistan (Table 1).

Methods: To overcome the issue of spurious regression, time series econometrics keeps tabs on the time series properties of the economic variables.

Before doing any empirical work, examination of time series whether it is stationarity or non-stationarity is important which is closely linked to the testing for unit roots. For each variable we need to determine the order of integration before applying the co-integration technique, for which we used Augmented Dickey Fuller (ADF) test.

Co-integration may give helpful information about the relationship between the non stationary variables. Co-integration theory endeavors to study interrelationships between long-run movements in economic time series. To check co-integration between economic growth and its major determinants in Pakistan Johansen co-integration test has been proposed for this study. In case of this study there are six variables $InGDP_t$, $InOCO_t$, $InECO_t$, $InGCO_t$, $InCCO_t$ and $InFER_t$, which can all be endogenous, i.e. we have that using matrix notation for

$$Z_t = [lnGDP_t \quad lnOCO_t \quad lnECO_t \quad lnGCO_t \quad lnCCO_t \quad lnFER_t]$$

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \cdots + A_k Z_{t-k} + u_t \tag{6}$$

which is comparable to the single-equation dynamic model for two variables. Thus, in a vector error correction model (VECM) it can be reformulated as follows (Equation 7):

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \cdots + \Gamma_{k-1} \Delta Z_{t-k-1} + \Pi Z_{t-1} + u_t \tag{7}$$

where $\Gamma_i = (I - A_1 - A_2 - A_3$ (i = 1, 2, ..., k-1) and $\Pi = -(I - -A_1 - A_2 - \ldots -- A_k)$. Here we need to cautiously examine the 6×6 Π matrix. (The Π matrix is 6×6 due to the fact that we have five variables of interest in $z_t = [InGDP_t \; InOCO_t \; InECO_t \; InGCO_t \; InCCO_t \; InFER_t]$). The information regarding the long-run relationships is contained in Π matrix. In fact $\Pi = \alpha\beta/$ where á will incorporate the velocity of tuning back to equilibrium coefficients and $\beta/$ will be the long-run matrix of coefficients.

Therefore the β/Z_{t-1} term is equivalent to the error-correction term, that in multivariate framework can contains up to (n - 1) vectors.

Using annual data taken k = 2, so that we have only two lagged terms and the model is then the following (see Equation 8):

$$\begin{pmatrix} \Delta lnGDP_t \\ \Delta lnOCO_t \\ \Delta lnECO_t \\ \Delta lnGCO_t \\ \Delta lnCCO_t \\ \Delta lnFER_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta lnGDP_{t-1} \\ \Delta lnOCO_{t-1} \\ \Delta lnECO_{t-1} \\ \Delta lnGCO_{t-1} \\ \Delta lnCCO_{t-1} \\ \Delta lnFER_{t-1} \end{pmatrix} + \Pi \begin{pmatrix} lnGDP_{t-1} \\ lnOCO_{t-1} \\ lnECO_{t-1} \\ lnGCO_{t-1} \\ lnCCO_{t-1} \\ lnFER_{t-1} \end{pmatrix} + e_t \tag{8}$$

or

$$\begin{pmatrix} \Delta lnGDP_t \\ \Delta lnOCO_t \\ \Delta lnECO_t \\ \Delta lnGCO_t \\ \Delta lnCCO_t \\ \Delta lnFER_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta lnGDP_{t-1} \\ \Delta lnOCO_{t-1} \\ \Delta lnECO_{t-1} \\ \Delta lnGCO_{t-1} \\ \Delta lnGCO_{\ t-1} \\ \Delta lnFER_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} & \beta_{52} & \beta_{62} \end{pmatrix} \begin{pmatrix} lnGDP_{t-1} \\ lnOCO_{t-1} \\ lnECO_{t-1} \\ lnGCO_{t-1} \\ lnCCO_{t-1} \\ lnFER_{\ t-1} \end{pmatrix} + e_t \tag{9}$$

To figure out the number of co-integrating vectors Johansen method used two statistics: the trace test and the Maximum Eigenvalue (λ-max) test [78]. The trace test tests the null hypothesis (H_0) that the number of distinct co-integrating vectors is less than or equal to r against a general alternative. The Maximum Eigenvalue (λ-max) test tests (H_0) that the number of cointegrating vectors is r against the alternative of (r + 1) cointegrating vectors.

