Energy Consumption, Trade and GDP: A Case Study of South Asian Countries

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By

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Abstract

Using panel co-integration approach over the period 1980-2009 for South Asian economies, this study investigates the dynamic linkages between energy consumption, trade and GDP. The results show that, in the short run, feedback relationship holds between energy consumption and GDP and between energy consumption and exports. In the long run, the feedback relation holds between energy and GDP while unidirectional causality holds from export to energy. Thus, feedback hypothesis between energy and GDP holds in the short as well as in the long run. The feedback relationship between trade and energy consumption suggests that any shortage of energy supply will lessen the trade and this reductions in trade will lessen the benefits of trade in the region since results have also shown that reduction in export can impede GDP growth.

Key Words: Energy Consumption; Growth; Trade; Panel Co-Integration

JEL Classification: F14; F21; Q40

1. Introduction

Acute shortage of energy sources in developing countries in general and South Asian countries in particular has shown that energy has become a binding input for any production process. Energy consumption, being a vital input in production process, affects GDP directly. Availability of energy at reasonable cost improves competiveness of home products in international market, increases exports and affects GDP indirectly. In addition, demand for heavy machinery and electrical equipment- basic components for industrial growth also depends on sufficient supply of energy.

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Ghali and El-sakka (2004) documented that energy is a limiting factor to GDP growth. The production is a work process that requires energy to transform material into goods or services. Stern (2000) noted that there exists a long run relationship among GDP, labor, capital and energy consumption and energy is a key factor in explaining GDP.

The relationship of trade and GDP has been widely discussed in classical theories from the era of Adam Smith to date. Trade enhances economic growth by increasing local market size, by allocating resources efficiently, by improving economies of scale and by increasing capacity utilization. Blassa (1978) documented that export orientation is an important factor in explaining inter-country differences in growth of income with labor and domestic and foreign investment. Further, the growth of exports depends upon the level of energy consumption in the industrial sector for gaining better export production. The machinery and equipment used in production, processing and transportation of goods for export require energy to operate (Sadrosky 2011). Theoretically, it could be that energy consumption and trade has a long run relationship but there is little empirical evidence of investigation of this dynamic relationship.

The relationship between energy consumption and output is a vastly studied area in energy economics (e.g. Lee, 2005; Khan and Qayyum, 2006; Noor and Siddiqi, 2010) and the relationship between trade and output is a broadly studied area in international economics (e.g. Kemal et al, 2002; Din, 2004). However, the long run relationship among energy consumption, trade and GDP is relatively less studied area of economics particularly for South Asian countries. The understanding of the dynamics among these variables has important implications for new energy and trade policies. For example, if unidirectional Granger causality or no Granger causality is observed between trade and energy consumption then energy conservation policies which could create energy shortages, will have no effect on trade policies which are designed to promote economic growth and welfare of the nation. On the other hand, if there exists bidirectional causality between energy consumption and trade then energy conservation policies to reduce energy wastage can offset the positive effects and benefits of trade promotion and thus economic growth of the country will impede.

This study is different from previous studies in following ways: First, most of previous studies focus either on energy-GDP relationship or export-GDP relationship for South Asian economies. This study explores the simultaneous relationship between trade, GDP and energy consumption.

Second, in this study panel co-integration approach is used to estimate the long run relationship between the variables and this approach is considered more advantageous over a single equation technique and thus provides better estimates for the dynamic relationship between the variables.

The roadmap for the remainder of this study is as follows. Section 2 outlines the review of literature related to the topic. Section 3 describes the theoretical framework and methodology. Section 4 presents and describes the empirical findings and its economic relevance with interpretation and final section contains policy implications and concluding remarks about the study.

2. **Literature review**

This analysis presents a brief literature review of the existing studies on the trade and energy with GDP relationship. Literature review is divided into three part; (1) review of energy and GDP relationship, (2) review of trade and GDP relationship and (3) review of energy, trade and GDP relationship.

Energy consumption and GDP:

In the literature, a number of studies have explored the relationship between GDP and energy consumption. The neo-classical growth theories consider labor and capital as important factors of production while ignore the importance of energy. However, following the energy crisis of 1970's, the importance of energy for GDP growth received a considerable importance. Initially, Kraft and Kraft (1978) studied the casual relationship between energy and GNP. Since then there is a plethora of studies in this regard and there are mixed results for the relationship of these two variables. There are four basic hypothesis for the causality relationship between energy consumption and economic growth: First, neutrality hypothesis which suggests that there is no significant causal relationship between energy consumption and GDP. Second, conservation hypothesis which suggests that there is a one-way causality relationship running from GDP to energy consumption. Third, feedback hypothesis which suggests that there is a two-way causality relationship between energy consumption and GDP. Fourth, growth hypothesis suggests there is a one-way causality relationship running from energy consumption to GDP.

