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Energy- GDP Nexus and the Role of Exports: An Empirical Evidence from Pakistan and South Asian Region

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Abstract: The purpose of the study is to present the influence of electricity generation on Pakistan's real GDP and real exports using time series data. The results of Johansen's co integration test revealed that electricity generation, labor force employed, gross fixed capital formation and terms of trade have a positive influence while the exchange rate has a negative relationship with real GDP. In another model, electricity generation, labor force employment, gross fixed capital formation, relative prices are evidence of an increase in real exports. On the other hand, the exchange rate is negatively associated with Pakistan's real exports.

Keywords: Electricity Production, Exchange Rate, Terms of Trade, Real GDP, Real Exports, Relative Price, Solow Growth Model.

Research Paper

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INTRODUCTION

Electricity plays an important role in the economy especially in developing economies like Pakistan because the efficient use of various resources is directly dependent on electricity. Almost every sector, be it agricultural, industrial or domestic, is directly dependent on electricity.

This research is done keeping in mind the current and prolonged economic situation of Pakistan. Pakistan is facing serious problems of energy crisis and negative net exports. Pakistan's imports are higher than it exports, causing a sizeable trade deficit and creating a shortage of foreign exchange reserves. On the other hand, it also faces various problems such as industrial closure, declining production, rising unemployment, underutilization of resources, inflation and falling investment. Exports and electricity generation are closely linked to each other because when electricity production increases, industries that have closed restart and start producing, which can contribute to an increase in the final product that will be used to meet domestic needs and the surplus will be available for export. When exports increase, it will gain a share of foreign exchange for Pakistan, making the balance of payments favorable. On the other hand, there will be an increase in job opportunities and thus the purchasing power of the masses will increase, which will increase aggregate demand and thus result in an increase in real GDP.

LITERATURE REVIEW

Much literature has been published on the subjects of real GDP and real exports in Pakistan and internationally. A few studies are considered here to summarize the previous studies divided into two subsections. One is from Pakistani economy and another from international economies regarding the same

Reviews from International Economies

Lack'o (1999) conducted an analysis to reveal that in post-socialist countries, the variation of electrical intensities did not necessarily reflect the growth of hidden elements of the economy. The data used by the researcher were time series for the period between 1989 and 1994. The variables used in the research were the maximum unemployment rate, the variation in official production, the variation in the participation of industry in the production of GDP and the variation in electricity consumption. The results showed that the growth of hidden elements of the economy was not founded to be necessarily affected by the variation of electrical intensities in post-socialist countries. In eighteen post-socialist countries, results based on econometric and statistical analyzes revealed that to explain differences in electrical intensity changes, recorded measured and structural changes were found to be sufficient. The researcher Asafu-Adjaye (2000) taking the variables Price, Energy Consumption and Income, tried for Thailand, Indonesia, India and the Philippines to explore

the causal relationship between income and energy consumption. This paper used annual time-series data covering the period 1973 to 1995. Research using the Granger causality test found that in Indonesia and India, one-way Granger causality ranged from energy to income, energy and prices, in the case of the Philippines and Thailand, were mutually causal. In the causal chain, the effects on prices were relatively less significant. The findings concluded in this research do not support the idea that income and energy were neutral with respect to each other, except that in the case of India and Indonesia, neutrality was observed in the short term. Chontanawat, Hunt, and Pierse (2006) attempted to test causality between GDP and energy variables using annual time series data ranging from 1960 to 2000 for 30 OECD countries and data ranging from 1971 to 2000 for most of the 78 non-OECD countries on the variables real GDP and final electricity consumption. The causal link between GDP and energy consumption was more frequent in the case of OECD countries. The causal link between energy and GDP was found in OECD countries. The degree of causality from energy to GDP was found to be lower in developing countries than in developed countries. Akta¸s and Yilmaz (2012) attempted to inspect the causal relationship for Turkey using annual time series data spanning from 1970 to 2004. After applying the Granger causality test, it was found that there is a two-way causal relationship. A one-way causality has been found ranging from GNP to long-term electricity consumption.