The presence of co-integration between time series does not imply causation. It is suggested by Granger causality test that there will be at least unidirectional Granger causality if there is a co-integration relationship around the variables. To figure out the causality course between electricity consumption and its determinants, the Granger causality test based on the vector error correction model (VECM) will be utilized. Following VECM has been estimated to ascertain the causality direction (Equation 10):

$$\begin{bmatrix} \Delta lnGDP_t \\ \Delta lnOCO_t \\ \Delta lnECO_t \\ \Delta lnGCO_t \\ \Delta lnCCO_t \\ \Delta lnFER_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \end{bmatrix} + \begin{bmatrix} A_{11i} & A_{12i} & A_{13i} & A_{14i} & A_{15i} & A_{16i} \\ A_{21i} & A_{22i} & A_{23i} & A_{24i} & A_{25i} & A_{26i} \\ A_{31i} & A_{32i} & A_{33i} & A_{34i} & A_{35i} & A_{36i} \\ A_{41i} & A_{42i} & A_{43i} & A_{44i} & A_{45i} & A_{46i} \\ A_{51i} & A_{52i} & A_{53i} & A_{54i} & A_{55i} & A_{56i} \\ A_{61i} & A_{62i} & A_{63i} & A_{64i} & A_{65i} & A_{66i} \end{bmatrix} \times \begin{bmatrix} \Delta lnGDP_{t-i} \\ \Delta lnOCO_{t-i} \\ \Delta lnECO_{t-i} \\ \Delta lnGCO_{t-i} \\ \Delta lnCCO_{t-i} \\ \Delta lnFER_{t-i} \end{bmatrix} + \begin{bmatrix} \delta \\ \gamma \\ \lambda \\ \varphi \\ \vartheta \\ b \end{bmatrix} \times [ECT_{t-1}] + \begin{bmatrix} \xi_{1t} \\ \xi_{2t} \\ \xi_{3t} \\ \xi_{4t} \\ \xi_{5t} \\ \xi_{6t} \end{bmatrix}$$

The residuals ξ_{1t}, ξ_{2t}, ξ_{3t}, ξ_{4t}, ξ_{5t} and ξ_{6t} are stationary and have spherical distribution. ECT_{t-1} is the lagged error-correction term resulting from the co-integration equation. The suitable lag order for the VECM is determined by VAR lag order selection criteria. Eventually, the short run Granger causality test is carried out by computing *F*-statistics on the lagged explanatory variables while the t-significance of ECT_{t-1} speaks to the long run causality relation.

Table 2: ADF Test Results on Level and First Difference

Augmented Dickey-Fuller (ADF) test on the levels and on the first difference of the variables (1972 - 2013).

Variables	Level			First Difference			Decision
	None	Constant	Constant and trend	None	Constant	Constant and trend	
LNGDP	3.3307 (1)	2.4331 (1)	-0.7743 (1)	-0.8449 (0)	-2.5825 (0)	-3.9502* (0)	Non-stationary at level but stationary at first difference, i.e. I (1)
LNOCO	2.5034 (0)	-0.4328 (0)	-1.6940 (0)	-2.3690* (0)	-4.1105* (2)	-4.0567* (2)	Non-stationary at level but stationary at first difference, i.e. I (1)
LNECO	2.8129 (1)	1.4810 (0)	-2.7562 (1)	-2.7269* (0)	-4.6221* (0)	-4.8411* (0)	Non-stationary at level but stationary at first difference, i.e. I (1)
LNGCO	3.4937 (2)	3.1100 (2)	-2.0388 (2)	-1.5588 (2)	-2.3428 (2)	-3.8397* (2)	Non-stationary at level but stationary at first difference, i.e. I (1)
LNCCO	1.3973 (0)	-0.3089 (0)	-1.8047 (0)	-4.6178* (0)	-4.8896* (0)	-4.7831* (0)	Non-stationary at level but stationary at first difference, i.e. I (1)
LNFER	0.7590 (0)	0.2153 (0)	-1.1028 (0)	-5.9604* (0)	-6.1363* (0)	-6.4420* (0)	Non-stationary at level but stationary at first difference, i.e. I (1)

Note: The null hypothesis is that the series is non-stationary, or contains a unit root. The asterisk * denote the significant at 5% level. The figure in parenthesis is the optimal lag length.

RESULTS

This study conducted Augmented Dickey Fuller Test (ADF Test) ADF test for unit root analysis to check stationarity and integration order of series, Johansen co-integration test for testing co-integration and Multivariate Granger test for causality analysis. In this section results of all these tests are discussed in detail.