Using ARDL approach and annual data over the period 1972-2004, Khan and Qayyum (2005) find out that energy plays a vital role in the Pakistan, India, Sri-lanka and Bangladesh to enhance and promote economic growth and energy shortfall can retard the economic growth.

Noor and Siddiqi (2010) find out a negative long run relationship between energy and GDP in South Asian countries (Pakistan, Bangladesh, Nepal, Sri-lanka and India). Using panel co-integration and fully modified OLS. In the short run, they found unidirectional causality running from energy to GDP.

Using a sample of 18 developing countries, Lee (2005) suggests that energy conservation policies are harmful in selected countries and his findings are in support of growth hypothesis. He used panel co-integration technique and panel VECM to check the relationship between energy and GDP over the period 1975-2001. The results supported long run relationship between these two variables after allowing for individual county effects and energy is impetus for GDP growth in these countries.

Lee and Chang (2008) confirm a long run relationship between energy consumption, GDP, capital stock and labor using panel co-integration technique for 16 Asian countries over the period of 1971-2002. Their results are in support of growth hypothesis as there is found one way causality running from energy consumption to GDP.

Narayan and Popp (2012) argue that there are some countries where energy conservation policies have minimal effects on GDP growth. They found mixed results for the long-run Granger causality relationship between energy and GDP for 93 countries using annual data from 1980 to 2006. They found a long-run relationship between energy and GDP for Asia,

Chen et al. (2006) suggest that electricity used and GDP have a feedback relationship for ten newly industrialized Asian countries selected in the long run but one way causality running from GDP to electricity is found for short run. The panel co-integration technique is used to investigate the relationship by using panel data from the period 1971-2001. They favor conservative policies to avoid wastage of energy and for a sufficient supply in the long run to enhance economic growth.

Dahmardeh et al. (2012) suggest that there exists a feedback relationship between energy consumption and GDP growth for 10 Asian developing countries selected. They used panel data of the variables concerned for the period 1980-2008. The panel VECM is used to investigate the causality relationship between the two variables and it is found unidirectional causality running from energy consumption to GDP in short run while a bi-directional causality between the two variables in the long run.

Ghali and El-sakka (2004) are of the view that energy is a limiting factor to GDP growth and there is a bi-directional causality relationship between them. They used co-integration technique and VECM to study the long run relationship and causality direction between the two variables for Canada.

Asufu-Adjaye (2000) is of the view that energy and GDP with price are endogenous in many cases and there is found unidirectional causality running from energy to GDP for India and Indonesia and bidirectional causality for Philippines and Thailand. Their findings were based on co-integration and VECM approach by using ML method of estimation. They were unable to refute the neutrality hypothesis in short run for India and Indonesia. Their results are in support of the notion that more energy dependent countries are vulnerable to energy shocks more than those of less energy dependent countries.

Trade and GDP growth:

The relationship of trade and GDP growth is discussed in classical theories from the era of Adim Smith and many other classical economists. They support export promotion on the basis of comparative advantage to increase economic welfare and GDP growth. Kemal, et al. (2002) has investigated the export-led growth hypothesis for five South Asian countries (Pakistan, Bangladesh, India, Nepal and Sri lanka) by using co-integration technique in a restricted VAR model. Their findings were in support of export oriented growth policies as there was found a one way causality running from exports to GDP growth for Pakistan and India and a two way long run causality for the remaining three countries.

Din (2004) also investigated the export-led growth hypothesis for five South Asian economies with incorporating the role of imports. The findings suggest that there is long run relationship among the GDP, exports and imports for Pakistan and Bangladesh while a short run bidirectional causality were found in Bangladesh, Sri lanka and India after controlling for imports but no long run relationship found for Nepal, India and Sri lanka.

Awokuse (2008) has investigated the prevalence of export-led and import-led growth hypothesis in 3 Latin American countries (Peru, Colombia, Argentina) using a neoclassical production function and estimating it by multivariate co-integrating VAR. The findings were in support of import-led growth hypothesis as there was found unidirectional or bidirectional causality from imports to GDP growth for the 3 countries selected but impulse response also provide support for export-led growth hypothesis in Argentina and Peru.

Bahmani-Oskee et al. (2005) suggest that there exists a co-integrating relationship between exports and GDP growth when GDP is taken as dependent variable but the converse was not found true so they support the growth-led export hypothesis. Their findings were based on panel of 62 developing countries from the period 1960-1999

Giles and Williams (1999, 2000) suggest that findings of export-led growth hypothesis with standard causality techniques are not consistent when specification or methodology is changed and interpretation of ELG hypothesis needs extreme care in this situation. They reinvestigated the two ELG applications of Sadorsky's 1996 study for Canada and Oxley's study for Portugal. They also show that Granger causality test is found to be sensitive to the degree of deterministic component and to the method used to check for non-stationarity.

