Electricity Consumption and Economic Growth in Kazakhstan: Fresh Evidence from a Multivariate Framework Analysis

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Abstract:

This paper visits the relationship between electricity consumption and economic growth by incorporating trade openness, capital and labour in production function using annual data of Kazakhstan. We have applied the ARDL bounds testing and the VECM Granger causality approach to examine long run and causality relationship between the variables.

Our results confirm the existence of long run relationship among the series. The empirical evidence reveals that electricity consumption adds in economic growth. Trade openness stimulates economic growth. Capital and labour promote economic growth. The causality analysis finds electricity consumption Granger causes economic growth. The feedback effect exists between Trade and economic growth. This study opens new insights for policy makers to articulate comprehensive economic, trade and energy policy to sustain long run economic growth.

Keywords: Electricity, Growth, Kazakhstan
JEL Classification: F15, B28

Introduction

Energy is increasingly becoming a major force in the pursuit of sustainable development. The attribute of neutrality ascribed to energy by neoclassical model is contestable as consistent growing sources of modern energy could directly aid livelihoods, and indirectly via promotion of economic growth. As a major source of energy, accessibility of electricity aids the process of meeting residential and domestic needs; positively contributes to capital and labour productivity; promotes export potentials of countries (Narayan and Smyth, [30]); creates employment (Narayan and Smyth, [29]) and decreases the poverty level (Poveda and Martínez, [41]); and ultimately improves socio-economic development (Poveda and Martínez, [41]). Countries' level of development appears to be associated with intensity of electricity usage as only 24.84% of the population in least developed countries had access to electricity, while about 81.41% of the population in middle income countries had access to electricity in the year 2009. In the same year, electricity consumption in European Union was 11-fold of the consumption in Sub-Saharan Africa, in spite of Sub-Saharan having a larger population in 2009 (World Bank, [64]).

Recognizing the importance of electricity in economic development agenda, there has been upsurge of empirical literatures to verify the true connection of electricity consumption and economic activity in different countries and regions. Including the pioneering study of Kraft and Kraft [22], causality tests are recurrently employed in existing energy papers to determine the causality relationship between electricity consumption and economic growth. The causality running from electricity consumption towards economic growth infers that electricity influences economic growth and thus electricity expansionary is compatible with improvement of economic performance of the country. The causality running from economic growth to electricity consumption implies that economic growth is not dependent on electricity usage and therefore, conservation policies should be pursued. The feedback hypothesis between electricity consumption and economic growth means both variables are interrelated, supporting expansionary policies. Neutral hypothesis between economic growth and electricity consumption suggests the limited role of electricity consumption for economic growth[1].

Empirical studies on causal relationship between electricity consumption and economic growth are wide-ranging providing ambiguous results (see Aqeel and Butt, [4]; Yoo, [66]; Yoo, [67]; Chen et al. [7]; Ho and Siu, [15]; Hu and Lin, [18]; Jamil and Ahmad, [19]; Narayan and Smyth, [29]; Shahbaz et al. [51]; Shahbaz and Lean, [49]; Shahbaz and Feridun, [47]). Further, few studies have considered electricity consumption and economic growth relationship in selected African economies (see Jumbe, [20]; Wolde-Rufael, [63]; Akinlo, [2]; Squalli, [56]; Odhiambo, [32, 33, 34]; Solarin, [54] and, Solarin and Bello, [55]). However, we are not aware of any study investigating causal relationship between electricity consumption and economic growth in case of Kazakhstan.

In the present study, we investigate the direction of causality between economic growth and electricity consumption by incorporating trade openness as a potential determinant of both electricity consumption and economic growth in case of Kazakhstan. It is vital to explore the nexus between these variables in case of Kazakhstan because being one of the fastest growing economies in Central Asia; it is faced with electricity challenges to fulfil its growing energy needs. The country has experience on average 7.7% economic growth rate between 2002-2011 (World Bank, [64]), whereas Kazakhstan's power sector is among the most efficient in the

Central Asia as it went through major power sector reform since it's independence in 1991. In order to avoid bias caused by omission of relevant variables, trade openness is added to turn the study into a trivariate investigation. In practice, trade openness and electricity consumption may individually have direct influence on economic growth. They may also serve as intermediate variables to each other, when impacting the economy. Economic growth may in turn also affect either electricity consumption or trade openness. In case of Kazakhstan, inclusion of trade openness as a control variable is plausible as it enhances aggregate demand, which in effect causes electricity consumption to grow.

The remainder of the paper is patterned as follows. Section 2 deals with literature review related to electricity consumption and economic growth Section 3 provides a summary of electric power in Kazakhstan and Section 4 illustrates the methodology employed in this study. Section 5 provides empirical results and the last section completes the paper.

2. Review of Literature

2.1 Economic Growth and Electricity Consumption

Theoretical and empirical studies on electricity consumption and economic growth linkage are widespread partly due to the significant role of energy in sustainable economic development. However, researchers are unable to arrive at a consensus on the flow of causality between energy consumption and economic growth. Conflicting results are present in papers on developed countries that adopt energy as proxy for energy usage (see Stern, [57]; Fatai et al. [9]; Glasure, [12]; Hondroyiannis et al. [16]; Ghali and El-Sakka, [9]; Oh and Lee, [35]; Ho and Siu, [15] and Payne, [37]).

Similarly, papers with emphasis on developing countries that employ electricity use as proxy for energy consumption do produce different findings, thereby justifying differing hypotheses. For example, Aqeel and Butt, [4] revealed one-way causation actually flows from electricity utilization to Pakistan's economy. Shahbaz and Lean, [49] probed the relationship between electricity consumption and economic growth in case of Pakistan by incorporating capital and labour in production function over the period of 1972-2009. They reported that electricity consumption adds in economic growth and bidirectional causality exists between both the series. On contrary, Jamil and Ahmad, [19] also did same exercise and suggested that electricity conservation policies would be appropriate. A similar inference is drawn by Shahbaz and Feridun, [47] on relationship between electricity consumption and economic growth using bivariate system[2].