Augmented Dickey-Fuller (ADF) unit root tests have been conducted for all the variables concerning their stationarity properties. The detailed results are shown in Table 2.

The results disclose that at level all the variables selected particularly for this research are non-stationary, however, at first differences they are stationary, therefore we say that over a period of 1972 - 2013 all variables are first differenced stationary or series are integrated of order I(1).

When series are integrated of the same order, we can proceed to test for the presence of co-integration by using Johansen co-integration technique. Results of unit root test (Table 2) indicate that all series are integrated of same order i.e., all series are I (1). Hence we used Vector autoregressive (VAR) model based Johansen (1988, 1990) approach to co-integration as it provides consistent results in multivariate cases.

It is necessary to decide the optimal lag structure and the suitable selection of deterministic segments in the VECM framework to test for co-integration with the Johansen-Juselius co-integration approach [78].

Table 3: Johansen Co-integration Test Results

Hypothesized No. of CE(s)	λ-trace	5 % CV	Prob. values	λ-max	5 % CV	Prob. values
None*	170.5677	95.75366	0.0040*	76.10508	40.07757	0.0214**
At most 1	94.46265	69.81889	0.1373	33.99750	33.87687	0.1847
At most 2	60.46515	47.85613	0.1784	25.86553	27.58434	0.2845
At most 3	34.59962	29.79707	0.2586	22.78617	21.13162	0.3617
At most 4	11.813345	15.49471	0.3538	11.67405	14.26460	0.5948
At most 5	0.139397	3.841466	0.5089	0.139397	3.841466	0.7089

Note: The asterisks *, **, ***signifies the hypothesis refusal at 1%, 5% and 10% respectively.

Table 4: Long Run Elasticities

Long Run Elasticities

Dependent variable = $\ln GDP_t$

Variables	Coefficient
Constant	2.0563 *
$\ln OCO_t$	1.0927 *
$\ln ECO_t$	0.9527 **
$\ln GCO_t$	0.3566 **
$\ln CCO_t$	0.2140 **
$\ln FER_t$	1.1852*

Note: The asterisk * and ** denote the significant at 1% and 5% level respectively

With respect to these, to decide the optimal lag structure the system-wise Akaike's Information Criterion (AIC) has been employed, which suggested optimal lag length of 2.

Table 3 illustrates the results of Johansen-Juselius co-integration test. Results by λ_{Trace} and λ_{max} indicates the rejection of null hypothesis of no co-integrating vector and results revealed the presence of single co-integrating vector. Therefore, the results in Table 3 confirm the validity and robustness of the long-run relationship between variables.

Since it is evident that economic growth and its determinants are cointegrated, computation of short and long run coefficients are needed. Long-run coefficients are presented in Table 4.

The results demonstrate that in the long run, oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves are statistically significant. The explanatory variables LNOCO, LNECO, LNGCO, LNCCO, LNFER are positively related to LNGDP. It can be assessed that an increment in oil consumption of about 1% can add up 1.09% to the gross domestic product of Pakistan. This exposes the fact that oil consumption is an important factor that can cause major increase/decrease in economic growth of Pakistan. Similarly 1% increase in electricity consumption can cause 0.95% rise in GDP, whereas natural gas consumption and coal consumption can add up to 0.35% and 0.21% in GDP respectively. Though the impact of natural gas and coal are comparatively less in long-term than that of oil and electricity consumption. As it is evident that in Pakistan coal consumption is comparatively lesser than all the three other energy resources, whereas these results also proportionate the importance of energy resources, as oil has higher impact on GDP, than comes electricity with little less impact, after that natural gas and in the end comes coal consumption which reflects weak relationship with GDP in contrast with other energy resources employed.

