The Electricity Consumption and Economic Growth Nexus in Pakistan: A New Evidence

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The Electricity Consumption and Economic Growth Nexus in Pakistan: A New Evidence

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Abstract

This study examines the Granger causality between electricity consumption and Gross Domestic Product (GDP) for Pakistan using annual data covering the period 1971 to 2007. Augmented Dickey-Fuller test and Phillips-Perron test reveal that both the series, after logarithmic transformation, are non-stationary and individually integrated at order one. Engle and Granger Cointegration test exhibits the absence of long-run relationship among the variables. Two tests of causality, standard Granger Causality test and Modified WALD test (T-Y test) affirm the existence of unidirectional Granger causality from electricity consumption to economic growth without any feedback effect. Therefore, an immediate effort to increase electricity availability is required and energy conservation policies are supposed to halt the economic growth.

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I. Introduction

In this bifurcated world of agrarian and industrial economies, electricity is equally important for both. The developed countries need electricity to run their industrial sector while the developing countries need it to 'catch up' with the developed economies. The electricity generation processes are much sophisticated in the developed countries as compared to the developing countries. The developed countries also outnumber the developing states in the alternative sources of energy. They are generating electricity even from the biomass while most of the developing countries are still unable to efficiently utilize their prime inputs of electricity generation such as coal, hydel power and natural gas.

During the past few years, numerous studies have been conducted to examine the relationship between electricity consumption and economic growth of an economy. So far, it has been found that there is a strong relationship between electricity consumption and economic growth. Ferguson et al. (2002)[1] has studied the issue in over 100 countries and found that there is a strong correlation between electricity consumption and economic growth. However, the existence of strong relationships does not necessarily imply a causal relationship[2].

The electricity consumption in Pakistan has been by and large on a rise throughout the economic history of the country. Aqeel and Butt (2001)[3] have examined a unidirectional causal relationship running from electricity consumption to economic growth elucidating that rise in electricity consumption leads towards higher economic growth. However during the last decade, the economy of Pakistan has faced immense fluctuations. It has recorded a growth rate of 9 percent during the fiscal year 2004-05, as well as a growth rate of 2.4 percent in the fiscal year 2008-09[4]. On the other hand, the electricity consumption has increased at a more or less persistent rate of 6 percent during 1998-2007[5]. The terrorism and political turmoil stricken country has been facing lowered economic growth rates amid to the global meltdown. Likewise, the government's inability to add to the installed capacity of the power generation sector has given rise to a severe energy crisis. The power sector recorded an increase of 53 percent in electricity generation between 1994 and 1999 (from 11,320MW to 17,400MW) but this increase was reduced to a mere 12 percent between 1999 and 2007 (from 17,400MW to 19,420MW). There has been no significant increase in the installed capacity since then and it is reported to stand at 19,575MW in March 2009[6]. The actual electricity generation from an installed capacity of 19,420MW is 15,903MW. Whereas, the demand for electricity varies between 17,000-19,000MW depending on the seasonal variations, giving rise to a shortage of 3000-4000MW.[7] According to a statement issued by the Government of Pakistan, the load shedding is causing a loss of Rs.219 billion per annum along with a loss of 400,000 jobs and exports worth Rs.75 billion. [8]

Thus theoretically, it may be concluded that economic growth and electricity consumption go side by side. But this needs to be justified empirically and also the nature of causation needs to be determined in order to examine

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[1] Ferguson, R., W. Wilkinson and R. Hill. (2000). Electricity use and economic development. *Energy Policy*, 28, 923–934.
[2] Yoo, S.-H. (2005). The causal relationship between electricity consumption and economic growth in the ASEAN countries. *Energy Policy*, 34, 3573-3582.
[3] Aqeel, Anjum and M. S. Butt. (2001). The relationship between energy consumption and economic growth in Pakistan. *Asia-Pacific Development Journal*, 8, 101-110.
[4] Pakistan, Government of. Economic Survey 2008-09. *Ministry of Finance*, pp-7
[5] Ibid. pp-226
[6] Ibid. Table 14.2
[7] Pakistan, Govt of (2009). Private Power and Infrastructure Board (PPIB), Ministry of Water and Power.
[8] Letter issued by GOP in response to the reservations of ADB over RSAs (http://www.ppib.gov.pk/ADB/GOP%20Response%20to%20ADB%20Report%2029-01-10.pdf)

that which variable happens to be the driving force and which is being driven. In other words the study examines if Pakistan is facing electricity consumption restricted economic growth, economic growth restricted electricity consumption or a simultaneous bias existent between economic growth and electricity consumption.