Shirazi and Manap (2004) found a feedback relationship between imports and GDP and unidirectional long run causality from exports to GDP by implying Johansen co-integration technique and Toda and Yamamoto causality test for Pakistan using the data from 1960-2003.

Energy consumption, Trade and GDP

There are few studies that investigated the ties between energy consumption, trade and GDP. In particular, Narayan and Smyth (2009) noted statistically significant feedback relationship between GDP, electricity used and exports for a panel of Middle Eastern countries. Further a short run granger causality running from electricity used to real GDP and from income to export while in long run Granger causality running from exports and electricity used to GDP and from export and real GDP to electricity used.

Lean and Smyth (2010a) found evidence of unidirectional causality relationship running from electricity consumption to exports in Malaysia by using capital, labor, GDP, export and electricity used in a production function framework. Further export-led growth hypothesis was supported for the country. The annual data from 1970 to 2008 was used to estimate the relationship for above mentioned variables. While in a similar kind of investigation, Lean and Smyth (2010b) noted unidirectional causality relationship from GDP growth to electricity generation while no causal relationship was found between exports and electricity generation. Further export-led growth or growth led export hypothesis were not supported in Malaysia by employing the data from 1970 to 2008.

Sadorsky (2011a) noted unidirectional short run granger causality running from export to energy consumption while a feedback relationship between energy consumption and import for a panel of 8 Middle Eastern countries. Further bidirectional causal relationship between energy consumption and GDP was found and long run elasticity estimated by FMOLS showed that both export and import increments will increase energy demand in the countries selected.

Sadrosky (2011b) noted for seven South American countries, a long run relationship between GDP, labor, capital and trade (imports or exports) by using an aggregate production function and short run dynamics show a feedback relationship for export and energy consumption and unidirectional causality running from energy to imports. In the long run a causal relationship was found for trade (exports or imports) and energy consumption.

By considering these studies it is clear that energy consumption and trade are inter-correlated and most of the studies described, favor a feedback relationship between energy consumption and trade in short run as well as in the long run. The present study contributes to the literature by investigating the dynamic linkages between trade and energy in the production framework for the South Asian economies as there is little or no empirical literature on this topic for this region.

3. Analytical Framework and Descriptive analysis

Sadorsky (2011b) modeled the relationship between energy consumption, trade and GDP by using a production framework with labor, capital formation for seven South American economies. The present study also uses the same model to estimate the long run linkages among energy consumption, trade and GDP for five South Asian economies.

$$Y= f\ (K, L, E, T, S) \qquad (3.1)$$

Taking natural logarithms of above function after parameterization and adding an error term in it, equation (3.1) can be written as.

$$y_{it} = \alpha_1 k_{it} + \alpha_2 l_{it} + \alpha_3 e_{it} + \alpha_4 t_{it} + s_i + \varepsilon_{it} \qquad (3.2)$$

In above equation countries are denoted by subscript (i=1……….N) and the subscript t designates the time span (t=1…………..,T) and this is a broad specification which sanctions for individual fixed country effects(S) and a random error term (ε). The estimation of the above equation will provide the long run elasticities and the coefficients of the independent variables are expected to a have positive effect

3.2 Descriptive Analysis:

To analyze the characteristics of variable under consideration, this section outlines the average annual growth rates of the countries, correlations among the different variables and graphical analysis of all the variables.

3.2.1 Average annual growth rates of the variables:

First of all, we take the average annual growth rate of the variables the results are given in table (3.2.1):

Table 3.2.1 Average annual growth rates of the variables from 1980-2009.

Country	Energy consumption	Real GDP	Real capital formation	Labor	Real export
Bangladesh	4.472259739	4.740199304	7.781782842	2.725675323	13.20962832
India	4.207516017	6.08846928	8.55492917	2.625724838	14.36076241
Pakistan	4.378186429	4.985839842	4.327417544	3.248734042	8.874416989
Sri-Lanka	2.56055973	4.76591611	4.399257597	1.180351229	7.667946868
Nepal	2.736395369	4.56373306	0.845101381	2.903873765	9.277615628

Average annual growth rate of the energy consumption in the countries ranges from a high value of 4.47 per year for Bangladesh to a low range of 2.56 per year for Sri Lanka. For all of these countries, growth rate of energy consumption is more than 2.5 % per year and even more than 4% per year for three countries. For Pakistan and Bangladesh average annual growth rate of energy consumption are almost equal to their average annual growth rate of real GDP and for the remaining 3 countries, the growth rate of the two variables are also closely related which means that for all of these countries energy consumption and real GDP are growing almost at the same rate. Particularly, India stands out for having high GDP growth rate while all remaining countries have almost average annual GDP growth rate of 4% per year. Bangladesh and India are the countries having the positive double digit average annual growth rate in exports. Real capital formulation have a high average annual growth rate of more than 4% per year for all of the countries except for Nepal which has a lowest growth rate of 0.84 % per year.