Ghosh, [10] applied Granger causality to examine causal relationship between electricity consumption and economic growth and reported the presence of expansion hypothesis in case of India. However, in the case of India, the findings of Ghosh, [11] support conservation policies. Shiu and Lam, [53] used data of electricity consumption and economic growth to test the direction of causality for Chinese economy. Their results indicated unidirectional causal relation running from electricity consumption to economic growth and same inference is drawn by Yuan et al. [69]. Moreover, Yang, [65] applied both Granger causality and Hsiao Granger causality tests and detected bidirectional causality in case of Taiwan. On other hand, Hu and Lin [18] reported unidirectional causality flowing from economic growth to electricity consumption for Taiwan.

For Turkish economy, Altinay and Karagol, [3] investigated the relationship between electricity consumption and economic growth. They concluded that electricity consumption Granger causes economic growth. Acaravci and Qzturk, [1] re-examined the electricity-growth nexus by incorporating employment as control variable in case of Turkey. They reported unidirectional causality running from electricity consumption to economic growth. On contrary, Halicioglu, [14] also did same exercise to assess the relationship between electricity consumption and economic growth in Turkey. His empirical evidence indicated unidirectional causality running from economic growth to electricity consumption.

In case of Malaysia, Tang, [62] investigated the relationship between electricity consumption and economic growth using monthly frequency data over the period of 1972:1 to 2003:4. The results reported no cointegration between the series and feedback hypothesis was found using MWALD Granger causality test. Chandran et al. [6] probed the nexus between electricity consumption and economic growth by incorporating electricity prices. Their results reported that variables are cointegrated for long run relationship and electricity consumption Granger causes economic growth. On contrary, Lean and Smyth, [23] reported that unidirectional causality is running from economic growth to electricity consumption supporting the electricity conservation and management policies. Lorde et al. [25] investigated the cointegration and causality between electricity consumption and economic growth in case of Barbados. Their empirical evidence revealed cointegration and feedback hypothesis between electricity consumption and economic growth.

Country-specific studies in case of Africa also exist including Odhiambo, [32] who investigated causality between the both variables in case of South Africa and findings reported feedback hypothesis between electricity consumption and economic growth. Similarly; Jumbe, [20]; Ouédraogo, [36] and KouaKou, [21] detected bidirectional relationship between electricity consumption and growth in Malawi, Burkina Faso and Cote D'Ivoire, respectively. However, Odhiambo, [34] examined causality between electricity consumption and economic growth with labour participation as an intermediate variable and concluded that economic growth is Granger caused by electricity consumption for Kenya. Same conclusion is reached by Odhiambo, [33] on relationship between electricity consumption and economic growth using bivariate system for Tanzania.

Recently, Solarin and Bello, [55] probed the electricity-growth nexus for Nigerian economy by incorporating capital and labour in production function. They validated the presence of growth hypothesis which suggesting the exploration of new sources of energy to sustain economic growth. Tang and Tan, [61] re-investigated the relationship between electricity consumption and economic growth using Portuguese data by incorporating electricity prices and employment as potential determinant of electricity consumption and economic growth. They reported feedback effect between electricity consumption and economic growth. Economic growth and electricity prices Granger cause employment. In case of Romania, Shahbaz et al. [50] examined the dynamic relationship between electricity consumption, capital use and economic growth by applying cointegration and causality approaches. Their results indicated cointegration between the variables. The causality analysis revealed bidirectional causality between electricity consumption and economic growth while capita use Granger causes electricity consumption.

2.2 International Trade and Energy Consumption

The relationship between international trade and energy consumption has been investigated by various researchers. For example, Narayan and Smyth, [30] used multivariate Granger causality approach to investigate causal relationship between energy consumption, exports and economic growth in case of Middle Eastern countries[3]. Their empirical exercise did not show any relationship between exports and energy consumption. Erkan et al. [8] examined the relationship between energy consumption and exports in case of Turkey. They applied Johansen-Juselius cointegration approach and the VECM Granger causality approach for long run and causal relationship between the variables respectively. Their results showed cointegration between exports and energy consumption while energy consumption Granger causes exports. Similarly, in case of Malaysia, (Lean and Smyth, [23, 24]) reported that exports and energy consumption (energy generation) do not seem to Granger cause each other.

Sami, [44] used data of Japan to investigate the impact of exports on energy consumption by incorporating income per capita in energy demand function. The empirical analysis indicated cointegration between the variables and the VECM Granger causality confirmed from exports and economic growth to energy consumption. Sultan, [60] also investigated the relationship between aggregate output, exports and energy consumption in case of Mauritius. The results reported that variables are cointegrated and energy consumption and exports Granger cause economic growth. Sadorsky, [42] used panel cointegration data estimation techniques for the period of 1980-2007 in case of Middle East[4]. He found short-run dynamics of Granger causality from exports to energy consumption, and feedback relationship between imports and energy consumption. The long run positive effects of both exports and imports on energy consumption were also observed. Using Turkish data, Halicioglu, [13] investigated the causal relationship between economic growth, exports and energy consumption using multivariate Granger causality approach. The results showed long run relationship between the variables and unidirectional causality from exports to energy consumption in short run.

Hossain, [17] applied multivariate Granger causality approach to examine causal relationship between economic growth, exports, remittances and energy consumption using the data of SAARC countries[5]. The results of Johansen Fisher panel cointegration approach confirmed cointegration between the series and neutrality effect found between exports and energy consumption. Sadorsky, [43] also confirms the long run relationships between energy and exports; energy and imports; and energy and trade (exports and imports) using data of 7 South American countries[6]. For the short run dynamics, feedback relationship between energy consumption and exports, and energy consumption Granger causes imports is also revealed. In case of Pakistan, Shahbaz et al. [46] reinvestigated relationship between energy consumption and economic growth by incorporating exports in energy demand function. They applied the ARDL bounds testing for long run and innovative accounting approach for causal relationship between the variables. Their results indicated that variables are cointegrated and energy consumption Granger causes exports.