II. Review of Literature

Numerous studies have examined the causal relationship between energy[9] consumption and economic growth since 1970s. The results of these studies can be generalized in four categories. The first category includes the findings of unidirectional causality from economic growth to energy consumption. The pioneer study by Kraft and Kraft (1978) found a unidirectional causality from GNP growth to electricity consumption in the United States of America for the time period of 1947-1974. Later on Cheng and Lai (1997) examined the same relationship for Taiwan, Soytas and Sari (2002) for Italy and Korea, Ghosh (2002) for India, Oh and Lee (2004) for Korea, Yoo (2005) for Indonesia and Thailand, Mehrara (2006) for Oil Exporting Countries, Wolde-Rufael (2006) for Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe, Mozumder and Marathe (2006) for Bangladesh, Zamani (2006) for Iran and Zahid Asghar (2008) for Pakistan have found the unidirectional relationship from economic growth to energy consumption. For this category, the policies for energy conservation can be implied with only little or no adverse effect on economic growth.

The second category of findings includes the findings of unidirectional causality from energy consumption to economic growth. Cheng (1996) for Brazil, Aqeel and Butt (2001) for Pakistan, Soytas and Sari (2002) for Turkey, France, Germany and Japan, Shin and Lam (2002) for China, Narayan and Singh (2005) for Fiji Islands, Altinay and Karagol (2005) for Turkey, Wolde-Rufael (2006) for Benin, Congo D.R. and Tunisia and Yuan et al. (2008) for China have found unidirectional causality from energy consumption to economic growth. Restrictions on energy use for this category may lead to adverse feedback effect for economic growth and an improved energy provision may lead to higher economic growth.

Third category includes the studies that have found bidirectional causality between energy consumption and economic growth. Soytas and Sari (2002) for Argentina, Paul and Bhattacharya (2004) for India, Yoo (2004) for Korea, Yoo (2005) for Malaysia and Singapore, Wolde-Rufael (2006) for Egypt, Gabon and Morocco and Lise and Montfort (2006) for Turkey have found bidirectional causality in their targeted countries. This category holds that higher energy consumption may lead to higher economic growth and then following a simultaneous bias effect, the higher economic growth may lead to even higher energy consumption and vice versa. Fourth category consists of studies that have found no causality between economic growth and energy consumption. Yu and Hwang (1984), Cheng (1996) for Venezuela and Mexico and Wolde-Rufael (2006) for Algeria, Congo Rep., Kenya, South Africa and Sudan have found no causality between the two variables. For this category, conservation or expansion of energy usage may not affect the economic growth. (The review of literature is summarized in Table 1)

[9] Energy and Electricity may be used alternatively for this section.

III. Methodology

The study examines the time series data of GDP (at constant US dollar of 2000) and electricity consumption (in Giga Watt Hours) for the period 1971-2007. The data has been taken from various publications of Government of Pakistan and World Bank. The functional form of the model is developed following Aqeel and Butt (2001)[10] and Wolde-Rufael (2006)[11]:

$$\boldsymbol{Y_t = f(E_t)} \qquad \textbf{(1)}$$

Where Y is the GDP in constant US dollar and E is total electricity consumption.

The log-linear form of the above model can be expressed as:

$$\boldsymbol{LY_t = \beta_0 + \beta_1 LE_{t+}\varepsilon_t} \qquad \textbf{(2)}$$

Where LY is the log of GDP and LE is the log of electricity consumption. β_1 refers to the elasticity of total electricity consumption.