3.2.2 Correlations for the variable (in growth rate):

The results for correlations among the different variables of the panel are given in the table (3.2.2).

Table 3.2.2
correlations

	Δy	Δk	Δl	Δe	Δx
Δy	1				
Δk	0.399259	1			
Δl	-0.018871	0.027312	1		
Δe	0.264079	0.184006	0.105531	1	
Δx	0.260941	0.109095	-0.002224	0.203518	1
Δm					

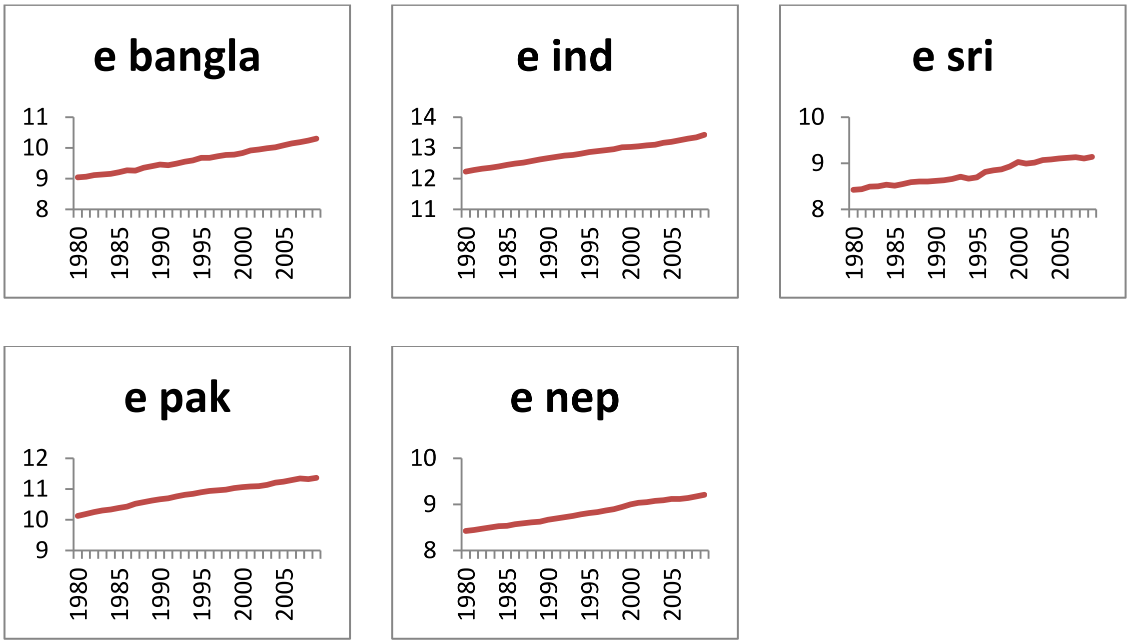
Observation=150

The growth rate in energy consumption shows a highest correlation with the growth rate of real GDP and lowest correlation with the growth rate of labor. This suggests that energy is important to explain GDP and energy and labor are weakly independent from each other. The growth rate in GDP shows a highest correlation with the growth rate of capital formulation. This suggests that capital formation plays significant role to enhance GDP. Most of the correlations are positive which supports our theoretical model. Labor growth is negatively correlated with the GDP growth and exports. GDP growth and energy growth rates are also having a positive correlation, which suggests that increase in GDP also increase energy consumption. All the correlations support our theoretical model.

3.3 Graphical analysis of the trend of the variables:

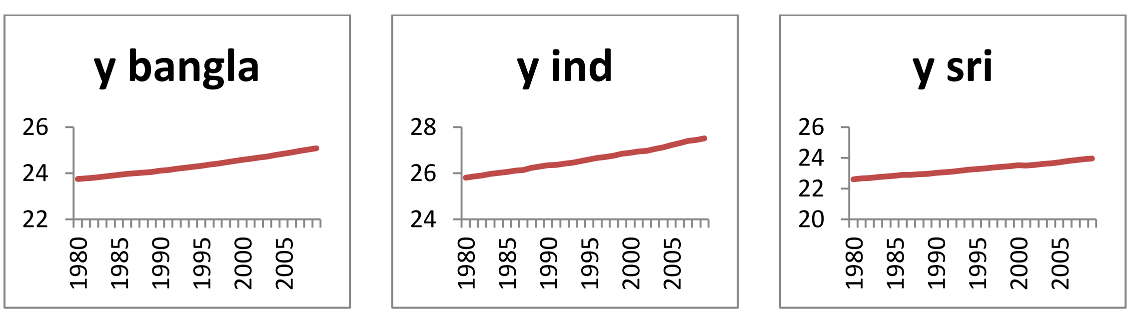
To analyze the trend and long run behavior of the variables under analysis we have done graphical analysis.