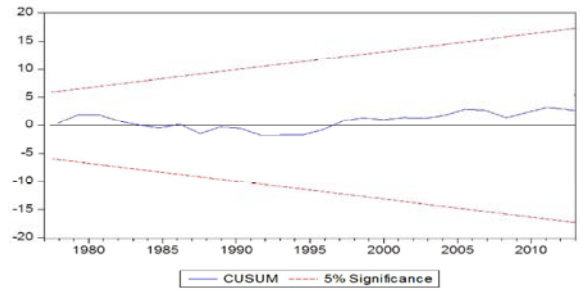

Fig. 1: Graph Of CUSUM For Long Run Parameters

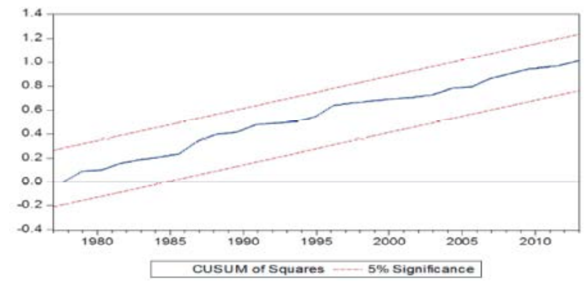

Fig. 2: Graph Of CUSUM For Long Run Parameters

Table 5: Short Run Elasticities

Short Run Elasticities

Dependent variable = $\Delta\ln ECO_t$

Variables		Coefficient
Constant		0.4835 *
$\Delta\ln OCO_t$		0.7693 *
$\Delta\ln ECO_t$		0.5644 *
$\Delta\ln GCO_t$		0.1523 **
$\Delta\ln CCO_t$		0.0831***
$\Delta\ln FER_t$		0.6354 **
ECT_{t-1}		-0.5862
R^2	0.7145	
Adj - R^2	0.6456	
F-statistic	13.3526	
D.W	2.1348	

Note: The asterisk *, ** and *** denote the significant at 1%, 5% and 10% level respectively

While looking at the results obtained for foreign exchange reserves, depicts that 1% increase in foreign exchange reserves can cause an increase of 1.18% in economic growth, higher than the impact of other applied energy resources. Foreign exchange reserve is a variable of essential importance in Pakistan which helps in raising gross domestic product (GDP) of country [79].

To inspect the stability of long-run parameters the CUSUM and CUSUMSQ tests are applied. Graphs of both CUSUM and CUSUMSQ statistics are plotted in Figure 1 and Figure 2 individually. The long-run coefficients are stable, as indicated in Figure 1 and Figure 2 that the plotted data points are inside the critical bounds.

The results in the short-run dynamic coefficients interfaced with the long-run relationships obtained from the ECM are given in Table 5.

Results revealed in short-run, are quite similar in terms of their significance when compared, with the obtained long-term results. All variables employed indicate positive connections with the economic growth (GDP). It is evident from obtained statistics that a rise of about 0.76% can be observed in economic growth of Pakistan with an increase of about 1% in oil consumption in short-run and an increase of 1% in electricity consumption can cause an increase of about 0.56% in economic growth. Similarly in the short-run natural gas and coal consumption cause an increase of 0.15% and 0.08% respectively with 1% increase. Even in short-run with 1% increase in energy resources (oil, electricity, natural gas and coal) economic growth is increased, showing positive relation among the energy variables, though proportions of their increase are comparatively less than their long-run impact on economic growth.

Whereas values for foreign exchange reserves also exposes gradually decreased impact in short-run over economic growth. As with the rise of 1% Foreign exchange reserves, an increase of 0.63% in economic growth is observed.

The estimated value of error correction coefficient (ECT_{t-1} and its expected sign makes it empirically reliable and the obtained value about -0.5862. Obtained error correction value has confirmed the reliability of relationship between all the incorporated variables. Negative (-) sign against the obtained value indicates that the deviation in data series from the previous years to recent year is non symmetrical, while it is being converted from short-run to long-run. This non symmetrical attitude refers that almost 58.6% deviations reverse back toward long-run due to recent year's shocks.

R^2 shows that how best the selected data fits to the regression line, whereas the obtained results for R^2 shows higher frequency of closeness between the data points of about 71.4% indicating that this model best fits for the selected time series. Similarly results obtained from estimated Durbin Watson revealed that there exist no auto correlation between the residuals.

Extracted results signify that economic growth, oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves are cointegrated in Pakistan. All the employed variables (oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves) positively contributes to the economic growth in the long-run which is also suggested by previous studies [10, 34, 36, 64, 79].

Table 6: Multivariate Granger Causality

Multivariate Granger Causality Analysis.