This study uses the traditional Granger Causality Test and the Modified WALD Test (MWALD) as proposed by Toda and Yamamoto (1995)[12].

Granger Causality Test and Stationarity of Series

Granger Causality Test has been traditionally used to examine the nature of causal relationship (Ebohon (1996), Ghosh (2002) and Yoo (2005)). A time series (X) Granger causes another time series (Y) if the prediction error of current Y diminishes by using past values of X along with the past values of Y.

In order to conduct the Granger Causality Test, the series need to be stationary. Therefore, the unit root tests are applied to test the stationarity of both the series. The unit root tests used in this study are Augmented Dickey-Fuller (ADF) Test and Phillips-Perron Test. PP test takes the problem of serial correlation into consideration which makes it more authentic than the ADF test. If the series is found to be non-stationary then, by using the Difference Stationary Process, the series is differenced to order one and the stationarity is tested. If the series is stationary at first difference, it is said to be integrated at order 1 denoted as I(1). Otherwise, higher differences are taken unless the series becomes stationary, which is denoted as I(d), where d is the order of difference at which series becomes stationary.

Cointegration

The next step involves the testing of cointegration between the series. If the series are non-stationary at level and cointegrated, then the Granger Causality Test may produce spurious results. In this case causality can be tested by using Error Correction Model (ECM) with the addition of an Error Correction Term in the Vector Autoregressive (VAR) model. However, if the error estimated from linear relationship of non-stationary series is non-stationary, then there is no long-run relationship and hence Granger Causality Test could be used.

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[10] Ibid. 3

[11] Wolde-Rufael, Yemane. (2006). Electricity consumption and economic growth: a time series experience for 17 African countries. Energy Policy, 34, 1106-1114.

[12] Toda H.Y. and T. Yamamoto. 1995. Statistical inference in vector autoregressions with possibly integrated process. Journal of Econometrics, 66, 225-250.

Granger Causality and the Vector Autoregressive Model

The Granger Causality test (Granger (1988)[13] and Engle and Granger (1987)[14]) is estimated using the following model:

$$\Delta LE_t = \alpha_1 + \sum_{i=1} \beta_i \, \Delta LE_{t-i} + \sum_{j=1} \gamma_j \, \Delta LY_{t-j} + \epsilon_t \qquad (3)$$

$$\Delta LY_t = \alpha_2 + \sum_{i=1} \theta_i \, \Delta LY_{t-i} + \sum_{j=1} \delta_j \, \Delta LE_{t-j} + \epsilon_t \qquad (4)$$

Where Δ is the difference operator and explains the order of integration of the series. Moreover, the optimal lag length is determined by using Schwarz Information Criteria (SIC) or Akaike's Final Prediction Error (FPE).

For equation (3), LY Granger Causes LE if H_0: $\gamma_j = 0$ is rejected against H_A: at least one $\gamma_j \neq 0$ and for equation (4), LE Granger Causes LY if H_0: $\delta_j = 0$ is rejected against H_A: at least one $\delta_j \neq 0$. Bidirectional causality exists if both the null hypotheses are rejected against the the respective alternative hypotheses. And there will be no causality if both the null hypotheses are accepted.

Toda-Yamamoto Augmented Granger Causality Test

Toda and Yamamoto (1995)[15] introduced a relatively simple and straightforward causality test involving the WALD test based on augmented VAR modeling that asymptotically has a chi-square distribution irrespective of the order of integration or cointegration properties of the variables. The test is valid regardless of whether the series is I(0), I(1) or I(2), cointegrated or noncointegrated. The test artificially augments the correct VAR order (k) by the maximum order of integration (d_{max}). Then $k+d_{max}$ th order of VAR is estimated and the coefficients of the last lagged d_{max} are ignored and linear restrictions are implied on VAR (k)[16]. This validates that standard asymptotic distribution is prevalent in the test statistic for Granger Causality test and valid inferences could be made.

