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Electricity conservation dynamics with GDP and exports in Pakistan

Muhammad Shakeel *

Department of Economics, Federal Urdu University of Arts, Science and Technology, Islamabad Campus, Pakistan

Abstract: This study examines the role of exports in energy-GDP nexus for Pakistan by employing aggregate production function framework with and without adding exports with labor, capital stock, electricity-use and real gross domestic product (GDP). The time spans of the data are selected from year 1980 to 2014. The test of Johansson co-integration is employed with VECM and Toda and Yamamoto causality tests for the time series variables. Empirical findings demonstrates that there is long run co-integrated relationship among real GDP, labor, capital stock and electricity-use both with including/excluding exports in the models. The empirical analysis of error correction term reveals that exports are key and statistically significant in the long run for assessing the dynamics of energy-GDP nexus in the country. The long run estimates shows that labor, capital and electricity are positively contributing to the real GDP in the country. The causality test reveals that there is no causal relationship between electricity-use and real GDP and between electricity-use and exports both in short-run and long-run. These findings imply that energy conservation strategies for electricity-use may be implemented in the country as these will not cascade down the GDP growth or export expansion process of the economy.

Key words: *Causality direction; Electricity use; Error correction mechanism; Energy conservation; GDP growth*

1. Introduction

Socio-economic development of an economy depends on many factors namely; economic growth, trade openness, technological improvements, human capital formation, foreign direct investment etcetera. Nonetheless, classical and neo-classical economist has emphasized the role of labor specialization and accumulation of capital stock to spurt economic/output growth and thereby tacitly canvassed the role of economic growth in improving the standards of living and cascading down the poverty levels in the economy. The role of labor force and capital stock has been unequivocally contemplated inevitable and indispensable in the production process of the country. The contribution of capital stock is reported to be four times higher relative to that of energy in gross domestic product (GDP) growth (Lee et al., 2008). The neo-classical economists nevertheless, do not emphasize much on the role of energy use in the economic development process. Usage of energy in shape of oil, natural gas, coal and electricity in different production processes is clearly compulsory and no capital machinery can be run without using energy (Sadorsky, 2012; Shakeel and Iqbal, 2014).

Energy can be evidently stated as basic input for its pivotal role in the production process (Stern, 2000; 2004). There is no production process that can be completed without using energy irrespective of how much amount of labor or capital were involved to produce the goods and services. Energy in disaggregated form is pervasive directly as an input in the production of goods and services in different sectors of the economy and therefore impacts the real gross domestic product (GDP) of the country. By the same token, exportable sector also embeds different types of energy including oil, natural gas, coal and electricity as a binding input to produce and to export the goods and services. Thus increasing the exports segment of a country, which directly adds to the real GDP, require huge amount of energy to operate in the production of exportable (Sadorsky, 2012). In this manner, energy use has an indirect role via exports' multiplier to impact the real GDP of the economy (Sadorsky, 2012; Hossian, 2014; Shakeel et al., 2014; Raza et al., 2015).

In spite of the direct as well as indirect role of energy use to impact the real GDP and exports mentioned earlier, there is a dearth of concurrent empirical evidence on the issue for a single country, a specific region or a panel of countries. There are a few studies endeavored to explore the long run dynamic linkages between energy usage and real GDP with incorporating the role of exports and thereby providing the consistent bearings in empirical manners for energy policies. In line with the preceding discussion, the present study endeavors to provide consistent empirical findings of energy-GDP nexus employing aggregate production function with and without adding exports variable in the model(s). Furthermore, capital stock has been used in this study whereas the existing studies on this issue have either used bivariate models or they have used fixed capital formation as a proxy to capital stock. Along these

* Corresponding Author.

lines, the present study amends the model framework with covering the dearth and limitations of the existing literature on the issue discussed and thereby, attempts to provide important bearings for devising energy (electricity) conservation policies in the country. The empirical findings of short-run and long-run dynamics among electricity-use, real GDP and exports will provide new guidelines in envisaging effective energy policy-agenda for sustainable economic performance and export expansion in Pakistan.

2. Literature review

For review of energy-GDP-exports nexus, there are a few studies namely; Narayan and Smyth, 2009; Lean and Smyth, 2010; Sadorsky, 2011; Sadorsky, 2012; Shahbaz et al., 2013 Shahbaz et al., 2014; Farhani et al., 2014; Hossain, 2014; Shakeel et al., 2014; Shakeel and Iqbal, 2014; Raza et al., 2015 among others. These studies have articulated the coherent long run relationship among the energy usage, real GDP and exports for different developed and under-developed economies of the world. They also acknowledged the contemporary rise in the energy usage due to changes in exports demand, albeit the role of energy conservation on economic performance posits mixed or inconclusive bearings for these regions of analyses. These researchers however, do not provide evidence for the case of electricity-GDP-exports nexus in Pakistan. The present study endeavors to cover this gap.