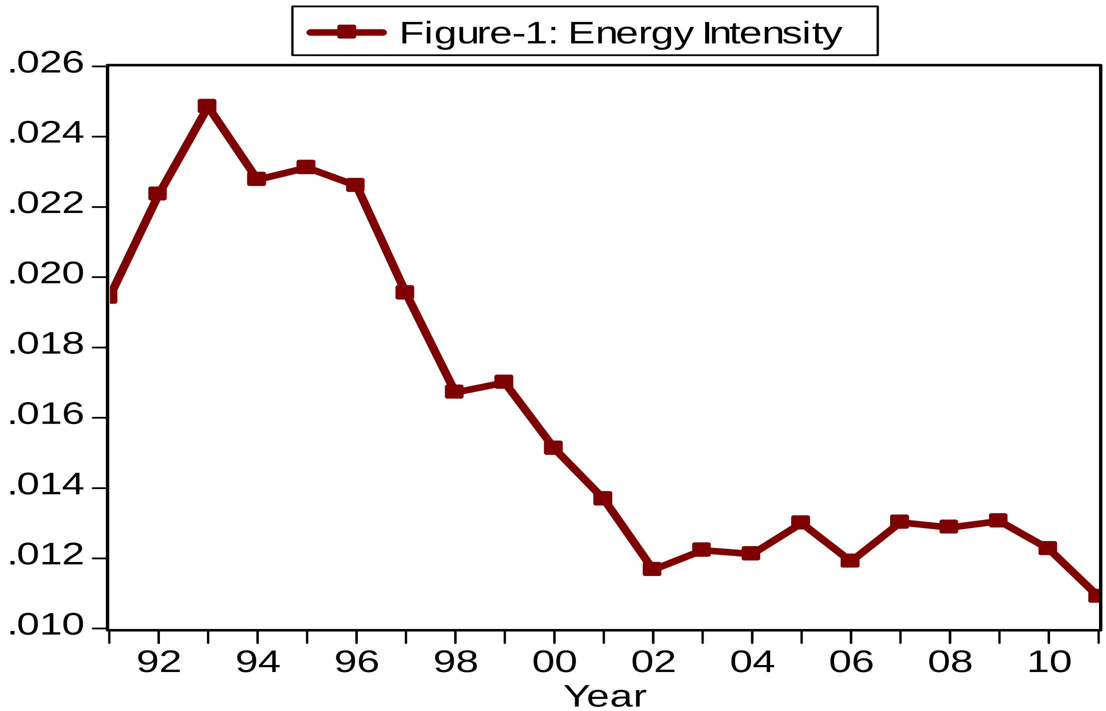
Overall, existing energy literature shows that there is none of studies investigating the relationship between electricity consumption and economic growth in Kazakhstan. The direction of causality between both variables is very important and helpful for policy makers in articulating a comprehensive energy policy to stimulate economic growth in long span of time.

This study is a pioneering effort to fill this gap in energy literature regarding Kazakhstani economy.

3. Kazakhstani Economy

Kazakhstan is one of the most successful Central Asian countries. Kazakhstan has essentially completed its transitional phase and gradually emerging into an industrial country. As such it holds many lessons for other transitional and developing economies. It's economic performance and policies deserve to be studied carefully. This paper analyzes issues and evidence relating to economic growth and electricity consumption in Kazakhstan.

Kazakhstan's economy has gone through stages of economic growth since its independence. The period from 1990 to 1997 was the period of negative economic growth, or at best stagnation (in 1995−1997, economic growth was close to zero). Kazakhstan entered the phase of strong and sustained growth since 1998. Even though Kazakhstan is significant oil and gas producer, its oil and gas reserves are in the West, far from the major population and industrial centers in the North and Southeast. The country has a unified grid system with two main parts: one serving the North and a second in the Southeast, which is linked into the Central Asian grid. Coal is the main uel for power and coal's role in power generation is increasing. The government of Kazakhstan has few dedicated programs to promote energy efficiency. Kazakhstan launched a major reform of its electricity system in 1996. The power generation stations and distribution networks were then privatized in 1997. The Ministry of Finance agreed to take on most of the past liabilities of the companies being privatized. The government also established a wholesale power market in 1996 and this market working efficiently since then.



Kazakhstan is open to international trade. Its main export goods are oil, petroleum products, coal, iron ore, chemical products, machinery, cereal, wool and meat. Its main export partners are China (number one), followed by Russia and Germany. According to a declaration of the vice-minister of the economic development dated in November 2010, Kazakhstan could join the WTO in 2012. The country mainly imports machinery, electric and electronic equipment and food products. Kazakhstan's main import partners are Russia (31.2%), China (12.7%), Ukraine (7.6%), Germany (7.2%) and France (1.6%). Kazakhstan recovered from its recent financial crisis mainly due to the revenue generated through oil export. Government of Kazakhstan bailed out its financial sector with the skillful use of its oil revenue. From our discussion, we can clearly see the inter-linkages among the electricity consumption, economic growth and trade openness in Kazakhstan. This paper is modest attempt to fill the research gap in this direction.

4. Data sources and methodological framework

We have combed world development indicators (CD-ROM, 2011) to obtain data on real GDP, electricity consumption, trade (exports + imports), capital and labor over the period of 1991-2011. We have used series of population to normalize the series into per capita. All data are of annual frequency.

Natural scientists and some ecological economists argue that energy enhances domestic production and thus promotes economic growth. Mainstream economists believe that capital and labor are primary factors (Stern, [57]), and efficient use of energy depends on the primary inputs of production and as such capital and labor should also be incorporated in production function to examine their marginal contribution in domestic production (Stern, [58]). In this paper, we use extended neoclassical production function by incorporating trade openness to investigate the causal relationship between electricity consumption and economic growth in Kazakhstan. The general form of neoclassical production function thus includes trade openness, electricity consumption, capital and labor.

$$Y_t = f(E_t, TR_t, K_t, L_t) \tag{1}$$

All series are in log-linear form. In our empirical specification we implement the following multivariate neoclassical production function framework:

$$\ln Y_t = \alpha_1 + \alpha_E \ln E_t + \alpha_{TR} \ln TR_t + \alpha_K \ln K_t + \alpha_L \ln L_t + \mu_t \tag{2}$$

where $\ln Y_t$, $\ln E_t$, $\ln TR_t$, $\ln K_t$ and $\ln L_t$ are log of real GDP per capita, per capita electricity consumption in KWH, real trade per capita [(real exports + real imports) / population] proxy for trade openness, real capital per capita and labor per capita respectively, and μ_t is the error term and assumed to be normally distributed.