The study follows the model proposed by Wolde-Rufael (2006)[17]:

$$LE_t = \alpha_1 + \sum_{i=1}^{k+d_{max}} \beta_{1i} \, LE_{t-i} + \sum_{i=1}^{k+d_{max}} \gamma_{1i} \, LY_{t-i} + u_t \qquad (5)$$

$$LY_t = \alpha_2 + \sum_{i=1}^{k+d_{max}} \theta_{1i} \, LY_{t-i} + \sum_{i=1}^{k+d_{max}} \delta_{1i} \, LE_{t-i} + u_t \qquad (6)$$

The above system of equations is estimated by Seemingly Unrelated Regression (SUR) method. For equation (5), LY Granger Causes LE if H_0: $\gamma_i = 0$ is rejected against H_A: at least one $\gamma_i \neq 0$ and for equation (6), LE Granger Causes LY if H_0: $\delta_i = 0$ is rejected against H_A: at least one $\delta_i \neq 0$ (where i=1,…,k and the parameters of i=k+1,…,d_{max} are ignored). Bidirectional causality exists if both the null hypotheses are rejected against the the respective alternative hypotheses. And there will be no causality if both the null hypotheses are accepted.

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[13] Granger C.W.J. (1988). Causality, cointegration and control. *Journal of Economic Dynamics and Control*, 12, 551-559.
[14] Engle, R.F., and C. W. J. Granger (1987). Cointegration and error correction: representation, estimation, and testing. *Econometrica*, 55, 251–276
[15] Ibid. 12
[16] Wolde-Rufael, Y. (2008). Energy consumption and economic growth: the experience of African countries revisited. *Energy Economics,* 31, 217-224.
[17] Ibid. 11

IV. Results and Discussion

The first stage consists of examining the stationarity of series after log transformation. The graphs of both series explain that the series are non-stationary at level (Figure 1), while the first differences of the series are stationary (Figure 2).

Figure 1: at level

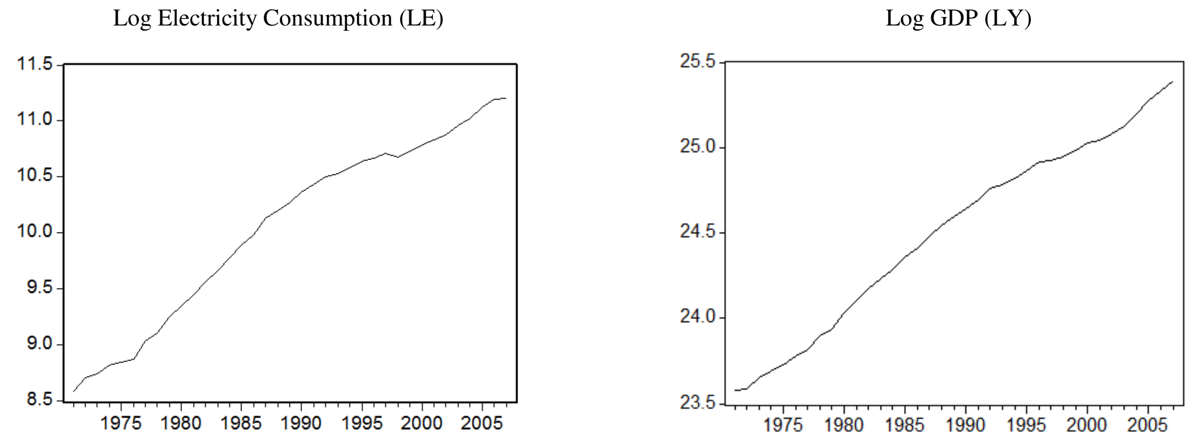
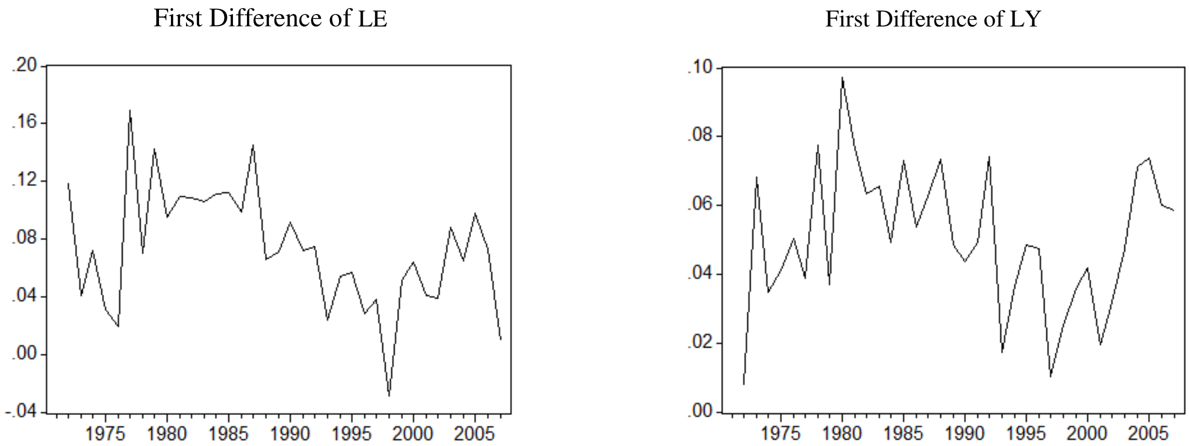