Dhungel (2008) conducted the study to determine the causal relationship between total commercial oil and energy, per capita coal consumption, per capita real gross domestic product, and electricity using annual time series data from 1980 to 2004. One-way causality was found ranging from per capita real gross domestic product to per capita electricity consumption; from commercial consumption of energy, oil and coal to real Gross Domestic Product by Capital.

Noor and Siddiqi (2010) attempted to inspect the causal link between economic growth and energy consumption in five South Asian countries. The researchers used annual time-series data from 1971 to 2006. The ratio of per capita electricity consumption for India, Nepal and Bangladesh was found to be positive, meaning that an increase in energy consumption would lead to an increase in per capita GDP. While in the case of the other two countries, Sri-Lanka and Pakistan, the coefficient of energy consumption was negative, which means that an increase in energy consumption would reduce per capita GDP. Similarly, one-way causality has been found to exist from labor to capital.

Shahbaz and Feridun (2012) empirically analyzed the co integration and causality between economic growth, capital and electricity consumption using annual time-series data from 1980 to 2011 in Romania. The ARDL cointegration test was applied, which resulted in the co integration of capital, economic growth and electricity consumption. The marginal effect of capital and electricity consumption on economic growth revealed that economic growth was positively influenced by electricity consumption and was statistically significant. Capital has also been found to be an important driver of economic growth and to have a positive relationship with economic growth. Bidirectional causality has also been found between capital use and economic growth, as well as between economic growth and electricity consumption. On the other hand, a one-way causal relationship from capital use to electricity consumption was discovered.

Uslu and Polat (2011) conducted research to determine the relationship between Employment, electricity consumption and real income using annual time series data from 1923 to 2006 for Turkey. The results showed that employment, electricity consumption and real income were co integrated in the long run. Causality was found from real income and employment to electricity consumption. No causality was found in the real income and employment equations.

Reviews from Pakistan Economy

Aqeel and Butt (2001) attempted to trace the causal relationships between economic growth and energy consumption in Pakistan. In this research work, data from the annual time series of the variables Gross Domestic Product and Electricity Consumption were used, covering the period from 1955-1956 to 1995-1996. The results of the study revealed that economic growth leads to growth in oil consumption. As for the gas sector, both gas consumption and economic growth have not influenced each other. On the other hand, however, in the electricity sector; electricity consumption was driving economic growth.

Shahbaz y Feridun (2012) attempted to find a balance relationship between economic growth and electricity consumption. Data from the annual series of storms from 1971 to 2008 were used. The study explored that economic growth and electricity consumption were encountered in a balanced relationship and, in the case of Pakistan; economic growth would lead to electricity consumption, but not to vice versa. The investigation concluded that the economic growth caused the consumption of electricity, but not to the vice versa in Pakistan. In respect of politics, they suggested that, like the conservation of electricity consumption, the government should adopt policies that are respectful with the environment. The use and exploration of energy sources such as wind, solar and hydroelectric power that are respectful of the environment could maintain the balance between the environment and economic growth.

Masuduzzaman (2012) explored the co integration between the GDP, the Electricity Consumption and the Inversion. In his investigation, data from the annual series of storms from 1981 to 2011 were

used. There was a unidirectional relationship that caused electricity consumption until economic growth. Also, the results of the causality test explored that the inversion caused the economic growth and the electricity caused the inversion, but not the vice versa. The short-term elasticity of economic growth with respect to the inversion and the consumption of electricity were less than its long-run elasticity.

Hye and Riaz (2008) determined the relationship between energy consumption and economic growth. They used annual time-series data covering the period 1971 to 2007. They observed that when they applied the ARD. On the other hand, they applied Granger causality to find out the direction of causality between energy consumption and economic growth and explored that both short term and long term changes in economic growth cause changes in energy consumption.