4.1. Zivot-Andrews Unit Root Test

Time series variables always show some trends that's why the properties of stationarity is necessary. Stationarity properties of the macroeconomic variables can be investigated by applying a variety of unit root tests which are available in applied economics. Numerous stationarity tests such as ADF by Dickey and Fuller, [71]; P-P by Philips and Perron, [40]; Ng-Perron by Ng-Perron, [40] have been applied to test the unit root properties of the variables. These unit root tests do seem to have information about structural breaks arising in the series. The drawback about the absence of structural break points has been removed by Zivot-Andrews, [70] by developing three new econometric models. These econometric models are very useful in investigating the stationarity properties of the macroeconomic variables in the presence of structural break points in the series. These models allow (i) a one-time change in variables at level form, (ii) a one-time change in the slope of the trend component i.e. function and (iii) a model has one-time change both in intercept and trend function of the variables to be used for empirical propose. Zivot-Andrews, [70] adopted three models to check the hypothesis of one-time structural break in the series as follows:

$$\Delta x_t = a + ax_{t-1} + bt + cDU_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \qquad (3)$$

$$\Delta x_t = b + bx_{t-1} + ct + bDT_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \qquad (4)$$

$$\Delta x_t = c + cx_{t-1} + ct + dDU_t + dDT_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \qquad (5)$$

In the above equation dummy variable is represented by DU_t showing mean shift occurred at each point with time break, while trend shift variables is shown by DT_t. So,

$$DU_t = \begin{cases} 1 \ldots if \quad t > TB \\ 0 \ldots if \quad t < TB \end{cases} \text{ and } DU_t = \begin{cases} t - TB \ldots if \ t > TB \\ 0 \ldots if \ t < TB \end{cases}$$

The null hypothesis of unit root break date is $c = 0$ which indicates that series is not stationary with a drift not having information about structural break point while $c < 0$ hypothesis implies that the variable is found to be trend-stationary with one unknown time break. Zivot-Andrews unit root test fixes all points as potential for possible time break and does estimate through regression for all possible break points successively. Then, this unit root test selects that time break, which decreases one-sided t-statistic to test $\hat{c}(= c - 1) = 1$. Zivot-Andrews intimate that in the presence of end points, asymptotic distribution of the statistics is diverged to infinity point. It is necessary to choose a region where end points of sample period are excluded. Further, Zivot-Andrews suggested the trimming regions i.e. (0.15T, 0.85T) are followed.

4.2. The ARDL Bounds Testing for Cointegration

This paper applies the autoregressive distributed lag (ARDL) bounds testing approach to cointegration developed by Pesaran et al. [39] to examine a long run relationship among electricity consumption, trade openness, economic growth, capital and labour. The method has several advantages over the traditional ones. For example, the method applies even if the regressors are integrated at I(1) or I(0) or I(1)/I(0). A dynamic unrestricted error correction model can be derived from the ARDL bounds testing through a simple linear transformation. The ARDL bounds testing approach is better suited for small sample as in this paper. An unrestricted error correction model (UECM) combines the short-run dynamics with the long-run equilibrium without losing any long-run information. The UECM is expressed as follows:

$$\begin{aligned}\Delta\ln Y_t = {} & \vartheta_1 + \vartheta_D D + \vartheta_Y \ln Y_{t-1} + \vartheta_E \ln E_{t-1} + \vartheta_{TR} \ln TR_{t-1} + \vartheta_K \ln K_{t-1} + \vartheta_L \ln L_{t-1} + \sum_{i=1}^{p} \vartheta_i \Delta\ln Y_{t-i} \\ & + \sum_{j=0}^{q} \vartheta_j \Delta\ln E_{t-j} + \sum_{k=0}^{r} \vartheta_k \Delta\ln TR_{t-k} + \sum_{l=0}^{s} \vartheta_l \Delta\ln K_{t-l} + \sum_{m=0}^{t} \vartheta_m \Delta\ln L_{t-m} + \mu_t\end{aligned} \tag{6}$$

$$\begin{aligned}\Delta\ln E_t = {} & \alpha_1 + \alpha_D D + \alpha_Y \ln Y_{t-1} + \alpha_E \ln E_{t-1} + \alpha_{TR} \ln TR_{t-1} + \alpha_K \ln K_{t-1} + \alpha_L \ln L_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta\ln E_{t-i} \\ & + \sum_{j=0}^{q} \alpha_j \Delta\ln Y_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta\ln F_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta\ln K_{t-l} + \sum_{m=0}^{t} \alpha_m \Delta\ln L_{t-m} + \mu_t\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta\ln TR_t = {} & \beta_1 + \beta_D D + \beta_Y \ln Y_{t-1} + \beta_E \ln G_{t-1} + \beta_{TR} \ln TR_{t-1} + \beta_K \ln K_{t-1} + \beta_L \ln L_{t-1} + \sum_{i=1}^{p} \beta_i \Delta\ln F_{t-i} \\ & + \sum_{j=0}^{q} \beta_j \Delta\ln Y_{t-j} + \sum_{k=0}^{r} \beta_k \Delta\ln E_{t-k} + \sum_{l=0}^{s} \beta_l \Delta\ln K_{t-l} + \sum_{m=0}^{t} \beta_m \Delta\ln L_{t-m} + \mu_t\end{aligned} \tag{8}$$

$$\begin{aligned}\Delta\ln K_t = {} & \rho_1 + \rho_D D + \rho_Y \ln Y_{t-1} + \rho_E \ln E_{t-1} + \rho_F \ln F_{t-1} + \rho_K \ln K_{t-1} + \rho_L \ln L_{t-1} + \sum_{i=1}^{p} \rho_i \Delta\ln K_{t-i} \\ & + \sum_{j=0}^{q} \rho_j \Delta\ln Y_{t-j} + \sum_{k=0}^{r} \rho_k \Delta\ln E_{t-k} + \sum_{l=0}^{s} \rho_l \Delta\ln TR_{t-l} + \sum_{m=0}^{t} \rho_m \Delta\ln L_{t-m} + \mu_t\end{aligned} \tag{9}$$

$$\Delta \ln L_t = \sigma_1 + \sigma_D D + \sigma_Y \ln Y_{t-1} + \sigma_E \ln E_{t-1} + \sigma_{TR} \ln TR_{t-1} + \sigma_K \ln K_{t-1} + \sigma_L \ln L_{t-1} + \sum_{i=1}^{p} \sigma_i \Delta \ln L_{t-i}$$
$$+ \sum_{j=0}^{q} \sigma_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \sigma_k \Delta \ln E_{t-k} + \sum_{l=0}^{s} \sigma_l \Delta \ln TR_{t-l} + \sum_{m=0}^{t} \sigma_m \Delta \ln K_{t-m} + \mu_t \quad (10)$$