Figure 2: at first difference



The graphical results are further supported by the ADF and Phillips-Perron (PP) tests of unit root. The order of integration is determined by the test results that include the intercept and trend in the test equation (the results of the unit root tests are given in Table 2). It is examined that LE and LY are non-stationary at level and stationary at first difference and the null hypothesis of non-stationarity is rejected at 1% level of significance for the differenced series. Thus both series are said to be integrated at order 1 i.e. I(1).

Engle-Granger Cointegration Test

The regression equation (Eq. 2) is estimated to be:

$$\widehat{LY} = 17.7736 + 0.6695\ (LE) \qquad (7)$$

Unit root tests are applied on the residuals estimated by Eq. 7 and the results are given in Table 3. The null hypothesis of non-stationarity of the residuals is accepted at 51% level of significance and it is concluded that there is no long run relationship between the variables.

Granger Causality Test and Vector Autoregressive Model

The optimal lag length for the VAR model (Eq. 3 and Eq. 4) is estimated to be 2 by using the SIC and FPE criterions. The estimated VAR model is given in Table-4 and the results of the Granger Causality Test are given in Table-5. The results suggest that there exists a unidirectional causality from LE to LY. Hence it may be concluded that growth in electricity consumption in Pakistan Granger causes its economic growth without any feedback effect. A higher consumption of electricity in Pakistan will lead to higher economic growth and a lower electricity consumption will end up with lowered economic growth. However, an increase or reduction in economic growth will not affect the electricity consumption behavior of the economy.

Toda-Yamamoto Augmented Granger Causality Test

The optimal lag-length for the VAR model in Eq.5 and Eq.6 is found to be 1 by using SIC, however other criterions like Likelihood Ratio (LR), Hanon and Quinn (H-Q) Criterion and Final Prediction Error (FPE) exhibit that the optimal lag-length is 2 lags. Thus for this model, we consider 2 as the optimal lag length (i.e. k=2). The maximum order of integration has been estimated to be 1 for both the series (i.e $d_{max}=1$). Therefore, a VAR($k+d_{max}=3$) is estimated to use the modified WALD test for linear restriction on the parameters of VAR(k=2) having an asymptotic χ^2 distribution. The coefficients of the extra lag (d_{max}) are ignored and linear restrictions are applied only on the k-lags. The estimated VAR model as proposed by the Toda-Yamamoto augmented Granger Causality Test is given in Table 6 and the results of the test are given in Table 7.

The results of the T-Y test show that there exists a unidirectional causality from LE to LY. The final results of this test are same as that of the Granger causality test and hence it is affirmed that the trends of electricity consumption and economic growth exhibit consistent unidirectional causal relationship from electricity consumption to economic growth. These results are also in line with the results inferred by Aqeel and Butt (2001)[18]. Hence we may conclude that Pakistan faces an electricity consumption restricted economic growth.