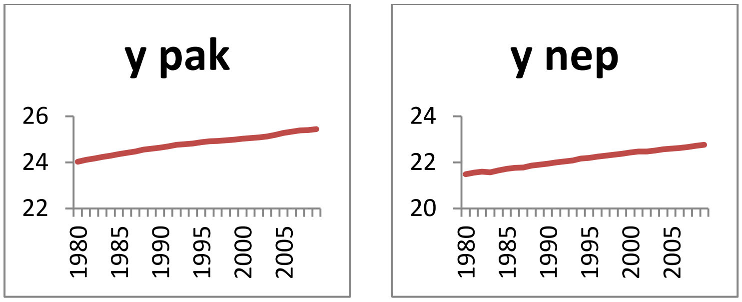
Figure 1) Natural log of energy consumption.



The above figure (1) contains the time series graph of natural log of energy consumption for each country of the South Asian region. All the countries have a positive trend across time, although the trend varies by the countries. The largest energy consumer country is India with Pakistan standing at second position in this regard. Bangladesh is the third largest energy consumer of the South Asian region while Nepal and Sri Lanka stand at fourth and fifth position respectively. The time series plot of the energy consumption shows that Sri Lanka is the least energy consumer while India the biggest energy consumer in the South Asian region.

Figure 3) Natural log of real GDP.

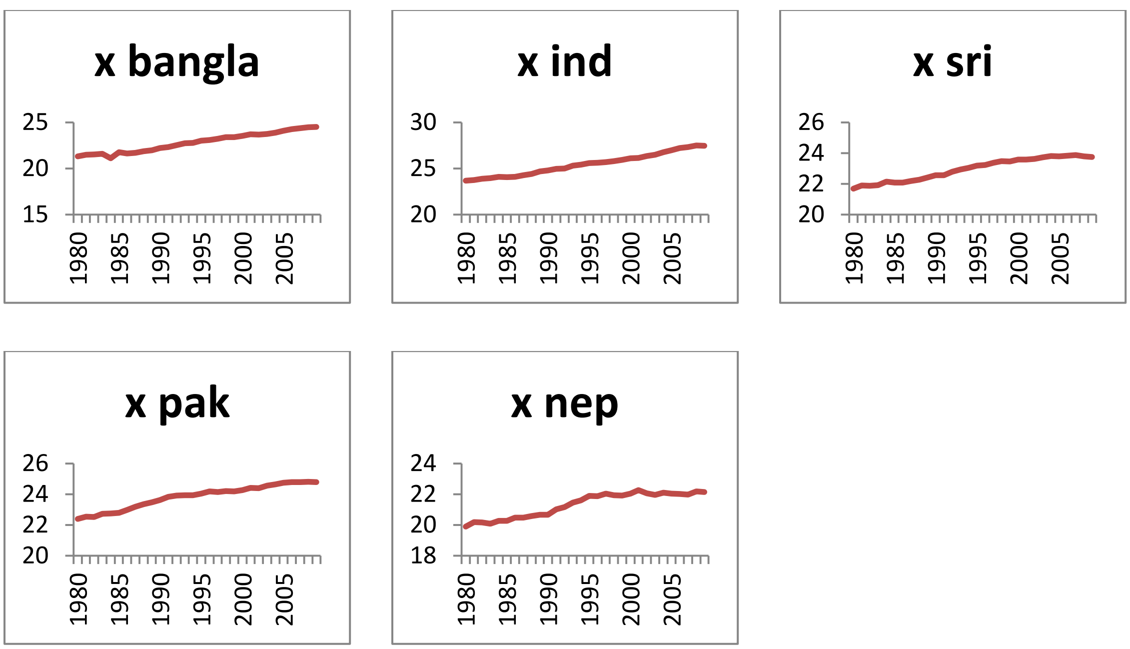




The above figure (3) contains the time series graph of natural log of real GDP for each country of the South Asian region. Overall, real GDP have a positive trend across the time for each of the countries. The economic performance of India and Bangladesh is quite impressive as GDP has been an upward and fairly tight linear trend and there are no huge declines in the trend. The largest economy in the South Asian region is India while Nepal is the smallest.

Figure 4contains the time series graph of natural log of real exports for each country of the South Asian region. All the countries have a positive trend across time, although the trend varies by the countries. India is the largest exporter while Pakistan is the second largest exporter of the panel. Nepal is the smallest exporter with a varying trend.