The notation Δ is the 1st difference operator and μ_t is the error terms. The F-statistic used to make decision about the hypothesis is sensitive with lag order selection. The latter is chosen based on the minimum value of Akaike Information Criteria (AIC). Pesaran et al. [39] developed F-test to determine the joint significance of the coefficients of lagged level of the variables. The absence of cointegration among the series (eq. 3) is, $H_0 : \vartheta_Y = \vartheta_E = \vartheta_{TR} = \vartheta_K = \vartheta_L = 0$ against the alternate of cointegration is, $H_a : \vartheta_Y \neq \vartheta_E \neq \vartheta_{TR} \neq \vartheta_K \neq \vartheta_L \neq 0$. Pesaran et al. [39] generated two asymptotic critical values, the upper critical bound (UCB) and lower critical bound (LCB) to make decisions about cointegration. The LCB is used if all the series are I(0), and the UCB otherwise. The computed F-statistics are based on, $F_Y(Y / E, TR, K, L)$, $F_E(E/Y, TR, K, L)$, $F_{TR}(TR/Y, E, K, L)$, $F_K(K / Y, E, TR, L)$ and $F_L(L/Y, E, TR, K)$ (equations (6) - (10)) respectively. A long run relationship among the series is sustained if calculated F-statistic exceeds the UCB. There is no such relation, if the calculated F-statistic lies below the LCB. Our decision is inconclusive if the F-statistic lies between the LCB and the UCB. In such a case, error correction method may be suitable to investigate the cointegration. We use the critical bounds generated by Narayan, [27] rather than Pesaran et al. [39]. The latter is suitable for large samples (T = 500 to T = 40, 000). Narayan and Narayan, [28] points out that the critical in Pesaran et al. [39] are significantly downwards and thus may produce biased outcome. The UCB and LCB by Narayan, [27] are more appropriate for small sample (T = 30 to T = 80).

4.3. The VECM Granger Causality Approach

After confirming cointegration we examine causality between pairs of the series which we do using the VECM. The VECM is restricted form of unrestricted VAR (vector autoregressive). All the series are considered endogenous in the system of error correction model (ECM) where the response variable is explained both by its own lags, lags of independent variables, and the lagged residuals. The VECM in five variables case can be written as follows:

$$(1-L)\begin{bmatrix} \ln Y_t \\ \ln E_t \\ \ln TR_t \\ \ln K_t \\ \ln L_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} b_{11i}b_{12i}b_{13i}b_{14i}b_{15i} \\ b_{21i}b_{22i}b_{23i}b_{24i}b_{25i} \\ b_{31i}b_{32i}b_{33i}b_{34i}b_{35i} \\ b_{41i}b_{42i}b_{43i}b_{44i}b_{45i} \\ b_{51i}b_{52i}b_{53i}b_{54i}b_{55i} \end{bmatrix} \times \begin{bmatrix} \ln Y_{t-1} \\ \ln E_{t-1} \\ \ln TR_{t-1} \\ \ln K_{t-1} \\ \ln L_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha \\ \beta \\ \delta \\ \phi \\ \varphi \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad (11)$$

Where ε_{it} are error terms assumed N~(iid). A significant (ECT_{t-1}) shows the speed of convergence from short to the long run equilibrium. Estimated ECT_{t-1} if negative and significant, confirms long run causality. Short run causality is checked by the joint significance of χ^2 on the first difference lagged independent variables. For example, the significance of $\alpha_{22,i} \neq 0\forall_i$ implies that electricity consumption Granger causes economic growth; and causality runs from economic growth to electricity consumption is indicated by the significance of $\beta_{22,i} \neq 0\forall_i$. The same inference can be drawn for rest of causality hypotheses. Finally, we use Wald or F-test for joint significance of estimates of lagged terms of the independent variables and error correction term. This further confirms the existence of short-and-long run causality relations and known as measure of strong Granger causality (Oh and Lee, [35]).

5. Results and their Interpretations

Our empirical discussion starts from descriptive statistics and correlation matrix. The results are reported in Table-1. The results specify that all the series have been normally distributed. The mean is and variance is constant of the residual terms of the series. The correlation matrix reveals that there is a positive and strong correlation exists between electricity consumption and economic growth. Trade openness, capital and labour are positively correlated with economic growth. Electricity consumption is positively linked with trade openness and capital but negative correlation exists between labour and electricity consumption. A positive correlation is found capital and trade while same inference is drawn for labour and trade. Finally, capital and labour are positively interlinked.

Table-1: Descriptive Statistics and Correlation Matrix

Variables	$\ln Y_t$	$\ln E_t$	$\ln TR_t$	$\ln K_t$	$\ln L_t$
Mean	12.2826	8.3047	12.2051	10.9923	-0.6796
Median	12.2190	8.3042	12.2888	10.9712	-0.6788
Maximum	12.7739	8.6835	12.7561	11.8921	-0.6201
Minimum	11.8871	7.9509	11.5104	10.1455	-0.7374
Std. Dev.	0.3093	0.1999	0.4105	0.5992	0.0406
Skewness	0.2854	0.0685	-0.3849	0.0526	-0.0194
Kurtosis	1.6660	2.4111	1.6884	1.5938	1.5281
Jarque-Bera	1.8422	0.3198	2.0238	1.7399	1.8968
Probability	0.3980	0.8521	0.3635	0.4189	0.3873

$\ln Y_t$	1.0000				
$\ln E_t$	0.4155	1.0000			
$\ln TR_t$	0.8199	0.6988	1.0000		
$\ln K_t$	0.7668	0.8679	0.8405	1.0000	
$\ln L_t$	0.7931	-0.1778	0.4102	0.2430	1.0000

The next step is to test the unit root properties of economic growth, electricity consumption, trade, capital and labor. In doing so, we have applied ADF (Dickey and Fuller, [71]) unit root test to test the order of integration. Although, the ARDL bounds testing approach to cointegration is flexible whether variables are integrated at I(0) or I(1) or I(0)/ I(1). But it is important to have information about the unit root properties of the variables. The assumption of the ARDL bound testing approach is that the series under investigation should be integrated at I(0) or I(1). If any variable is found to be stationary beyond that order of integration, then process of computing the ARDL F-statistic becomes unusable. Just to ensure that none of the variables is stationary at 2^{nd} difference. The results of ADF root test are detailed in Table-2. The results indicate that economic growth, electricity consumption, trade, capital and labor have unit root problem at level with constant and trend. Both series are stationary at 1^{st} difference indicated by statistics of ADF. This shows that series have same order of integrated i.e. I(1).