V. Policy Implications

The results of the study suggest that economic growth in Pakistan is restrained by the level of electricity consumption. The 0.9% growth in electricity consumption during the fiscal year 2007-08 (as compared to 7.6% increase during 2006-07) has restricted the economic growth to a mere 4.1% in 2007-08 (as compared to 6.7% in 2006-07). This slowdown in electricity consumption is subject to the shortage of electricity in the power sector. Therefore, need of the time is to increase the availability of electricity in the power sector of Pakistan. Some important policy options for the development of power sector are being discussed below.

Pakistan has not been efficiently utilizing its coal reserves. The electricity produced from coal accounts for a mere 0.1% of the total electricity production in a year. Whereas, the lignite coal reserves in Pakistan are estimated to be 185.5 billion tons of which Thar lignite coal reserve holds175 billion tons. By utilizing the Thar coal reserve (6000-11000 btu[19]/lb.) 100,000MW of electricity can be generated, with an estimated consumption of 536 million tons per year[20].

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[18] Ibid. 3

[19] British Thermal Unit: The **British thermal unit** (BTU or Btu) is a traditional unit of energy equal to about 1.06 kilojoules. It is the approximate amount of energy needed to heat one pound of water one degree Fahrenheit.

[20] Pakistan, Government of. (2008). *Pakistan's Thar coal power generation potential*. Private Power and Infrastructure Board, pp-1.

The hydroelectricity potential of Pakistan is approximately 41722MW but the total installed capacity is only 6595MW. [21] Major projects like Kala Bagh Dam, Bhasha Dam and the raising project of the Mangla Dam have been lingering on for many years now.[22] The inefficiency in this sector must be tackled with proper planning and the share of hydel power should be increased in the total electricity production. Nuclear energy is another source of producing electricity. At present, Pakistan Atomic Energy Corporation produces 437MW. It is far less than what PAEC can produce and should have been producing to meet the energy crisis. Though Chashma-II project (325MW) is underway, still large amount of cheap energy can be obtained from this source. [23]

Apart from these fundamental sources of energy, the Alternate Energy Development Board (AEDB) is developing feasibility plans for alternative sources of energy. These sources include Wind power projects (11 Independent Power Producers (IPPs) have completed their Feasibility Studies for 50 MW wind power projects each), Bio-Gas projects (an American firm has been asked to undertake Feasibility Study for generation of up to 10MW of electricity from solid waste) and Small Hydro projects(16MW hydro power project under process in Gilgit).[24] Though there have been considerable efforts to induce the small scale electricity generation projects, there is a strong need to execute these projects on urgent basis.

In essence, rather than focusing on much maligned Rental Service Agreements of Rental Power Projects[25], Government of Pakistan should focus on other available alternatives. It should utilize its existent resources to a fuller extent rather than hiring others' resources at high opportunity cost of worsened macroeconomic conditions. The policy orientation needs a drastic modification. And indigenous resources like hydel energy production as well as development of coal mining and new gas fields should be given top priority.

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[21] Pakistan, Government of. (2008). *Hydel Power Potential*. Private Power and Infrastructure Board, pp-3.
[22] Ibid.
[23] http://www.paec.gov.pk/paec-np.htm
[24] Ibid. 21
[25] For details, visit: www.ppib.gov.pk

