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Abstract:

We investigate the relation between electricity consumption and economic growth by incorporating trade openness, capital, and labor in production function of Kazakhstan using annual data for 1991-2014. We apply the ARDL bounds testing and the VECM Granger causality approach to examine long run and causality relation between the variables. Our results confirm the existence of long run relation among the series. The empirical evidence reveals that electricity consumption adds in economic growth. Trade openness stimulates economic growth, and capital and labor promote economic growth, as well. The causality analysis shows that electricity consumption Granger causes economic growth and trade openness. We also document feedback effect between trade openness and economic growth. Our study provides new insights for policy makers to articulate a comprehensive economic, trade and energy policy to sustain long run economic growth in Kazakhstan.

Keywords: Electricity, Economic growth, Kazakhstan, VECM

1. Introduction

Electricity is the prime source of energy and a major policy concern for sustainable development. Its accessibility helps to meet residential and domestic needs, contributes to capital and labor productivity, promotes export potentials of countries to create employment, decreases the poverty level, and eventually improves socio-economic development. As such, electricity plays a vital role in the development of a country, virtually bringing benefits to all productive sectors of an economy. Growing energy consumption, particularly commercial sector signifies the potential for higher economic activities of a country (Jumbe, 2004). These facts have attracted many authors to investigate the role of electricity in different countries. Kraft and Kraft (1978), in their pioneer work, investigated the relation between electricity consumption and economic development and other authors follow suits for different countries.

A large body of empirical studies including Aqeel and Butt (2001), Yoo (2005), Yoo (2006), Chen et al. (2007), Ho and Siu (2007), Hu and Lin (2008), Jamil and Ahmad (2010), Narayan and Smyth (2005), Shahbaz et al. (2011), Shahbaz and Lean (2012b), Shahbaz and Feridun (2012), Tang and Shahbaz (2013), Tang et al. (2013), Zeshan and Ahmed (2013), and Sbia et al. (2014) investigate the relation between electricity consumption and economic growth and provide mixed results. The mixed empirical results in the literature primarily reflect the differences among empirical settings – country, period, and estimation methodologies (Al Mamun et al. 2014). For example, Zhang (2011) investigate the relation between energy consumption and economic growth in Russia, a country with similar historical energy baggage like Kazakhstan. Using time-varying methodology Zhang (2011) finds that energy consumption and economic growth are complementary, i.e., energy consumption causes economic growth and resulting economic growth leads energy consumption. Damette and Seghir (2013) examine the relation between energy consumption and economic growth in oil exporting countries namely Brazil, Canada, Mexico, Norway and Russia using panel cointegration and causality approaches. Damette and Seghir (2013) document that economic growth has a positive impact on energy consumption. Das et al. (2012) apply a generalized method of moments (GMM) approach to investigate the dynamics of electricity consumption and economic growth nexus in 45 developing countries over the period 1971–2009. Their results show a positive relation between electricity consumption and economic growth in a full panel. They document a positive growth-electricity nexus for Asia, the Pacific, and the sub-Saharan African region. Narayan and Smyth (2009) study the relation among electricity, exports, and output in a panel of six Middle Eastern countries and provide evidence of a statistically significant feedback effect among these variables.

Squalli (2007) investigates the relation between electricity consumption and economic growth for OPEC members by using the bounds test based on the unrestricted ECM. The paper finds a unidirectional causality running from electricity consumption to economic growth in Indonesia, Nigeria, UAE, and Venezuela while economic growth Granger causes electricity consumption in Algeria, Iraq, Kuwait, and Libya. Chen et al. (2007) find evidence of long-run bidirectional causality between electricity consumption and economic growth in a panel of 10 Asian countries. They document a short-run unidirectional causality running from economic growth to electricity consumption, although the short-run adjustment is slow and sluggish before building up to long-run causality. The absence of a reverse causality from electricity to economic growth indicates that energy conservation would not hamper economic growth in their sample. Moreover, economising electricity consumption can be achieved without compromising economic growth. Yoo (2006) investigated the causal relation between electricity consumption and economic growth among the four members of the Association of South East Asian Nations (ASEAN), namely: Indonesia, Malaysia, Singapore, and Thailand. Their results indicate the bidirectional causality between electricity consumption and economic growth in Malaysia and Singapore. Apergis and Payne (2011) applied a panel ECM method for a sample of 16 emerging market economies over the period of 1990–2007. Their results revealed the unidirectional causality from economic growth to renewable electricity consumption in the short run, but bidirectional causality in the long run. Wolde-Rufael (2006) found limited support for electricity- led growth hypothesis for 15 transitional economies for the period 1975-2010 using a bootstrap panel causality approach.