Table-2: Unit Root Analysis

Variables	ADF Unit Root Test	
	T-statistic	Prob-Values
$\ln Y_t$	-2.9834	0.1643
$\Delta \ln Y_t$	-6.0602 (3)*	0.0005
$\ln E_t$	-2.4031 (1)	0.3661
$\Delta \ln E_t$	-6.1600 (2)*	0.0005
$\ln TR_t$	-2.7736 (1)	0.2222
$\Delta \ln TR_t$	-3.3135 (0)***	0.0941
$\ln K_t$	-2.1278(1)	0.4991
$\Delta \ln K_t$	-6.0600 (2)*	0.0006
$\ln L_t$	-0.9113 (1)	0.9305
$\Delta \ln L_t$	-5.0006 (2)*	0.0010

Note: * and *** represent significant at 1 and 10 per cent level of significance. Lag order is shown in parenthesis.

Table-3: Zivot-Andrews Structural Break Unit Root Test

Variable	**At Level**		**At 1st Difference**	
	T-statistic	Time Break	T-statistic	Time Break
$\ln Y_t$	-4.213 (1)	2009	-5.808 (2)*	2004

$\ln E_t$	-4.079 (1)	1998	-5.894 (0)*	2001
$\ln TR_t$	-4.763 (0)	1994	-5.796 (0)*	2000
$\ln K_t$	-4.417 (0)	1996	-5.554 (0)**	2001
$\ln L_t$	-2.790 (1)	2009	-5.380 (1)*	2009
Note: * and ** represent significant at 1% and 5% levels of significance. Lag order is shown in parenthesis.				

The problem with these unit root tests is that they do not have information about structural break stemming in the series. In such an environment, application of these tests provides unreliable and biased results. Baum, [5] forced to apply structural break unit root test to examine unit root properties of the variables. The reason is that misleading results about order of integration of the variables would be help for policy makers in articulating comprehensive economic policy. To overcome this objection, we choose to apply Zivot-Andrews (Zivot and Andrews, [70]) structural break unit root test which allows having information about single unknown structural break stemming in the time series.

The results are reported in Table-3. The results indicate that the variables do have unit root problem at level with a structural break both in intercept and trend. All variables are found to be stationary at 1st difference. This implies that the variables are integrated at I(1). The unique integrating properties of the both series leads us to implement the ARDL bounds testing approach to cointegration examining the long run relationship between economic growth, electricity consumption, trade, capital and labor over the study period in case of Kazakhstan. An appropriate lag order of the variables is needed to apply the ARDL bounds testing. Various lag length criterion are available indicated in Table-4. We followed Akaike information criterion to select appropriate lag length. It is pointed by Lütkepohl, [26] that AIC has superior power properties for small sample data compared to any lag length criterion. Our decision about lag length is based on the minimum value of AIC. The results are reported in Table-4. It is found that we cannot take lag more than 1 in such small sample data.

Table-4: Lag Order Selection

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	94.23065	NA	5.74e-11	-9.3927	-9.1441	-9.3506
1	203.5336	149.5725*	8.97e-15*	-18. 3030*	-16.7754*	-18.0143*
2	228.8786	21.3431	1.76e-14	-18.2667	-15.5691	-17.8403

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

The next step is to examine a long run relationship among the variables. The results of the ARDL bound testing approach to cointegration reported in Table-5 show that our calculated F-statistics i.e. 11.361, 9.922 and 12.158 exceed upper critical bounds at the 1% and 5% level of significance when economic growth, trade openness and labor are used as predicted variables.

Our sample consists of 21 observations (1991-2011) so, critical values from Pesaran et al. [39] are inappropriate. As such, we chose to use the lower and upper critical bounds generated by Narayan, [27]. We find three cointegration vectors and thus a long run relationship among economic growth, electricity consumption, trade openness, capital and labor for Kazakhstan over the period of 1991-2011.

Table-5: ARDL Cointegration Analysais

Variable	$\ln Y_t$	$\ln E_t$	$\ln TR^2$	$\ln K_t$	$\ln L_t$
F-statistics	11.361*	3.943	9.922**	1.177	12.158*
Structural Breaks	2009	1998	1994	1996	2009
Critical values#	1 % level	5 % level	10 % level		
Lower bounds	10.150	7.135	5.950		
Upper bounds	11.130	7.980	6.680		
$Adj-R^2$	0.9126	0.9549	0.7721	0.9962	0.9833
F-statistic	13.6851*	23.5190*	5.3559**	28.1550*	15.8727*

Note: *, ** and *** show significant at 1%, 5% and 10% levels respectively. # Critical values bounds are from Narayan, [27] with unrestricted intercept and unrestricted trend.

The existence of long run relationship between the variables leads us to examine long run impacts of electricity consumption, trade openness, capital and labor on economic growth. The results are reported in Table-6. The results reveal that electricity consumption has positive impact on economic growth and it is statistically significant at 1 per cent level of significance. It is noted that a 1 per cent increase in electricity consumption is linked with 0.2796 per cent increase in economic growth keeping other economic agents (variables) constant. The impact of trade openness is positive on economic growth at 1 per cent level of significance. All else is same, a 0.1846 per cent in economic growth is stimulated by a 1 per cent increase in trade openness. Capital and economic growth are positively related and this relation is statistically significant at 5 per cent significant level. It is documented that a 1 per cent increase in capital stock raises domestic production and hence economic growth by 0.0947 per cent keeping other things constant. The impact of labor on economic growth is positive and significant at 1 per cent level. The evidence shows that keeping other things constant, a 1 per cent increase in labor leads economic growth by 5.5003 per cent. This shows that labor plays a vital role in production function to increase economic growth.