Figure 4 Natural log of real exports.



The trend of all the variables is positive which suggest that there could be a long run relationship among these variables and this is consistent with our specification of the model.

4. Methodology and data construction

This section provides a discussion on methodology to estimate the long run linkages among energy consumption, trade and GDP for the panel of South Asian economies.

Panel Unit Root Test:

As a first step to check for the co-integration it is necessary to ensure that the order of integration of the variables are same, so for this motive, three types of panel unit root test are used.
Levin et al (2002), proposed a test to check the non-stationarity of the variables in a panel data set. The null hypothesis of this test is that there is a unit root while the alternative hypothesis is that there is no unit root. This test assumes that there is common unit root process across all the cross section and cross sectional independence for the individual processes.

Im, Pesaran and Shin (IPS) (1997), modified the LL Levin et al. test by allowing the coefficient of the lagged dependent variable to be heterogeneous. They proposed a test based on the average of single unit root test statistics. IPS test is different from LL test with respect to the alternative hypothesis as LL test assumes common unit root process while IPS assumes individual unit root process.

Maddala and Wu (1999) proposed a model which can be estimated with an unbalanced panel and they also prefer heterogeneous alternative. This test perform well as compare to LL or IPS test when error of different cross section units are cross correlated and further MW has a small size distortion when T (time period) is large and N (cross section) is small.

In all of the above tests, if the results do not reject the null hypothesis at standard significance levels, in level form for any variable but reject the null hypothesis for the same variable in the difference form then this variable would be declared as non-stationary or integrated of order one i.e. I(1).

Panel co-integration test:

According to the definition of Engle and Granger (1987), if any two variables X or Y are integrated of same order (one or more) and if we estimate them by OLS and their residuals u_t are found to be stationary (order of integration is one less than those of the estimated variables) then they are said to be co-integrated and have a long run equilibrium relationship. Using the same approach of testing the non-stationarity properties of the residual from ordinary regression of the variables, Pedroni (1999, 2004) has extended the above approach for a panel data setting. Panel co-integration approach has more power over single co-integration approach on time series data and thus estimates would be more precise and reliable in a panel data framework. Panel framework is advantageous when sample size of each cross sectional unit is short because by combining different cross sectional units, we can increase sample size with more degree of freedom and this yields more precise estimates as compare to those come from each cross section individually.

For panel co-integration approach of Pedroni, equation (3.4) is estimated by OLS for every member country (i=1…..N) and residuals obtained are used to estimate the following equation:

$$\mu_{it} = \rho_i \mu_{it-1} + \varepsilon_{it} \qquad (4.4)$$

In the above equation, $\rho_i$refers to the autoregressive parameter and ε_{it} are the stationary error terms. The null hypothesis of the co-integration test is:

Ho: ρ_i= 1, where i=1,…..,N

The acceptance of the above hypothesis means that there is no co-integration among the cross sections of the panel and Pedroni has provided seven statistics to test for the above null with the alternative of co-integration among all the cross sectional units of the panel.

The test is divided into two categories with respect to the alternative hypothesis. The first category is called within - dimension (panel test) in which the AR coefficient across the cross sectional units of the panel are pooled to apply unit root test on the residuals obtained by the procedure described before. There are four tests with respect to the within-dimension class and these tests involve calculating the average test statistics for the co-integration in the panel framework. These four tests are the panel-v, panel-PP-ρ panel-PP-t and panel-ADF-t statistics and the alternative for these statistics is as follow:

Ho: $(\rho_i = \rho) < 1$, where i=1,…..,N

The second category is called between-dimension (group-means approach) in which AR coefficients are averaged for each member country of the panel to apply unit root test on the residual obtained by OLS on equation (3.4). For the between-dimension approach, averaging is done in pieces and it includes group-PP-ρ statistic, the group-PP-t statistics and group-ADF-t statistics. The alternative hypothesis for these 3 tests is as follow:

Ho: $\rho_i = < 1$, where i=1,…..,N

So the null hypothesis is same for both categories but the alternative hypothesis is different for the within-dimension and between-dimension approach. The group-means or between dimension tests is considered less restrictive as it does not put a condition on the value of ρ to be common for all cross sections in the alternative hypothesis so this allows more heterogeneity of the parameters across the countries of the panel.

Dynamic OLS:

In case of the above panel co-integration test, if there is an indication for a significant co-integrating relationship then equation (3.2) can be estimated and these estimates will provide long run elasticities. However, estimating the equation in the context of panel with ordinary least square (OLS) will result in the estimators which are asymptomatically biased and their distribution depend on the nuisance parameters. Pedroni (2000, 2001) documented that nuisance parameter are the regressors that could generate unwanted endogeneity and serial correlation although they are not part of the true data generating process. So to address the problem of endogeneity and serial correlation, dynamic OLS proposed by Pedroni (2001) is used as this approach allow for standard inference by using corrections for these aforementioned problems. Fully modified OLS proposed by Pedroni (2001) is also applicable to draw inferences from panel data setting in presence of nuisance parameters.