3. Theoretical model and data description

We start with a simple model, assuming output (Y) in the economy depends on the availability of labor, (L), and capital, (K).

$$Y= Af(K, L) \quad (3.1)$$

Following the studies and the arguments advanced in the literature on the role and importance of energy in the production process and ground realities; we have also included energy in the production function as one of the arguments in equation 3.1. The modified function estimated in this study with the title of Model 1 can be written as:

$$Y= Af(K, L, E) \quad (3.1a)$$

Here E represents the total input of energy, in the economy measured with electricity and the data on electricity use is expressed in billion kilo watt hours

Following Sadrosky (2012), the relationship between GDP, energy and exports titled with Model 2 in this study can be written in the functional form as:

$$Y= Af(K, L, E, X) \quad (3.1b)$$

In the above equation: (3.1a,b) Y stands for annual GDP expressed in terms of 2010 US dollars, representing the output of the economy. K is the total capital stock measured in terms of 2010 US dollars. L in the equation represents the annual total input of labor in the economy. E in the model is electricity used. The annual values of export, measured in terms of 2010 US dollars, are represented by X. The data of the electricity-use are taken from International Energy Agency (2018). The data of capital stock has been collected from Penn World tables (Feenstra et al., 2015). The data of all the other variables are obtained from World Bank data source (WDI, 2018).

The parameterization of the equation (3.1 a, b) will be as follows

$$Y = A_0 K^{\propto 1} L^{\propto 2} E^{\propto 3} \quad (3.2)$$
$$Y = A_0 K^{\propto 1} L^{\propto 2} E^{\propto 3} X^{\propto 4} \quad (3.3)$$

Taking natural logarithms of above function, equation (3.2, 3.3) can be written as:

$$y_t = \alpha_0 + \alpha_1 k_t + \alpha_2 l_t + \alpha_3 e_t \quad (3.4)$$
$$y_t = \alpha_0 + \alpha_1 k_t + \alpha_2 l_t + \alpha_3 e_t + \alpha_4 x_t \quad (3.5)$$

Here the small case letters represent the variables, as explained above, in their natural logarithm forms. The intercept terms in model 1 (equation 3.4) and model 2 (equation 3.5) captures the impact of technological progress or Solow residual.

4. Econometric methodology

The following methodology has been employed to estimate the empirical linkages among the variables of model at hand.

4.1. The unit root test

To test for the unit root, Augmented Dickey Fuller test (ADF) as developed by the Dickey- Fuller (1979) has been used. This test uses following equation;

$$\Delta Z_t = \alpha_0 + \rho Z_{t-1} + \sum_{j=1}^{n} \gamma j \, \Delta Z_{i,t-j} + \theta_t t + \omega_t \quad (4.1)$$

Here, Z represents the time series which is to be tested, ρ which is the coefficient of lagged Z and ΔZ term are used to tackle the problem of autocorrelation in the series. θ_t is the coefficient of time trend and ω_t is white noise error term.

4.2. Johansen co-integration test

After the confirmation of the order of the time series, the second step is to check for the possible long term co-integration relationship among the variables in a given series. For this purpose, Johansen co-integration test has been used. This Johansen's (1989) methodology takes its starting point in the vector auto regression (VAR) of order p given by

$$Z_t = C_0 + C_1 Z_{t-1} + C_2 Z_{t-2} + C_3 Z_{t-3} \dots\dots\dots\dots\dots\; C_p Z_{t-p} + \mu_t \quad (4.2)$$

where Z is an nx1 vector of variables namely, real GDP (y), capital (k), labor (l), exports (x) and disaggregated energy usage (e) that are integrated of order one – commonly denoted I(1) – and μ_t is an nx1 vector of innovations.