Table 1

Study	Countries	Conclusion
Zahid Asghar Jr (2008)	Pakistan	EG→EC
Yuan, Kang, Zhao and Hu (2008)	China	EC→EG
Zamani (2006)	Iran	EG→EC
Lise and Montfort (2006)	Turkey	EG↔EC
Mozumder and Marathe (2006)	Bangladesh	EG→EC
Mehrara (2006)	Oil Exporting Countries	EG→EC
Wolde-Rufael (2006)	Benin, Congo D.R. and Tunisia	EC→EG
Wolde-Rufael (2006)	Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe	EG→EC
Wolde-Rufael (2006)	Egypt, Gabon and Morocco	EG↔EC
Wolde-Rufael (2006)	Algeria, Congo Rep., Kenya, South Africa and Sudan	No Causality
Yoo (2005)	Indonesia and Thailand	EG→EC
Yoo (2005)	Malaysia and Singapore	EG↔EC
Altinay and Karagol (2005)	Turkey	EC→EG
Narayan and Singh (2005)	Fiji Islands	EC→EG
Yoo (2004)	Korea	EG↔EC
Oh and Lee (2004)	Korea	EG→EC
Paul and Bhattacharya (2004)	India	EG↔EC
Ghosh (2002)	India	EG→EC
Shin and Lam (2002)	China	EC→EG
Soytas and Sari (2002)	Turkey, France, Germany and Japan	EC→EG
Soytas and Sari (2002)	Italy and Korea	EG→EC
Soytas and Sari (2002)	Argentina	EG↔EC
Aqeel and Butt (2001)	Pakistan	EC→EG
Cheng and Lai (1997)	Taiwan	EG→EC
Cheng (1996)	Brazil	EC→EG
Cheng (1996)	Venezuela and Mexico	No Causality
Yu and Hwang (1984)	United States of America	No Causality
Kraft and Kraft (1974)	United Stated of America	EG→EC

EC= Energy Consumption **EG**= Economic Growth → = Nature of Causality

Table 2: Unit Root Tests

Variables	Augmented Dickey Fuller Test		Phillips-Perron Test	
	Intercept	**Intercept and Trend**	**Intercept**	**Intercept and Trend**
LE	-2.512 (0.121)*	-0.344 (0.986)	-1.979 (0.2943)	-0.703 (0.9652)
ΔLE	-4.259 (0.0019)	-4.723 (0.0030)	-4.611 (0.0007)	-4.92 (0.0018)
LY	-1.35 (0.594)	-1.278 (0.8769)	-0.603 (0.857)	-1.2948 (0.8732)
ΔLY	-5.064 (0.002)	-5.2123 (0.0008)	-5.162 (0.0002)	-5.259 (0.0007)

*The values in the parentheses are the p-values Δ = first difference

Table 3: Cointegration Test

Variable	Augmented Dickey-Fuller Test	Phillips-Perron Test
$\hat{\varepsilon}_t$	-1.51 (0.5171)*	-1.4185 (0.5625)

* The values in the parentheses are the p-values

Table 4: Estimated VAR Model

Variables	C	ΔLE_{t-1}	ΔLE_{t-2}	ΔLY_{t-1}	ΔLY_{t-2}
ΔLE	-0.0283	0.1368	0.1625	0.6232	0.0112
ΔLY	0.0283	0.3538	0.0481	-0.0721	-0.0639

Δ First Difference Operator

Table 5: Granger Causality Test

Equation	Null Hypothesis	$\chi 2$-statistic	d.f.	p-value	Conclusion
Equation-3	LY does not Granger cause LE	1.586	2	0.4525	Do not reject H_0
Equation-4	LE does not Granger cause LY	18.255	2	0.0001	Reject H_0

d.f. = degrees of freedom

Table 6: Estimated T-Y Model

Variables	c	LE_{t-1}	LE_{t-2}	LE_{t-3}	LY_{t-1}	LY_{t-2}	LY_{t-3}
LE	-0.9745	1.0283	0.0120	-0.1001	0.6532	-0.5197	-0.0681
LY	-1.1856	0.34426	-0.3072	-0.0817	0.9224	0.0732	0.0722

Table 7: Toda and Yamamoto Augmented Granger Causality Test

		χ^2 - statistic			F-statistic			
Equation	**Null Hypothesis (H_0)**	**Coefficient**	**d.f.**	**p-value**	**Coefficient**	**d.f.**	**p-value**	**Conclusion**
Equation-5	LY does not Granger causes LE	1.7766	2	0.4113	0.8883	(2,27)	0.4230	Do not reject H_0
Equation-6	LE does not Granger causes LY	15.3753	2	0.0005	7.6876	(2,27)	0.0023	Reject H_0

d.f. = degrees of freedom

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