In this paper, 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 the production function of Kazakhstan. Despite the existence of vast empirical literature that studied the electricity-growth nexus, we are not aware of any papers that investigated the causal relation between electricity consumption and economic growth for Kazakhstan with an econometric technique that accommodates structural breaks. Additionally, the economic rationale for Kazakhstan as an empirical setting is unique. It is the dominant nation of Central Asia and generates 60% of the regions GDP. It is the largest landmass becoming independent after the dissolution of the Soviet Union in 1991. Kazakhstan is the ninth largest country in the world and is experiencing an average 7.7% economic growth rate over the period of 2002-2011 (World Bank, 2011), primarily driven by her oil/gas industries. It has the twelfth largest proven oil reserve in the world and is the thirteen largest oil exporting country and it is also the fastest growing economies in Central Asia. Kazakhstan is one of the top fifty innovative economies, as listed in Bloomberg Innovation Index of 2016. However, oil and gas are her primary industry, yet like many nations, it faces enormous challenges to fulfill its growing energy needs and to maintain its health economic growth outlook. Securing a sustainable and efficient energy supply and maintaining economic growth, while protecting the environment through reduction of greenhouse gases is of primary importance, but challenging to accomplish. However, electricity conservation policy without due attention to explore new sources of eco-friendly energy could be counterproductive as it may slow down economic growth if electricity Granger causes economic growth. Therefore, in the current study, we try to pinpoint the direction of causality between electricity consumption and economic growth in Kazakhstan to provide new direction to policymakers to devise future energy policy in Kazakhstan. Thus, our paper tries to close the research gap and makes an original contribution to the literature.

The remainder of the paper is structured as follows. Section 2 illustrates the methodology employed in this study. Section 3 provides empirical results, and the last section concludes the paper.

2. Data Sources and Methodological Framework

We obtained data on real GDP, electricity consumption, trade openness (exports + imports), capital and labor over the period of 1991-2014 from world development indicators (World Bank, 2015). We use population to normalize the series into per capita. All data are of annual frequency.

In this paper, we use extended neoclassical production function by incorporating trade openness to investigate the causal relation between electricity consumption and economic growth in Kazakhstan. The general form of neoclassical production function thus includes trade openness, electricity consumption, capital, and labor.

$$Y_t = f(E_t, TR_t, K_t, L_t) \quad (1)$$

where Y_t is real GDP per capita. E_t represents the per capita electricity consumption in kilowatt hours (KHW). It measures the consumption of the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. TR_t is per capita trade openness measured as the sum of real export and import divided by the size of the population. K_t and L_t represent the capital and labor in classical growth theory. All series are in log-linear form. In our empirical specification, we implement the following multivariate neoclassical production function framework:

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

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 [(total real exports + total real imports) / size of population] to proxy for trade openness, real capital per capita (fixed capital formulation normalized by population size and labor per capita (total labor force normalized by population size), respectively, and μ_t is the error term and assumed to be normally distributed.