4.3. Vector error correction and Granger causality

By following the approach of Johansen and Julius (1990), we can estimate the error correction model (ECM) for the time series analysis. With this approach, a change of the dependent variable is estimated with the level of the disequilibrium in the co-integration relationship and other independent variables with difference form with appropriate lag lengths. So the equation is as follows

$$\Delta y_t = \propto_1 + \sum_{j=1}^{p} \beta_{11j}\, \Delta y_{t-j} + \sum_{j=1}^{p} \beta_{12j}\, \Delta k_{t-j} + \sum_{j=1}^{p} \beta_{13}\, \Delta l_{t-j} + \sum_{j=1}^{p} \beta_{14}\, \Delta e_{t-j} + \sum_{j=1}^{p} \beta_{15}\, \Delta x_{t-j} + \gamma\mu_{t-1} + \omega_t \quad (4.3a)$$

The next step after estimating the error correction mechanism is to assess the causality directions between the variables for short and long run. For this purpose Toda and Yamamoto (1995) based causality test with error correction has been used.

$$y_t = \propto_1 + \sum_{j=1}^{p} \beta_{11j}\, y_{t-j} + \sum_{j=1}^{p} \beta_{12j}\, k_{t-j} + \sum_{j=1}^{p} \beta_{13}\, l_{t-j} + \sum_{j=1}^{p} \beta_{14}\, e_{t-j} + \sum_{j=1}^{p} \beta_{15}\, x_{t-j} + \gamma_{16}\mu_{t-1} + \omega_{1t} \quad (4.3b)$$

$$e_t = \propto_2 + \sum_{j=1}^{p} \beta_{21j}\, y_{t-j} + \sum_{j=1}^{p} \beta_{22j}\, k_{t-j} + \sum_{j=1}^{p} \beta_{23}\, l_{t-j} + \sum_{j=1}^{p} \beta_{24}\, e_{t-j} + \sum_{j=1}^{p} \beta_{25}\, x_{t-j} + \beta_{26}\mu_{t-1} + \omega_{2t} \quad (4.3c)$$

$$x_t = \propto_3 + \sum_{j=1}^{p} \beta_{31j}\, y_{t-j} + \sum_{j=1}^{p} \beta_{32j}\, k_{t-j} + \sum_{j=1}^{p} \beta_{33}\, l_{t-j} + \sum_{j=1}^{p} \beta_{34}\, e_{t-j} + \sum_{j=1}^{p} \beta_{35}\, x_{t-j} + \beta_{36}\mu_{t-1} + \omega_{3t} \quad (4.3d)$$

The equations (4.3b to 4.3d) are of the VECM based causality test where p is the appropriate lag length, y is the log of real GDP, k is the log of real fixed capital formation, l is the log of total labor force, e is the log of electricity. In the same way, x is the log of real exports, μ is the error correction term and ω shows the random disturbance terms. Wald test statistics based on least square estimates in augmented models provide the significance of causality direction in each equation with putting restrictions on $\beta_j{}'s = 0$, respectively.

5. Empirical results and discussions

The estimated outputs are presented in this section and these are discussed with respect to their statistical significance and economic relevance.

5.1. Result of unit root test

The unit root test reveals that GDP, labor, electricity and exports are integrated of order one at levels while capital stock is integrated of order one i.e. I(1) at first difference (Table 1). These series found to be stationary or integrated of order zero at first difference except for capital stock which is stationary at second difference. So these series could be used to test the possible long run linkages among the variables.

5.2. Results of co-integration test

This section has had the empirical estimates for the co-integration test with two models (Table 2). Model 1 is estimated without adding exports in the production function whereas Model 2 adds the exports in the electricity augmented production function for Pakistan. This strategy has been employed to test the significance of exports addition in the energy GDP nexus.

The results of Johansen co-integration test measured by trace statistics and Eigen statistics shows that there is co-integration between the variables of the model 1 and there are two co-integrating vectors at 5 percent and/or 10 percent level of significance. The values of trace statistics and Eigen statistics in respect of model 2, including export along with labor capital and electricity-use as independent variables and real GDP as a dependent also articulates that there exists a co-integration relationship among these variables / series. This implies that there is an error correction mechanism for these models showing the speed of convergence towards long run equilibrium path.

5.3. Long run estimates and error correction term

The third step is to estimate the long run coefficients and values of the error correction terms from estimating the equations (3.4, 3.5) respectively (Table 3).

The empirical outcome of model 1 depicts that labor have a value of 0.54 with significant t-value and thus this means that a one percent increase in labor causes 0.54 percent rise in real GDP. The value of capital coefficient is 4.68 with significant t-value and this means that capital stock is relatively more significant as compare to labor in improving real GDP of the country. In the same way, value of electricity coefficient is 0.48 with significant t-value and this means that electricity is also significant in improving real GDP of the country. The value of lagged error term is -0.25 with significant t-value. This indicates that mechanism of convergence dynamics for this model 1 is strong and 25 percent of error is corrected in first year and subsequently till the achievement of convergence; once the system is get disturbed with any economic shock.