Table-6: Long and Short Runs Analysis

Dependent Variable = $\ln Y_t$			
Long-Run Results			
Variable	Coefficient	Std. Error	T-Statistic
Constant	10.3879*	0.4160	24.9692
$\ln E_t$	0.2796*	0.0898	3.1107
$\ln TR_t$	0.1846*	0.0373	4.9407
$\ln K_t$	0.0947**	0.0397	2.3820
$\ln L_t$	5.5003*	0.3159	17.4094
R^2	0.9914		
F-statistic	405.4396*		

D. W Test	1.7945		
Short-Run Results			
Variable	Coefficient	Std. Error	T-Statistic
Constant	0.0207**	0.0085	2.4140
$\ln E_t$	0.1251	0.1115	1.1222
$\ln TR_t$	0.1240*	0.0387	3.2022
$\ln K_t$	0.2037*	0.0380	5.3495
$\ln L_t$	1.6721	1.1240	1.4876
ECM_{t-1}	-0.8656**	0.3193	-2.7110
R^2	0.8534		
F-statistic	15.1357*		
D. W Test	1.9715		
Short Run Diagnostic Tests			
Test	F-statistic	Prob. Value	
χ^2 *NORMAL*	2.2779	0.3201	
χ^2 *SERIAL*	0.6234	0.5539	
χ^2 *ARCH*	1.0159	0.3284	
χ^2 *WHITE*	1.3177	0.3548	
χ^2 *REMSAY*	0.0684	0.7979	
Note: * and ** represent significance at 1% and 5% levels respectively.			

The short run impact of electricity consumption, trade openness, capital and labor on economic growth is examined using the error correction method (ECM). In the short run, electricity consumption is positively and insignificantly linked with economic growth. The contribution of trade to economic growth is positive and statistically significant. Similarly, capital is also important determinant of economic growth and effect of labor on economic growth is positive but statistically insignificant. The significant and negative lagged ECM_{t-1} (-0.8656) confirms long run relationship. The term is significant at the 1 per cent level (lower segment of Table-6), which suggests that short run deviations in economic growth are corrected by 86.56 per cent every year towards the long run equilibrium and may take 1 year and 2 month to reach stable long run equilibrium path.

The short run model also passes diagnostic tests following CLRM assumptions. The results show that the variables are not serially correlated with residual term. There is no existence of autoregressive conditional heteroskedasticity. White heteroskedasticity is not found in the short run model. The short run model is well specified. The stability of long run and short run estimates has been tested by applying the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) are applied. It is suggested by Pesaran and Shin, [39] to apply these tests. The null hypothesis of both CUSUM and CUSUMsq may be accepted that if plots of both tests are moving between critical limits. The null hypothesis is regressions equation is correctly specified.

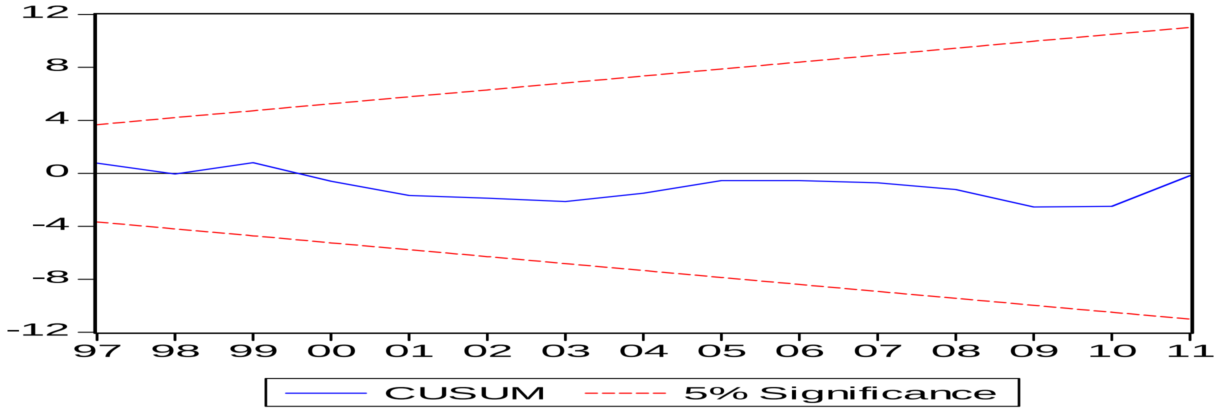


Figure-2: Plot of Cumulative Sum of Recursive Residuals. The straight lines represent critical bounds at 5% significance level

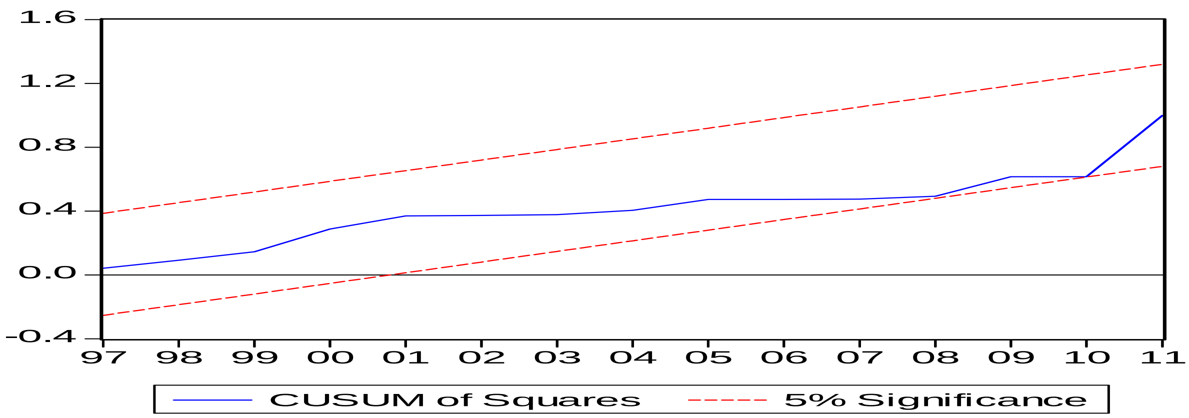


Figure-3: Plot of Cumulative Sum of Squares of Recursive Residuals. The straight lines represent critical bounds at 5% significance level

The CUSUM and CUSUMsq tests show that graphs of both tests do not cross lower and upper critical limits as shown in Figure-2 and 3. So, we can conclude that long and short runs estimates are reliable and efficient.