2.1 Zivot-Andrews Unit Root Test

We start our estimation strategy by augmenting the properties of the data series. Specifically, the 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 test by Dickey and Fuller (1979); P-P test by Philips and Perron (1988); Ng-Perron test by Ng-Perron, (2001) are usually applied to test the unit root properties of the variables. However, these unit root tests do not provide important information about structural breaks hidden in the series. For example, in the case of Kazakhstan, the period of 1995-1997 is characterized by privatization drive and market reform, which resulted in a recovery of Kazak economy from long recession in early 2000. Moreover, the privatization process helped the economy to open up and surely contributed to the oil export industry. Thus, we apply a unit root test that accounts for the possible structural break in the data. We apply Zivot-Andrews (2002) test. Based on Zivot (1993), Zivot-Andrews, (2002) developed three new econometric models that removed the drawback about the absence of structural break points in the time series. 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 the level form, (ii) a one-time change in the slope of the trend (iii) a mode that accommodates one-time change both in intercept and trend function of the variables. Zivot-Andrews, (2002) adopted three models to check the hypothesis of a 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, a dummy variable is represented by DU_t showing mean shift occurred at each point with time break, while trend shift variables are 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 (2002) unit root test fixes all points as the 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 (2002) intimate that in the presence of end points, the asymptotic distribution of the statistics diverges to infinity point. It is necessary to choose a region where end points of sample period are excluded.

2.2 The ARDL Bounds Testing for Cointegration

We apply the autoregressive distributed lag (ARDL) bounds testing approach to cointegration developed by Pesaran et al. (2001) to examine a long run relationship between electricity consumption, trade openness, economic growth, capital, and labor. Pesaran et al. (2001) methodology have several advantages over the traditional ones including Ganger causality of Engle and Granger (1987), cointegration test of Johansen (1988, 1991) concerning the order of integration. For instance, the bounds approach to cointegration is applicable even if the regressors are integrated at I(1) or I(0) or I(1)/I(0). Under this approach, model uses sufficient numbers of lags for capturing the data generating process by using a general-to-specific modelling framework (Laurenceson and Chai 2003). 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 a small sample. An unrestricted error correction model (UECM) combines the short-run dynamics with the long-run equilibrium without losing any long-run information. The bounds testing approach to cointegration identifies the cointegrating vectors as multiple cointegrating vectors are present in empirical model. This test allows using different variables with different optimal number of lags for computing ARDL F-statistic. The bounds testing approach to cointegration captures structural break information stemming in the series by accommodating dummy variable in empirical model. The UECM is expressed as follows:

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

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

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

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

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

The notation Δ is the 1st difference operator and μ_t is the error terms. The F-statistic used to decide on the hypothesis is sensitive to lag order selection. The latter is chosen based on the minimum value of Akaike Information Criteria (AIC). Pesaran et al. (2001) 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. (2001) generated two asymptotic critical values, the upper critical bound (UCB) and lowered 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 relation 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 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, (2005) rather than Pesaran et al. (2001). The latter is suitable for large samples (T = 500 to T = 40, 000). Narayan and Narayan, (2005) points out that the critical in Pesaran et al. (2001) are significantly downwards and thus may produce a biased outcome. The UCB and LCB by Narayan, (2005) are more appropriate for a small sample (T = 30 to T = 80).

2.3 The VECM Granger Causality Approach

After confirming cointegration, we examine causality between pairs of the series 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 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. The F-test further confirms the existence of short-and-long run causality relations and known as a measure of strong Granger causality (Oh and Lee, 2004).

3. Results and Interpretations

Our empirical discussion starts from descriptive statistics and correlation matrix. We report our descriptive results in Table-1. The results show that all the series have been normally distributed. The mean and variance are constant of the residual terms of the series. The variation occurs in capital use is more compared to trade openness variations. The deviations in labor are less than deviations in economic growth and electricity consumption. The correlation matrix reveals that there is a positive and strong correlation exists between electricity consumption and economic growth. Trade openness, capital, and labor are positively correlated with economic growth. Electricity consumption is positively linked with trade openness and capital, but the negative correlation exists between labor and electricity consumption. A positive correlation exists between capital and trade openness while same inference is drawn for labor and trade. Finally, capital and labor are positively interlinked. The basic assessment of our data provides an initial indication of a long-run relation between the variables.