The empirical findings of model 2, shows that labor, capital and electricity-use have statistically significant positive coefficients similar to model 1 but different in magnitude while exports have a negative coefficient. The value of lagged error term is statistically significant and negative as well. The export augmented model 2 improves the convergence mechanism of the system and helps to reduce omitted variable bias in assessing the accurate answer for the improvising energy-GDP related questions in the country. Consequently, these findings are consistent in statistical context and supports that export-augmented models are more appreciated in understanding the energy-GDP nexus by considering outcomes of the error correction models for the case of Pakistan.

5.4. Results of Granger causality test

The fourth step in the estimation procedure is to assess the direction of causality between the main variables of the model. The differences of real GDP is represented by **Δy**, of electricity by **Δe** and that of exports by **Δx** (Table 4).

The results are given without adding the exports in the model in first part while results of causality test with the addition of exports in the model are presented in the second part of the (Table 4). The outcome of the Granger causality test in the first part, without adding exports in the model 1, reveals that GDP growth is insignificant in explaining the movements in electricity usage or vice versa in the short run or long run.

Table 1: Results of ADF unit root test

Series	Levels		First Difference	
	Intercept	trend & intercept	intercept	trend & intercept
Real GDP	-1.743	-2.136	-3.422	-3.753
	(0.40)	(0.50)	(0.01)	(0.03)
Capital*	0.857	-1.142	-2.12	-3.01
	(0.99)	(0.90)	(0.23)	(0.14)
Exports	-1.582	-2.135	-6.078	-6.122
	(0.48)	(0.58)	(0.00)	(0.00)
Labor	0.857	-1.142	-5.002	-5.155
	(0.99)	(0.90)	(0.00)	(0.00)
	(0.29)	(0.69)	(0.01)	(0.02)
Electricity	-1.623	-1.971	-2.783	-4.445
	(0.45)	(0.59)	(0.07)	(0.00)

Note: probability values are given in parenthesis. Lag interval selected at 2

Table 2: Results of co-integration test with electricity use

Rank		Trace Statistics			Maximum Eigen Statistics	
Without exports						
0		118.9	(0.00)		68.5	(0.00)
1		50.6	(0.02)		26.1	(0.07)
2		24.6	(0.17)		13.8	(0.43)
With exports						
0		85.5	(0.00)		34.6	(0.00)
1		23.1	(0.21)		13.3	(0.39)
2		10.8	(0.27)		9.60	(0.23)

Table 3: Results of long run estimates with electricity use

Variables		Model 1		Model 2
Real GDP	(Normalized)	1		1
Labor		0.54		0.49
		(6.12)		(7.88)
Capital		4.68		7.19
		(4.79)		(8.23)
Electricity		0.48		0.68
		(8.06)		(10.5)
Exports		---		-0.15
				(-3.74)
Lagged Error term		-0.25		-0.16
		(-2.08)		(-1.88)

Note: t-values are reported in parenthesis. Akiake information criterion optimal lag length is 2.

Table 4: Results of Granger causality test with electricity use

Without export				All
	Δy	Δe	Δx	
Δy	1	2.02	---	2.39
	----	(0.36)		(0.88)
Δe	0.22	1	----	10.1
	(0.89)	---		(0.11)
Δx	---	---	----	---
With export				
	Δy	Δe	Δx	
Δy	1	3.12	5.42	7.82
	---	(0.21)	(0.06)	(0.45)
Δe	0.31	1	1.58	11.8
	(0.85)	---	(0.45)	(0.16)
Δx	1.51	0.67	1	3.86
	(0.46)	(0.71)	---	(0.86)

In the same manner, the outcome of causality test in the second part, adding the exports variable in the model 2, reveals that exports granger causes GDP growth in the short run but not in the long run. No other causality was found to be statistically significant. These findings are supporting the conservation and neutrality hypothesis of energy use which implies that electricity conservation policies do not curtail GDP or export growths and thus promotion of cleaner environmental strategies via energy conservations are sustainable with the economic objectives of growth enhancement and export expansion in the country.

6. Conclusion and implication

This study endeavors to provide the empirical evidence on the significance of exports in energy-GDP nexus and thereby the impact of energy (electricity) conservation strategies on sustainable GDP growth and export expansion in Pakistan. The analysis employs production function framework with and without adding exports with labor, capital stock, electricity-use and real GDP over the period 1980-2014. The test of Johansson co-integration is employed with VECM and Toda and Yamamoto causality tests to uncover the dynamic relationship among the variables of the study.