Ahmad, Hayat, Hamad and Luqman (2012) conducted research to determine the relationship between economic growth and energy consumption in Pakistan. A positive relationship has been found between Gross Domestic Product and Energy Consumption for Pakistan. Atif and Siddiqi (2010) attempted to determine the causal relationship between GDP and electricity consumption. The study used yearly time-series data spanning from 1971 to 2007. One-way Granger causality was found ranging from electricity consumption to economic growth. Javid, Javid and Awan (2013) determined that there is a long-term relationship between the variables Electricity consumption and real GDP per capita in the case of Pakistan. In the study, the researchers used annual time-series data from 1971 to 2008. The researchers found that there is a one-way causal link from electricity consumption to real per capita GDP, as well as that there is a long-term relationship between electricity consumption and real per capita GDP. Raza, Shah-baz and Nguyen (2015) also confirmed the bidirectional causal relationship between energy consumption and gross domestic product.

DATA AND METHODOLOGY

Data Sources, Type and Range

The study uses annual time series data. Log-Log forms of the models are used to estimate the results. Data for all variables are obtained from World Development Indicators published by the World Bank and the Economic Survey of Pakistan published by the Pakistan Federal Bureau of Statistics.

Methodological Discussions

Most macroeconomic models can have spurious regression problems because most macroeconomic variables are trending. So, to solve it, we can successively take the difference in the series until we get the stationary one. Once stationary is reached, we can take this stationary series for regression analysis. But this is not an ideal solution because applying the first difference can lose long-term properties and models formulated by taking the differences are not a altimate solution. The basic idea is that if there are economic time series that are integrated in the same order (non-stationary), that we know are correlated (mostly through a theoretical framework), then let's try to check if we can find a way to combine them into a single series that is not itself non stationary. If this is possible, then the series exhibiting this property is said to be co integrated. To estimate the results, the following tests would be applied in the given sequence.

Augmented Dickey Fuller test for examining Stationarity of variables:

1. Lag Length Selection using Akaike, Schwarz or Hannan - Quinn Information Criterion.
2. Johansen Co-integration test for long run estimates.
3. Error Correction Model for Short run estimates.

Augmented Dickey Fuller test (ADF)

Formally, stationary can be tested by finding out whether or not the time-series data contains a unit root. Augmented Dickey Fuller (ADF) tests can be used for this purpose.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \Delta Y_{t-i} + \epsilon_t$$

Here i= 1, 2, 3,. ..... ΔY_{t-i} it shows the i-time lagged value of dependent variable Y_t. ϵ_t is an error term

Lag Length Selection (Information Criteria)

In order to select a model, the information criteria are used. A model contains the Kullback-Leibler information quantity of information, which is the distance from the actual model and is measured by the log likehood function. The notion of an information criterion consists in providing a measure of information that strikes a balance between this measure of goodness of fit and the parsimonious specification of the model. The various information criteria differ in how to strike this balance

The basic information criteria are given by;
Akaike Information criterion (AIC) = - 2 (l / T) + 2 (k / T)
Schwarz Information Criterion (SC) = - 2 (l / T) + k log (T) / T
Hannan - Quinn Information Criterion (HQ) = - 2 (l / T) + 2 k log (log (T)) / T

Johansen Co-integration Test

Johansen (1988) provides the new co integration technique for short- and long-term associations for multivariate equations. To present this approach; it is useful to expand the error correction model from a single equation to a multivariate one. Suppose we have three variables, Yt, Xt and Wt, which can all be endogenous, i.e. we have that (using matrix notation for;

$\underline{Zt = [T_t, X_t, W_t]).}$

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots\ldots\ldots\ldots + A_k Z_{t-k} + \mu_t$$

Vector error correction model (VECM) can be reformulated is as follows;

$\Delta Z_t = r_1 \Delta Z_{t-1} + r_2 \Delta Z_{t-2} + r_{k-1} \Delta Z_{t-k} + \Pi Z_{t-1} + \mu_t$

Error Correction Model (ECM)

The Error Correction Model (ECM) approach is useful for estimating the short- and long-term effects of one time series on another. Error Correction Models (ECM) are a category of multiple time series models that directly estimate the speed at which a dependent variable returns to equilibrium after a change in an independent variable (Alam, Raza, Shahbaz, & Abbas, 2015). Economists are mainly interested in long-term relationships, this is a big problem, and to solve this concept cointegration and ECM are very useful.