Table 1: Descriptive Statistics and Correlation Matrix

Variables	$\ln Y_t$	$\ln E_t$	$\ln TR_t$	$\ln K_t$	$\ln L_t$
Mean	12.9584	8.3354	12.8211	11.7341	4.1888
Median	12.9134	8.3665	12.9550	11.8152	4.2010
Maximum	13.5155	8.6379	13.5581	12.3957	4.2266
Minimum	12.4653	7.9509	12.0885	10.8477	4.1379
Std. Dev.	0.3692	0.2009	0.4064	0.5530	0.0336
Skewness	0.0959	-0.2761	-0.4077	-0.3268	-0.3978
Kurtosis	1.4841	2.1135	2.0776	1.5483	1.5447
Jarque-Bera	2.3346	1.0908	1.5159	2.5345	2.7509
Probability	0.3111	0.5796	0.4686	0.2815	0.2527
$\ln Y_t$	1.0000				
$\ln E_t$	0.2559	1.0000			
$\ln TR_t$	0.7048	0.4563	1.0000		
$\ln K_t$	0.8293	0.0901	0.6422	1.0000	
$\ln L_t$	0.2938	0.9351	0.4160	0.1597	1.0000

Next, we move on 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, 1979) 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). However, 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 the process of computing the ARDL F-statistic becomes unusable. Just to ensure that none of the variables are stationary at the 2^{nd} difference. The results of ADF root test are detailed in Table 2. The results indicate that economic growth, electricity consumption, trade openness, 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 the same order of integrated, i.e., I(1).

Table 2: Unit Root Analysis

Variables	ADF Unit Root Test	
	T-statistic	Prob-Values
$\ln Y_t$	-2.8802 (2)	0.1877
$\Delta \ln Y_t$	-6.0610 (2)*	0.0004
$\ln E_t$	-3.1845 (1)	0.1130
$\Delta \ln E_t$	-6.1610 (1)*	0.0003
$\ln TR_t$	-1.4663 (2)	0.8070
$\Delta \ln TR_t$	-3.5349 (0)***	0.0613
$\ln K_t$	-2.7322 (1)	0.2348
$\Delta \ln K_t$	-6.5000 (2)*	0.0001
$\ln L_t$	-0.8123 (1)	0.9400
$\Delta \ln L_t$	-5.0400 (2)*	0.0009

Note: * and *** represent significant at 1 and 10 per cent level of significance. The 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, (2004) forced to apply structural break unit root test to examine unit root properties of the variables. The reason is that misleading results about the order of integration of the variables would be helpful for policy makers in articulating comprehensive economic policy. To overcome this objection, we choose to apply Zivot-Andrews (Zivot and Andrews, 1992) 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 the 1st difference. This implies that the variables are integrated at I(1). The unique integrating properties of the both series lead us to implement the ARDL bounds testing approach to cointegration examining the long run relation between economic growth, electricity consumption, trade openness, 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 is available indicated in Table 4. We followed Akaike information criterion to select appropriate lag length. It is pointed by Lütkepohl, (2005) 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 3: Zivot-Andrews Structural Break Unit Root Test

Variable	**At Level**		**At 1st Difference**	
	T-statistic	Time Break	T-statistic	Time Break
$\ln Y_t$	-4.543 (1)	2008	-6.988 (2)*	2001
$\ln E_t$	-4.371 (1)	1997	-6.516 (1)*	2000
$\ln TR_t$	-4.605 (0)	2009	-6.305 (2)*	2001
$\ln K_t$	-4.547 (0)	1995	-5.776 (1)**	2000
$\ln L_t$	-4.803 (1)	2007	-7.442 (1)*	2005
Note: * and ** represent significant at 1% and 5% levels of significance. The lag order is shown in parenthesis.				

The next step is to examine a long run relation among the variables. The results of the ARDL bound testing approach to cointegration reported in Table 4 shows that our calculated ARDL F-statistics, i.e., 13.903, 12.702 and 7.377 exceed upper critical bounds at the 1% and 10% level of significance when economic growth, trade openness and labor are used as predicted variables. Our sample consists of 24 observations (1991-2011) so, critical values from Pesaran et al. (2001) are inappropriate. As such, we chose to use the lower and upper critical bounds generated by Narayan, (2005). We find three cointegration vectors and thus a long run relation among economic growth, electricity consumption, trade openness, capital and labor for Kazakhstan over the period of 1991-2014.