The VECM Granger Causality Analysis

If cointegration is confirmed, there must be uni-or bidirectional causality between/ among the series. We examine this relation within the VECM framework. Such knowledge is helpful in crafting appropriate energy policies for sustainable economic growth. Table-7 reports results on the direction of long and short run causality. Our results indicate that electricity consumption Granger causes economic growth in long run. This implies that electricity consumption plays a vital role in enhancing domestic production and hence economic growth. This suggests exploring new sources of energy to sustain economic growth for long span of time. One of the priority areas in developing electric power industry and meeting environmental challenges in Kazakhstan today is the use of renewable energy resources and implementation of energy and resource saving programs.

The potential of renewable energy resources (hydropower, wind and solar energy) in Kazakhstan is very significant. However, the percentage of alternative energy generation in Kazakhstan is only 0.4% of the total amount, but has the potential for significant augmentation. The bidirectional causality exists between trade openness and economic growth. This reveals that consistent supply of electricity in perquisite increase economic growth rate by boosting trade. Electricity consumption also Granger causes trade openness, capital and labor in long run. The feedback effect is found between trade openness and labor and same inference can be drawn between economic growth and labor.

In short run, bidirectional causal relationship exists between economic growth and trade openness. The feedback effect is found between electricity consumption and capital. Economic growth Granger causes capital. The joint long-and-short runs causality analysis corroborates our long run and short run results.

Table-7: VECM Granger Causality Analysis

Type of Granger Causality											
Dependent Variables	Short-run					Long-run	Joint (short- and long-run)				
	$\ln Y_t$	$\ln E_t$	$\ln TR_t$	$\ln K_t$	$\ln L_t$	ECT_{t-1}	$\ln Y_t, ECT_{t-1}$	$\ln E_t, ECT_{t-1}$	$\ln TR_t, ECT_{t-1}$	$\ln K_t, ECT_{t-1}$	$\ln L_t, ECT_{t-1}$
	F-statistics [p-values]					(T-statistics)	F-statistics [p-values]				
$\ln Y_t$	…	0.2551 [0.7809]	21.3885* [0.0006]	1.9908 [0.1987]	0.6440 [0.5500]	-0.5680** (-2.8249)	…	3.5834*** [0.0661]	20.2469* [0.0004]	3.2763*** [0.0797]	2.7877*** [0.1095]
$\ln E_t$	1.7969 [0.2045]	…	1.0194 [0.3989]	2.9364*** [0.1045]	1.9711 [0.1950]	…	…	…	…	…	…
$\ln TR_t$	3.3674*** [0.0869]	2.1965 [0.1736]	…	0.0271 [0.9733]	0.1638 [0.8516]	-0.8887* (-3.5859)	4.5749** [0.0380]	7.3920** [0.0108]	…	5.7286** [0.0216]	8.2305* [0.0079]
$\ln K_t$	4.7632** [0.0388]	3.7722*** [0.0646]	0.4367 [0.6591]	…	1.6502 [0.2452]	…	…	…	…	…	…
$\ln L_t$	0.8667 [0.4563]	0.5671 [0.5884]	0.5431 [0.6009]	1.9244 [0.2078]	…	-0.7756** (-3.0887)	4.0423** [0.0507]	6.6304** [0.0146]	4.6038** [0.0374]	3.2822*** [0.0795]	…
Note: *, ** and *** show significant at 1%, 5% and 10% levels respectively. Prob-values and T-statistics are given in [] and () respectively.											

6. Conclusion and Future Directions

This paper visits the dynamics relationship between electricity consumption and economic growth in Kazakhstan by incorporating trade openness in production function. The empirical evidence indicates that electricity consumption, economic growth, trade openness, capital and labor are in the long-run equilibrium. We also find that electricity consumption, trade openness, capital and labor have positive and significant impact on economic growth. Unidirectional causal relationship is found running from electricity consumption to economic growth. Feedback hypothesis exists between trade openness and economic growth. Bidirectional causal relation is also found between trade openness and labour and, same views about economic growth and labour relationship.

Figure-1 shows the decline trend of energy intensity over the sample period. This decline in energy intensity is due to the adoption of energy efficient technology in various sources of energy in Kazakhstan and shift of economic activity. Furthermore, adoption of autonomous energy efficient techniques also plays an important role to decline energy intensity. Therefore we conclude that electricity conservation policies may inversely affect the rate of economic growth and in turn, cause a decline in economic growth and will in turn lower the demand for electricity. This fact suggests that the Government of Kazakhstan must change their policy focus to support research and development expenditures to explore new sources of energy in order to meet the rising demand for electricity and power; and adopt more advanced technology to produce and save energy. The adoption of advanced technology will not only prevent environmental degradation but also sustain economic development in the country. Additionally, alternative energies such as solar power, hydro power, and wind power should be seriously considered because these alternative energy production methods are environmentally friendly compared to the current fossil fuel powered production infrastructure.

Our model has the potential to further investigate the relationship between electricity consumption and economic growth by including other variables such as: renewable and non-renewable electricity consumption following Shahbaz et al. [52]; electricity prices and exports as indicated by Lean and Smyth, [23]; financial development and urbanisation explored by Shahbaz and Lean, [48]; exchange rate mentioned by Karanfil, (2009). The relationship between electricity consumption at disaggregated levels and economic growth could be explored such as in case of Kazakhstan, which had been conducted by Payne, [37] in the US. Analysis on disaggregated electricity consumption and economic growth will be more useful for policy makers to formulate a comprehensive policy with a view towards saving energy and reducing environmental degradation. Thus, our empirical model could serve as a benchmark for academic research as well.

Footnotes

1. Although this analogy is commonplace in existing energy literature, the signs of the long run coefficients are actually required to ascertain if electricity consumption and economic growth are positively related or otherwise.
2. Findings by Shahbaz and Feridun, [47] may be biased due to avoiding the role of capital and labor in production function and their impact on electricity consumption. Furthermore, Nawaz et al. [31] reported unidirectional causality running from economic growth to energy consumption.
3. Iran, Israel, Kuwait, Oman, Saudi Arabia and Syria
4. Bahrain, Iran, Jordan, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates
5. Bangladesh, India and Pakistan
6. Argentina, Brazil, Chile, Ecuador, Paraguay, Peru, Uruguay

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