Model Specification

The study focuses on the impact of electricity generation on Pakistan's real GDP and real exports and considers the supply side of electricity. Considering the Solow growth model, the given models incorporate employee labor (as a proxy for labour) and gross fixed capital formation (as a proxy for capital stock) as primary variables. Solow models extended in general form are specified below;

$LRGDP_t = \alpha_o + \alpha_1 LLABF_t + \alpha_2 LCAP_t + \alpha_3 LELPR_t + \alpha_4 LEXR_t + \alpha_5 LTOT_t + \mu_i LREXPT_t = \beta_o + \beta_1 LLABF_t + \beta_2 LCAP_t + \beta_3 LELPR_t + \beta_4 LEXR_t + \beta_5 LTOT_t + \beta_6 LRPR_t + \beta_7 LRGDP_t + \lambda_i$

Table 1: Definition of Variables

Variable	Definition	Expected Relationship	Unit of Measurement
LELPR	Electricity Production	Positive	GWH
LEXR	Exchange rate	Negative	Rupees per Dollar
LTOT	Terms of Trade	Positive	Ratio of Prices (PEXPORTS/PIMPORTS)
LCAP	Fixed Capital Formation	Positive	Million Rupees
LEXR	Exchange rate	Negative	Rupees per Dollar
LRGDP	Real GDP	Dependent Variable/ Positive with Exports	Million Rupees
LREXPT	Real Exports	Dependent Variable	Million Rupees
LLABF	Employed labor Force	Positive	Millions

RESULTS AND DISCUSSIONS

Augmented Dickey Fuller (ADF)

The first step in Johansen's co integration technique is to confirm the order of integration of all the variables used in the study. Table 2 presents the results of the ADF unit root test and reveals that all variables are integrate.

Table 2: ADF Unit Root Test

Variables	Test for Unit Root in	Include in Test Equation	Probability	Result
LREXPT	Level	Intercept	0.800	I(1)
	1st Difference	Intercept	0.000	
		Trend & Intercept	0.000	
LRGDP	Level	Intercept	0.550	I(1)
		Trend & Intercept	0.320	
	1st Difference	Intercept	0.000	
		Trend & Intercept	0.000	
LRPR	Level	Intercept	0.270	I(1)
		Trend & Intercept	0.320	
	1st Difference	Intercept	0.000	
LEXR	Level	Intercept	0.860	I(1)
		Trend & Intercept	0.540	
	1st Difference	Intercept	0.000	
		Trend & Intercept	0.000	
LELPR	Level	Intercept	0.320	I(1)
		Trend & Intercept	0.210	
	1st Difference	Intercept	0.020	
		Trend & Intercept	0.000	
LCAP	Level	Intercept	0.180	I(1)
		Trend & Intercept	0.130	
	1st Difference	Intercept	0.000	
		Trend & Intercept	0.000	

Variables	Test for Unit Root in	Include in Test Equation	Probability	Result
LLABF	Level	Intercept	0.520	I(1)
		Trend & Intercept	0.260	
	1st Difference	Intercept	0.000	
		Trend & Intercept	0.000	
LTOT	Level	Intercept	0.820	I(1)
		Trend & Intercept	0.760	
	1st Difference	Intercept	0.000	
		Trend & Intercept	0.000	

All the critical values are significant at 10 percent level of significance

Lag Length Selection Criteria

The second step of the Johansen co integration technique involves selecting the appropriate lag length using appropriate information criteria. We used the Schwarz Information Criterion (SC) and Hannan-Quinn Information Criterion (HQ) in our study and the results are shown in Table 3. The favorable lag length selected in the current analysis is assumed to be '1' in the real GDP model and in the real exports model where the information criteria values are minimal.