Table 4: ARDL Cointegration Analysais

Variable	$\ln Y_t$	$\ln E_t$	$\ln TR$	$\ln K_t$	$\ln L_t$

F-statistics	13.903*	2.357	12.702*	2.379	7.377***
Structural Breaks	2008	1997	2009	1995	2007
Optimal lags	1, 1, 1, 1, 0	1, 1, 1, 0, 1	1, 1, 1, 1, 1	1, 1, 0, 1, 1	1, 0, 1, 1, 1
Critical values#	1 % level	5 % level	10 % level		
Lower bounds	10.150	7.135	5.950		
Upper bounds	11.130	7.980	6.680		
$Adj-R^2$	0.9830	0.9431	0.9583	0.9895	0.9756
F-statistic	14.4930*	36.4080*	5.7503**	23.6589*	57.8081*
Note: *, ** and *** show significant at 1%, 5% and 10% levels respectively. # Critical values bounds are from Narayan, (2005) with unrestricted intercept and unrestricted trend.					

The existence of a long run relation between the variables leads us to examine long run impacts of electricity consumption, trade openness, capital and labor on economic growth. We report our results in Table 5. Our results reveal that electricity consumption has a positive impact on economic growth and it is statistically significant at 1 percent level of significance. Note that a 1 percent increase in electricity consumption is linked with 0.8064 percent increase in economic growth keeping other economic agents (variables) constant. The impact of trade openness is positive on economic growth at 1 percent level of significance. All else is same; a 0.0841 percent in economic growth is stimulated by a 1 percent increase in trade openness. Capital and economic growth are positively related, and this relation is statistically significant at 1 percent significant level. It is documented that a 1 percent increase in capital stock raises domestic production and hence economic growth by 0.0844 percent keeping other things constant. The impact of labor on economic growth is positive and significant at 1 percent level. The evidence shows that keeping other things constant, a 1 percent increase in labor leads economic growth by 0.8393 percent.

Table 5: Long and Short Runs Analysis

Dependent Variable = $\ln Y_t$			
Long-Run Results			
Variable	Coefficient	Std. Error	T-Statistic
Constant	21.4988*	2.6122	8.2299
$\ln E_t$	0.8064*	0.2532	3.1864
$\ln TR_t$	0.0841*	0.0230	3.6565
$\ln K_t$	0.0844*	0.0110	7.6727
$\ln L_t$	0.8393*	0.0660	12.7139

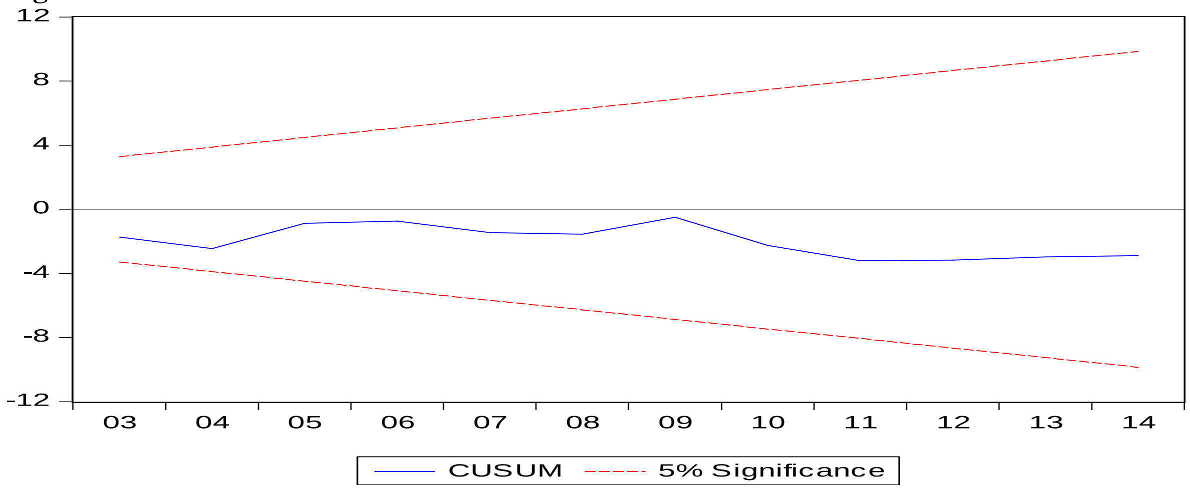
D_{2008}	0.0364	0.0285	1.2750
R^2	0.9802		
F-statistic	23.5721*		
D. W Test	1.5939		
Short-Run Results			
Variable	Coefficient	Std. Error	T-Statistic
Constant	0.0225**	0.0095	2.2647
$\Delta \ln E_t$	0.2491*	0.0796	3.1285
$\Delta \ln TR_t$	0.0230	0.0263	0.8735
$\Delta \ln K_t$	0.2033*	0.0416	4.8805
$\Delta \ln L_t$	0.2623***	0.1315	1.9943
D_{2008}	0.0113	0.0294	0.3843
ECM_{t-1}	-0.2715***	0.1532	-1.7722
R^2	0.7930		
F-statistic	12.2598*		
D. W Test	1.5914		
Short Run Diagnostic Tests			
Test	F-statistic	Prob. Value	
χ^2 *NORMAL*	2.2700	0.3202	
χ^2 *SERIAL*	0.8485	0.4489	
χ^2 *ARCH*	0.1602	0.6934	
χ^2 *WHITE*	0.4597	0.8003	
χ^2 *REMSAY*	0.0002	0.9886	
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 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 an 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} (-0.2715) confirms the long run relationship. The term is significant at the 1 percent level (lower segment of Table 5), which suggests that short run deviations in economic growth are corrected by 27.15 percent every year towards long run equilibrium and may take approximately, 3 and a half years to revert towards stable long run equilibrium path.