		Short-run						Long-run
Model	Dependent Variable	$\Delta \ln GDP_t$	$\Delta \ln OCO_t$	$\Delta \ln ECO_t$	$\Delta \ln GCO_t$	$\Delta \ln CCO_t$	$\Delta \ln FER_t$	ECT_{t-1}
		F-statistics [p-values]						
A	$\Delta \ln GDP_t$	–	6.6138* [0.0017]	5.8286** [0.0491]	3.2789*** [0.0792]	3.0373*** [0.0801]	9.5239* [0.0007]	-0.6472*
B	$\Delta \ln OCO_t$	4.8750** [0.0452]	–	2.1489 [0.1369]	1.5496 [0.2293]	0.6573 [0.4613]	6.7970* [0.00438]	-0.5816**
C	$\Delta \ln ECO_t$	9.2903* [0.0017]	3.3482 [0.1896]	–	2.6427 [0.1808]	1.4397 [0.2364]	4.5250** [0.0483]	-0.5641**
D	$\Delta \ln GCO_t$	4.7286** [0.0474]	0.9046 [0.6138]	0.8926 [0.5382]	–	0.0958 [0.9089]	2.0938*** [0.0889]	-0.4103**
E	$\Delta \ln CCO_t$	3.9926** [0.0492]	0.6619 [0.1888]	0.2452 [0.4262]	0.5428 [0.2244]	–	2.0675*** [0.0897]	-0.4421**
F	$\Delta \ln FER_t$	4.6523** [0.0479]	0.5382 [0.2416]	0.4682 [0.3262]	0.3741 [0.3844]	0.3023 [0.3984]	–	-0.6872*

Note: The asterisks *, **, and *** denote the significant at the 1%, 5%, and 10% levels, respectively.

The presence of cointegration between economic growth, oil consumption, natural gas consumption, coal consumption and foreign exchange reserves infers that there must be no less than one way of Granger causality, yet it does not demonstrate the bearing of causality. Therefore, to test the bearing of causality Granger proposes assessing a VECM to test causality course between economic growth, oil consumption, natural gas consumption, coal consumption and foreign exchange reserves in Pakistan. Table 6 exhibits the short and long run Granger causality results. It was specified prior that VECM gives short and long-run causal relationship amongst electricity consumption, GDP, number of electricity customers, electricity price and electricity shortages. The long-run Granger causality is analyzed through the significance of the one period lagged error-rectification term ECT_{t-1}, while the joint significance of the lagged explanatory variables infers the short-run causality.

Starting with the short-run impact, observed outcomes show that oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves (has highest significance level at 1%) are discovered to be statistically significant in economic growth function (model A). Oil consumption is found to be statistically significant in model B, electricity consumption in model C, natural gas consumption in model D and coal consumption in model E, equations. Economic growth is found to be statistically significant in oil consumption (Model B), electricity consumption (Model C), natural gas consumption (Model D), coal consumption (Model E) and foreign exchange reserves (model F) equations. In a short-run unidirectional causality is evaluated which is directed from foreign exchange reserves to oil consumption, electricity consumption, natural gas consumption and coal consumption. Whereas bidirectional causality exist among economic growth and oil consumption, economic growth and electricity consumption, economic growth and natural gas consumption, economic growth and coal consumption, economic growth and foreign exchange reserves.

Table 7: Results Of Multivariate Granger Causality Diagnostics Test

Multivariate Granger causality analysis diagnostics test

					Residual Diagnostics			
Model	Dependent Variable	R^2	Adj - R^2	F-statistic	χ^2 NORMAL Jarque-Bera	χ^2 SERIAL F-statistic	χ^2 BREUSCH F-statistic	χ^2 ARCH F-statistic
A	$\Delta\ln GDP_t$	0.753	0.681	6.694	1.300 [0.486]	0.220 [0.811]	0.563 [0.889]	0.300 [0.597]
B	$\Delta\ln OCO_t$	0.688	0.583	5.685	0.125 [0.958]	0.688 [0.516]	0.950 [0.549]	0.370 [0.531]
C	$\Delta\ln ECO_t$	0.656	0.562	4.375	1.731 [0.416]	0.180 [0.827]	1.381 [0.254]	0.083 [0.752]
D	$\Delta\ln GCO_t$	0.629	0.541	3.599	1.139 [0.552]	0.465 [0.639]	1.038 [0.474]	0.072 [0.766]
E	$\Delta\ln CCO_t$	0.593	0.515	2.428	0.563 [0.733]	0.716 [0.503]	0.400 [0.973]	2.455 [0.115]
F	$\Delta\ln FER_t$	0.552	0.483	1.925	1.147 [0.541]	0.562 [0.682]	1.102 [0.381]	0.274 [0.671]

Note: [.] indicates p-value.