In specific the empirical findings revealed that there is long run co-integration among real GDP, labor, capital stock and electricity-use with as well as without exports variable in the models. Furthermore, error correction term indicates that in model 2, there is evidence of a statistically significant convergence mechanism and thus adding exports are found key and helpful much in assessing the electricity-GDP nexus in Pakistan. The estimated long run elasticities showed that labor, capital and electricity-use are statistically significant in both of the models and these variables are positively contributing to improve the real GDP. The empirical findings for causality test revealed that there is no causal relationship between electricity-use and real GDP or between exports and electricity-use in short run or long run. These outcomes imply that electricity conservations strategies will not adversely affect the GDP or export growths. On this basis, it is suggested that energy conservation policies on electricity-use should be promoted to reduce nonproductive energy use in the economy. Moreover, new renewable energy technologies should be implemented to reduce the waste of energy and to enhance the economic growth in the country.

The implications also signifies that exports in the production function, through its impact on total productivity, impacts the economic growth and inclusion of the export variable is found to have important bearings for the assessment of energy-GDP nexus and implementation of energy conservation strategies in the country. Future research on this topic with the other energy components are encouraged keeping in mind the novel role of exports in the energy GDP nexus for Pakistan and other regions of the world.

References

Dickey, D. and Fuller, W. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of American Statistics Association, vol.74, pp.427–431.

Farhani, S., Shahbaz, M., and Rahman, M. (2014). Natural gas consumption and economic growth in France: Evidence for the role of exports, capital and labor (No. 2014-226).

Feenstra, R. C., Inklaar, R. and Timmer, M. P. (2015). The next generation of the Penn World Table. American Economic Review, vol.105 no.10, pp.3150-82.

Hossain, S. (2014). Multivariate granger causality between economic growth, electricity consumption, exports and remittance for the panel of three SAARC countries. European Scientific Journal, vol. 8 no. 1, pp. 346-376

International Energy Agency. (2018). Energy Balances of NON-OECD Countries. Paris, France.

Johansen, S. (1989). Likelihood-based Inference on Cointegration Theory and Applications. Centro Interuniversitario di Econometria.

Johansen, S. and Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. Oxford

Bulletin of Economics and statistics, vol. 52 no. 2, pp.169-210.

Lean, H. H. and Smyth, R. (2010). On the dynamics of aggregate output, electricity consumption and exports in Malaysia: evidence from multivariate Granger causality tests. Applied Energy, vol. 87 no. 6, pp.1963-1971.

Lee, C. C. and C. P. Chang (2008). Energy Consumption and Economic Growth in Asian Economies: A more Comprehensive Analysis Using Panel Data. Energy Economics, vol. 30, pp. 50–65.

Narayan, P. K. and Smyth, R. (2009). Multivariate Granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries. Energy Policy, vol. 37 no.1, pp. 229-236.

Raza, S. A., Shahbaz, M. and Nguyen, D. K. (2015). Energy conservation policies, growth and trade performance: Evidence of feedback hypothesis in Pakistan. Energy Policy, vol. 80, pp.1-10.

Sadorsky, P. (2011). Trade and energy consumption in the Middle East. Energy Economics, vol. 33, no.5, pp.739-749.

Sadorsky, P. (2012). Energy consumption, output and trade in South America. Energy Economics, vol. 34, no. 2, pp.476-488.

Shahbaz, M., Lean, H. H. and Farooq, A. (2013). Natural gas consumption and economic growth in Pakistan. Renewable and Sustainable Energy Reviews, vol. 18 pp.87-94.

Shahbaz, M., Nasreen, S., Ling, C. H. and Sbia, R. (2014). Causality between trade openness and energy consumption: What causes what in high, middle and low income countries. Energy Policy, vol. 70, pp.126-143.

Shakeel, M., Iqbal, M. M., (2014). Energy consumption and GDP with the role of trade in South Asia. In Energy Systems and Policies (ICESP), International Conference (pp. 1-5). DOI: 10.1109/ICESP.2014.7346987

Shakeel, M., Iqbal, M. M. and Majeed, M. T. (2014). Energy consumption, trade and GDP: A case study of South Asian countries. The Pakistan Development Review, vol. 53, no.4 pp.461-476.

Stern, D. I. (2004). Economic growth and energy. Encyclopedia of Energy, vol.2(00147), pp.35-51.

Stern, D. I. 2000, A multivariate cointegration analysis of the role of energy in the US macroeconomy. Energy economics, vol. 22 no. 2, pp.267-283.

Toda, H. Y. and Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. Journal of econometrics, vol. 66, pp.225-250.

World Bank (2018). World Development Indicators. https://data.worldbank.org/online database.