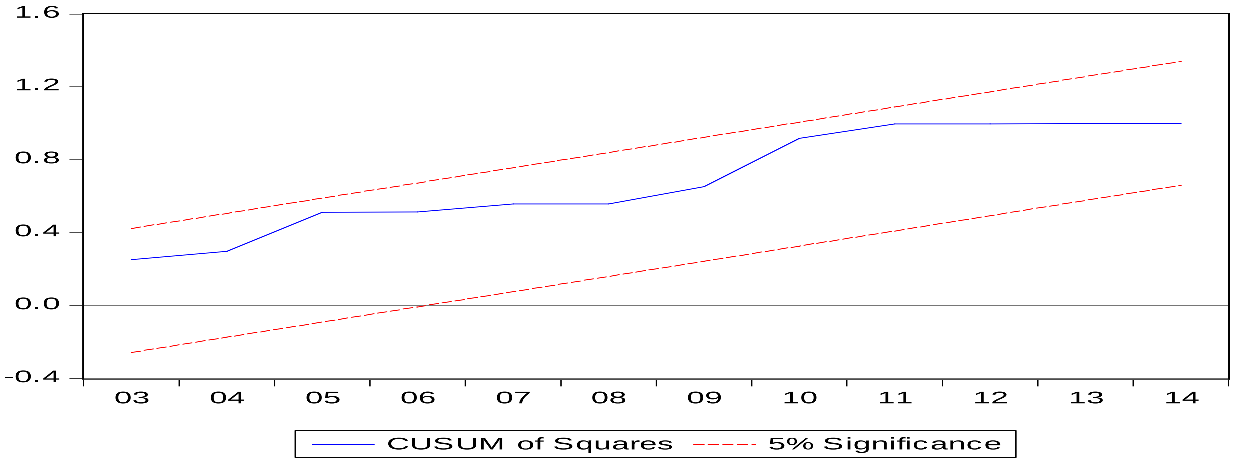
The short run model also passes diagnostic tests following classical linear regression model (CLRM) assumptions. The results show that the variables are not serially correlated with the residual term. There is no existence of autoregressive conditional heteroskedasticity. White heteroskedasticity is 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. It is suggested by Pesaran and Shin, (1999) 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 1: Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure 2: 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-1 and 2. Therefore, we can conclude that long and short runs estimates are reliable and efficient.

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 6 reports result in the direction of long run 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. However, coal is the main factor for energy consumption in Kazakhstan, which has serious environmental implication due to CO_2 gas emissions. Thus, exploring new sources of energy to sustain economic growth for a long-span of time is of real importance.