FMOLS employs a non-parametric correction to deal with endogeneity and serial correlation problem. DOLS employs a parametric correction of adding lead and lags dynamics of the right hand side variables. FMOLS is preferred over DOLS in small sample as DOLS approach can consume more degrees of freedom as compare to FMOLS but in large samples both approaches perform almost equivalently. The DOLS equation is written as:

$$y_{it} = \alpha_{ki}k_{it} + \alpha_{li}l_{it} + \alpha_{ei}e_{it} + \alpha_{ti}t_{it} + \sum_{j=1}^{p}\beta_{y1ij}\,\Delta y_{it-j} + \sum_{j=1}^{p}\beta_{k1ij}\,\Delta k_{it-j} + \sum_{j=1}^{p}\beta_{l1ij}\,\Delta l_{it-j} + \sum_{j=1}^{p}\beta_{e1ij}\,\Delta e_{it-j} + \sum_{j=1}^{p}\beta_{t1ij}\,\Delta t_{it-j} + s_i + \varepsilon_{it} \qquad (4.4)$$

Here p shows the lead and lags length, s_i is the country specific fixed effect and ε_{it} is a random error term. This study reports the results from DOLS for the variables.

4.5 Panel Granger Causality Test:

If there is found evidence in support of the co-integration relationship among the variables, then there exists an error correction mechanism by which a variable is adjusted towards its long run equilibrium. By following the approach of Engle and Granger (1987), we can estimate the error correction model (ECM) for the panel. 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. Further, there exists Granger causality in at least one direction, if a co-integration relationship is found between a set of variables. The panel VECM for equation (3.4) is written as follows:

$$\Delta y_{it} = \propto_{1i} + \sum_{j=1}^{p}\beta_{11ij}\,\Delta y_{it-j} + \sum_{j=1}^{p}\beta_{12ij}\,\Delta k_{it-j} + \sum_{j=1}^{p}\beta_{13}\,\Delta l_{it-j} + \sum_{j=1}^{p}\beta_{14}\,\Delta e_{it-j} + \sum_{j=1}^{p}\beta_{15}\,\Delta t_{it-j} + \beta_{16i}\mu_{it-1} + \omega_{1it} \qquad (4.5\text{ a})$$

$$\Delta k_{it} = \propto_{2i} + \sum_{j=1}^{p}\beta_{21ij}\,\Delta y_{it-j} + \sum_{j=1}^{p}\beta_{22ij}\,\Delta k_{it-j} + \sum_{j=1}^{p}\beta_{23}\,\Delta l_{it-j} + \sum_{j=1}^{p}\beta_{24}\,\Delta e_{it-j} + \sum_{j=1}^{p}\beta_{25}\,\Delta t_{it-j} + \beta_{26i}\mu_{it-1} + \omega_{2it} \qquad (4.5\text{ b})$$

$$\Delta l_{it} = \propto_{3i} + \sum_{j=1}^{p}\beta_{31ij}\,\Delta y_{it-j} + \sum_{j=1}^{p}\beta_{32ij}\,\Delta k_{it-j} + \sum_{j=1}^{p}\beta_{33}\,\Delta l_{it-j} + \sum_{j=1}^{p}\beta_{34}\,\Delta e_{it-j} + \sum_{j=1}^{p}\beta_{35}\,\Delta t_{it-j} + \beta_{36i}\mu_{it-1} + \omega_{3it} \qquad (4.5\text{ c})$$

$$\Delta e_{it} = \propto_{4i} + \sum_{j=1}^{p}\beta_{41ij}\,\Delta y_{it-j} + \sum_{j=1}^{p}\beta_{42ij}\,\Delta k_{it-j} + \sum_{j=1}^{p}\beta_{43}\,\Delta l_{it-j} + \sum_{j=1}^{p}\beta_{44}\,\Delta e_{it-j} + \sum_{j=1}^{p}\beta_{45}\,\Delta t_{it-j} + \beta_{46i}\mu_{it-1} + \omega_{4it} \qquad (4.5\text{ d})$$

$$\Delta t_{it} = \propto_{5i} + \sum_{j=1}^{p}\beta_{51ij}\,\Delta y_{it-j} + \sum_{j=1}^{p}\beta_{52ij}\,\Delta k_{it-j} + \sum_{j=1}^{p}\beta_{53}\,\Delta l_{it-j} + \sum_{j=1}^{p}\beta_{54}\,\Delta e_{it-j} + \sum_{j=1}^{p}\beta_{55}\,\Delta t_{it-j} + \beta_{56i}\mu_{it-1} + \omega_{5it} \qquad (4.5\text{ e})$$