Table 3: Lag Length Selection

Lag	Real GDP Model		Real Exports Model	
	SC	HQ	SC	HQ
0	-7.441649	-7.6111	-9.79439	-10.07042
1	-20.18214*	-21.20630*	-21.50122*	-23.07943*
2	-18.38154	-20.4644	-19.38237	-22.16276

No. of Co-Integrated Vectors

In the first model, the study found a number of co integrated equations using trace statistics and maximum Eigen value statistics. Based on the probabilities reported in Tables 4, the analysis rejects the null hypothesis that there is no co integrated vector (None). The track and maximal eigenvalue statistics confirm the long-term association between the variables in both the real GDP and real exports models.

Table 4: Unrestricted Cointegration Rank Test

No. of Co-integ. Equations	Trace Statistic	Prob.	Max-Eigen Statistic	Prob.
Real GDP Model				
None	144.5197	0.0000	57.27437	0.0002
At most 1	87.13533	0.0021	37.60232	0.0155
At most 2	49.42300	0.0435	24.21266	0.2409
At most 3	25.31135	0.2369	16.40147	0.1858
At most 4	8.828871	0.2629	8.403046	0.2188
At most 5	0.324825	0.4295	0.313825	0.4285
Real Exports Model				
None	0.718208	217.5509	125.5154	0.0000
At most 1	0.768569	147.6505	95.64366	0.0000
At most 2	0.714869	102.3727	69.71889	0.0000
At most 3	0.426826	63.24167	47.75613	0.0008
At most 4	0.278452	32.57168	29.68707	0.0226
At most 5	0.173961	13.27442	15.38471	0.1076
At most 6	0.002176	0.038224	3.731466	0.7262

Source: Authors' Estimation

Johansen Co-integration (Long run Estimates)

The long-term model estimates of real GDP and real exports are shown in Table 5, respectively. The first column shows the name of the variables, the second column describes the coefficients, the third column sets the standard errors, the fourth column reveals the t-statistics, and finally the fifth column contains the significant and non-significant relationships of all variables.

The labor force employed has a positive relationship with real GDP and real exports. The increase in labor can be justified so that our production process increases the country's total output. The increase in production will lead to an increase in real GDP and exports. These results correspond to (Uslu & Polat, 2011). Gross fixed capital formation (used as a proxy for the capital stock) proves positive with real GDP and real exports. The increase in capital formation will be indicative of the increase in the production of goods and

services. Eventually, it will lead to real GDP and real exports of Pakistan. Statistically, the capital ratio in the export model is negligible.

Electricity production was found to have positive associations with real GDP and real exports. The reason is that manufacturers will have the advantage of excessive energy supply, so they will establish more industries to make a profit. The creation of new industries will increase output, real GDP and real exports. Our findings are consistent with previous findings by Hye and Riaz (2008); Amed *et al*., (2012); Masuduzzaman (2012); Shahbaz and Feridun (2012); Xavier *et al*., (2013); Atif and Siddiqi (2010); Amed *et al*., (2012); Noor and Siddiqi (2010); Uslu and Polat (2011). The exchange rate is declared significant at the significance level of 1% of real GDP. Rate appreciation exchange rate will raise the prices of imported machinery and technology. It will discourage domestic investors from investing in the country to boost production. The decline in investment will cause a reduction in productivity, real GDP and real exports. Based on an empirical analysis, there is a positive association between the exchange rate, real GDP and real exports.

Table 5: Johansen Long Run Results

Variables	Coefficients	Standard Errors	T-Statistics	Conclusion
Dependent Variable: REAL GDP				
LLABF	1.740	0.750	2.260	Significant
LCAP	1.720	0.610	2.460	Significant
LELPR	0.580	0.120	3.090	Significant
LEXR	-1.430	0.540	-2.290	Significant
LTOT	1.850	0.770	2.340	Significant
Dependent Variable: REAL EXPORTS				
LLABF	4.220	1.310	3.060	Significant
LCAP	0.270	0.200	1.130	Insignificant
LELPR	1.810	0.290	4.760	Significant
LEXR	-2.530	0.280	-6.760	Significant
LRPR	1.010	0.230	3.030	Significant
LRGDP	2.650	1.140	2.040	Significant