1 **Table 6: The 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]				
$\ln Y_t$	…	1.9885 [0.1864]	0.7092 [0.5115]	2.3864 [0.1341]	1.0842 [0.5500]	-0.2000** (-2.4250)	…	3.5999*** [0.0649]	19.0010* [0.0009]	3.2700*** [0.0800]	2.90*** [0.1011]
$\ln E_t$	1.5923 [0.2407]	…	0.8699 [0.4420]	2.5304 [0.1180]	1.4325 [0.2725]	…	…	…	…	…	…
$\ln TR_t$	0.3849 [0.6893]	1.9594 [0.1871]	…	1.8852 [0.1977]	4.0565** [0.0479]	-0.7510* (-3.5859)	4.5760** [0.0378]	7.9080** [0.0104]	…	5.9000** [0.0210]	8.9000* [0.0065]
$\ln K_t$	8.1650* [0.0050]	1.0771 [0.3691]	1.1749 [0.3396]	…	0.0719 [0.2452]	…	…	…	…	…	…
$\ln L_t$	0.2211 [0.8051]	0.8289 [0.4620]	0.1097 [0.8970]	0.1651 [0.8498]	…	-0.0759** (-3.1886)	5.5000** [0.0490]	6.7000** [0.0142]	4.8989** [0.0369]	3.2800*** [0.0800]	…
Note: *, ** and *** show significant at 1%, 5% and 10% levels respectively. Prob-values and T-statistics are given in [] and () respectively.											

Hence, one of the main 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. However, consistent supply of electricity in perquisite increase economic growth rate by boosting trade. Electricity consumption also Granger causes trade openness, capital, and labor in the long run. The feedback effect is found between trade openness and labor, and same inference can be drawn between economic growth and labor. Finally, in short run, labor Granger causes trade openness. The unidirectional causality is running from economic growth to capital. The joint long-and-short runs causality analysis corroborates our long run and short-run results.

4. Conclusion and Future Directions

We visited the dynamics relation between electricity consumption and economic growth in Kazakhstan by incorporating trade openness in the production function. Our empirical evidence indicates that electricity consumption, economic growth, trade openness, capital, and labor are integrated into the long-run equilibrium. We also find that electricity consumption, trade openness, capital, and labor have a positive and significant impact on economic growth. The unidirectional causal relation is running from electricity consumption to economic growth. We provide evidence for the feedback hypothesis between trade openness and economic growth. The bidirectional causal relation also exists between trade openness and labor. The same is also true about economic growth and labor relationship. The causality running from electricity consumption towards economic growth infers that electricity influences economic growth. However, Kazakhstan's electricity production is mostly from coal, and it causes major environmental degradation from CO_2 emissions. Any coal conservation policy would reduce electricity production and will negatively affect economic growth. Therefore, policymakers must device polices to improve coal utilization through more advanced technology. Another viable policy option would be exploring and utilizing renewable energy. Kazakhstan has the potential to enhance the production of renewable energy. The government of Kazakhstan should initiate to improve institution and market structure to produce renewable energy such as hydroelectric power and wind power. Kazakhstan possesses five operational hydroelectric plants which provide roughly 12% of electricity generation. Other renewable energy sources though underdeveloped but have enormous potential for further development. From the geographic and metrological point of view, Kazakhstan has the potential to produce a high volume of electricity from wind engineering. Alternative energies such as solar power, hydropower, and wind power should be seriously considered as these alternative energy production methods are to a large extent environmentally friendly compared to the current fossil fuel powered electricity production infrastructure in the country.

Our model has the potential to further investigate the relation between electricity consumption and economic growth by including other variables such as renewable and non-renewable electricity consumption following Shahbaz et al. (2012a); electricity prices and exports as indicated by Lean and Smyth (2010a,b); financial development and urbanisation explored by Shahbaz and Lean (2012b); exchange rate mentioned by Karanfil (2009). The relation between electricity consumption at disaggregated levels and economic growth could also be explored for Kazakhstan extending the work of Payne (2009). The analysis of disaggregated electricity consumption and economic growth will be more useful for policymakers 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 further academic research, as well.

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