Turning to the long-run causality, different indication has been found in comparison with short-run causality. Experiential confirmation indicates that the one period lagged error-correction terms of ECT_{t-1}. were rejected in electricity consumption. This implies that causality is running from oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves to economic growth in long-run. The empirical outcome shows that the estimate of ECT_{t-1}. i.e. -0.6472 for economic growth is statistically significant. This infers that 0.6472% progression for gross domestic product is remedied through divergence for short-run towards equilibrium passage of long-run.

Similarly ECT_{t-1} is -0.6872 for foreign exchange reserves showing highest ratio of 0.6872% through which diverged time series is remedied back toward equilibrium in the long run, whereas oil consumption converges back to the equilibrium with the ratio of 0.5816%, electricity consumption with 0.5641%, natural gas consumption with 0.4103% and coal consumption with 0.4421% in the long run.

Results related to energy variables are similar to the previous research carried out for Pakistan [33,36], for 30 OECD [80] and non-OECD countries [78] and for South Asian countries [81]. Whereas results for financial variable, like foreign exchange reserves, are more likely some of previous researches made for Asian and African developing countries [82], for China [83] and for Pakistan [84].

Residual diagnostic tests like Breusch-Pagan-Godfrey of heteroskedasticity, ARCH test of heteroskedasticity, Breusch-Godfrey serial correlation LM test and normality test has been performed for all models. Table 8 shows results of these tests for all models.

Results of ARCH test of heteroskedasticity show that the residuals are homoskedastic and here is no ARCH affect in all models, which are desirable. Results of serial correlation LM test indicates that residuals of all models are not serially correlated, which is desirable. Residual normality test indicates that residuals of all the models are normally distributed, which is desirable.

CONCLUSION

Through cointegration and causality analysis an endeavor has been made to investigate the economic growth function for Pakistan from 1972-2012. Unlike the earlier studies on this subject in order to augment the unwavering quality of assessments contribution to the existing literature has been made by including economic growth, oil consumption, electricity consumption, natural gas consumption, coal consumption and foreign exchange reserves altogether in the energy-growth relationship.

It has been extracted through results that foreign exchange reserve is the major indicator causing an impact on GDP and government should take an initiative to reduce taxation on foreign remittances, so that foreign exchange reserves can be increased.

Furthermore, in the short-run and long-run the average elasticities of economic growth for foreign exchange reserves and oil consumption (in absolute terms) are greater than that of electricity, natural gas and coal consumption. As revealed through results, coal and natural gas are the energy resource that has least effect on economic growth, comparatively to other energy resources like oil and electricity. This will not only help in improving economic growth using indigenous energy resources but it will not only help in preserving foreign exchange reserves, being aimlessly consumed, but also it will cause economic growth to increase as exposed in the study. Government should take measures to increase the use of coal and natural gas instead of oil where it is convenient. Results revealed by short-run and long-run causalities are different because of their requirement of various policies and strategies at various levels. Economic growth depicts prosperity and sustainability of a country, so its effect can never be ignored, it will efficient if energy conservation techniques and renewable energy sources will be introduced for distributing energy consumption ratio.

Though coal consumption has lowest impact on GDP in contrast to other variables but its utilization can enhance economic growth and can heap investments from worldwide. Similarly natural gas is another important variable that is playing vital role, right after reduction in oil consumption in transport sector. In some way or the other all the applied variables show major impact on economic growth, which reveals the fact that economic growth can be increased by sustainable monitoring of energy resources and foreign exchange reserves in Pakistan.

Oil consumption has a high impact on economic growth after foreign exchange reserves, though it is the essential factor that can increase country's economic growth but its share can be replaced by electricity generated through renewable energy resources like hydel, wind or solar. This will not only help in decreasing oil imports bill which we pay via foreign exchange reserves but in turn, it will also be helpful in increasing economic growth as proved through results.

It has been exposed due to limited foreign exchange reserves, investment in energy sector has been decreased on great extent and it directly effects the economic growth in Pakistan. Decreasing energy and foreign exchange reserves is becoming a serious issue for the economic development in country.

Importance of foreign exchange reserves can never be ignored due to its high dependency on economic growth and energy consumption. Increase in foreign exchange reserves in Pakistan can be helpful in regaining its prosperity. In case of Pakistan, managing energy consumption throughout energy sector could add figures to our economic growth and for that very purpose planned policies regarding sector wise energy consumption are in need of being revised and implemented wisely.

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