Source: Authors' Estimation

The terms of trade are significant at the level of 1% of real GDP. It has a coefficient value of 1.95. It means that a 1% increase in the terms of trade will cause an average 1.95% increase in real GDP. It can be justified because an increase in export prices increases the profits of domestic producers. They will produce more for greater profits. In this sense, real GDP will increase. As for relative prices, it was expected to be positively correlated with real exports. Cheaper domestic goods and services will have a positive effect on supply both locally and internationally. In the results, it has a positive coefficient value with a significant t-value. Real GDP appears to have a significant influence on Pakistan's real exports during the study period with a coefficient of 2.56. A higher GDP motivates foreigners to trade with the nation by producing a higher level of production with more efficient resources at a lower cost. In the study, the results show similar estimates to the theory.

Vector Error Correction (Short Run Results)

The short-term results based on the vector error correction model (VECM) are shown in Table 6. The forward adjustment rate is most important in the short term. It shows how long it would take for the economy to reach long-run equilibrium from short-run equilibrium. The economy will converge to equilibrium in the long run when a negative sign with an adjustment rate and a positive sign show that the economy diverges from equilibrium in the long run. Here these models show that the economy converges towards long-run equilibrium due to the negative sign of the coefficient in both models.

Table 6: Short Run Results

Variables	Model 1 D(LRGDP)	Model 2 D(LEXPORTS)
Error Correction Term	- 0.04307	-0.252928
	(0.02109)	(0.04479)
	[- 2.87196]	[-2.69136]
D(LREXPT(-1))		-0.172966
		(0.14719)
		[-1.15395]
D(LRGDP(-1))	0.201551	-0.885881
	(0.28431)	(1.12031)
	[0.45098]	[-0.67464]

Variables	Model 1 D(LRGDP)	Model 2 D(LEXPORTS)
D(LLABF(-1))	0.215713	1.435386
	(0.34352)	(0.68763)
	[0.70622]	[1.82405]
D(LCAP(-1))	-0.010034	0.188799
	(0.04515)	(0.12739)
	[-0.44992]	[0.73813]
D(LELPR(-1))	0.141389	0.077221
	(0.06882)	(0.63125)
	[1.81063]	[0.17508]
D(LEXR(-1))	-0.209611	0.002048
	(0.04331)	(0.21797)
	[-2.04614]	[0.00429]
D(LTOT(-1))	0.004771	
	(0.02609)	
D(LRPR(-1))	[0.17257]	0.150672
		(0.14907)
		[1.14537]
Constant	0.026586	0.005426
	(0.00884)	(0.04737)
	[3.61633]	[0.22010]
R-squared	0.466900	0.511744
Adj. R-squared	0.432606	0.443430
F-statistic	4.632067	5.806184

CONCLUDING REMARKS

The purpose of the study is to examine the influence of electricity generation on Pakistan's real GDP and real exports using the Solow growth model. For this purpose, the study uses data from annual time series to estimate the results, the study uses the Log-Log shapes of the models in the Johansen Cointegration test. The augmented Dickey Fuller test concludes that all variables are stationary in the first difference.

Long-term results reveal that electricity generation, employed labor force, gross fixed capital formation and terms of trade have a positive association with real GDP, while the exchange rate has a negative effect on real GDP. In the export model, electricity generation, employed labor force, gross fixed capital formation, relative inflation, and real GDP are positive with real exports, while the exchange rate has a negative association with real exports.

Based on our findings, we can suggest that to increase real GDP and real exports, the government should increase electricity generation by immediately building new dams and the coal-fired power project. The government must make sincere efforts to maintain the terms of trade so that they can be useful for exports. The private sector should be encouraged to invest rather than privatize so that the workforce can get the job opportunities with all the future benefits. The exchange rate can be controlled by a fixed policy, but it is not desirable as long-term policy making if managed by a flexible exchange rate policy would be more beneficial to the economy.

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