In all of the above equations from (4.5a) to (4.5e), the Δ is used to show the first difference operator, p is the appropriate lag length, y is the real output, k is the real fixed capital formation, l is the labor force, e is the real energy consumption, t is the trade variable (measured by using real exports and all of the above variables are in natural logarithm form, μ is the error correction term and it is obtained by the residual estimated from equation (3.2. and ω shows the random disturbance terms. The panel VECM is obtained by using OLS with panel corrected standard errors. The coefficients of the lagged difference explanatory variables shows the short run dynamics and they are used to interpret the short run Granger causality relationship among the variables while for the long run Granger causality interpretation, adjustment coefficients of the lagged error term are used.

Data

Our study uses data set of balanced panel of five South Asian countries followed over the year 1980 to 2009 and contains annual data of the variables. The dimensions of the panel data set are selected to incorporate as many countries as possible with a reasonable time length of observations. The South Asian countries included in the sample are: Pakistan (PAK), Bangladesh (BAN), Sri Lanka (SRI), India (IND) and Nepal (NEP). Due to data limitations for Bhutan and Maldives, these two countries were not included in the sample. We used data of real GDP at 2000 constant US dollar. Data of total labor force is used to measure labor and includes both employed and unemployed workers. Data of real gross fixed capital formation is used to measure capital stock of the countries. Data of energy consumption in kilo tons of oil equivalent at constant 2000 US dollar is used to measure energy consumption. Data of merchandise export were taken as proxy to trade. Export is converted into real value by dividing it by consumer price index.

Data of consumer price index were obtained from the Penn World Table version 7.1 (Heston et al., 2012). Data of all the remaining variables were taken from World Bank source (CD-ROM 2012) which is World Development Indicator.

5. Empirical Results and Discussion

The prime emphasis of this study is to investigate the simultaneous linkages among energy consumption, trade and GDP for the South Asian region. This section contains a detailed discussion on the empirical findings of the study.

5.1 Results of Panel Unit Root Tests:

The results of all the panel unit root tests on the variables in level form do not reject the null hypothesis of unit root at the 5% significance level while for each variable in first difference form; the null of unit root is rejected at the conventional level of significance. Hence, all of the variables are integrated of order one at levels but their first differences were found to be integrated of order zero so it is possible that these variables have a long run equilibrium relationship that means they are co-integrated.

5.2 Result of panel co-integration test:

Table 5.2.1 Panel co-integration result for model with export

Alternative hypothesis: common AR coefficients. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.375831	0.0844	-0.688822	0.7545
Panel rho-Statistic	0.505718	0.6935	-0.912894	0.1806
Panel PP-Statistic	-1.013472	0.1554	-3.382694	0.0004
Panel ADF-Statistic	-0.284397	0.3881	-1.483608	0.0690

Alternative hypothesis: individual AR coefficients. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	0.700439	0.7582
Group PP-Statistic	-1.694875	0.0450
Group ADF-Statistic	-0.528387	0.2986

Null Hypothesis: No co-integration
Trend assumption: No deterministic trend
Lag selection: automatic SIC with a maximum at lag 5

The results of both the within-dimension and between-dimension tests summarized in above Table 5.2.1 reject the null hypothesis of no cointegrtion at 10% level of significance except for the Group ADF-statistics, Group ρ-statistics, panel v-statiscs and panel rho-statistics which do not reject the null hypothesis at 10% level of significance. Hence, we can conclude that the residuals from equation (3.4) with export as proxy to trade, are stationary and there is a panel co-integration relationship between real GDP, real fixed capital formation, labor, energy consumption and exports.

5.3 Results of short run and long run granger causality with VECM:

The understanding of the direction of causality between the GDP growth, energy consumption and trade is useful for new energy and trade policies. So to accomplish the task, we use the methodology outlined in section (4.5) to analyze the direction of short run as well as long run Granger causality relationship between different variables of the panel data set.

To analyze the Granger causality directions between GDP, energy, labor, capital and exports, equation 3.2 is estimated and their residual are saved. Then all equation from (4.5a) to (4.5e) outlined in section (4.5) are estimated. The results of Granger causality with VECM with exports are reported in Table (5.).

Table 5.: Result of Granger causality For VECM with exports.

From	To				
	Δy	Δk	Δl	Δe	Δx
Δy		4.49	-0.94	3.06	2.37
prob.		0.00	0.34	0.002	0.018
Δk	4.82		0.61	0.85	-0.10
prob.	0.00		0.54	0.39	0.92
Δl	-0.95	0.60		1.30	-0.20
prob.	0.34	0.54		0.19	0.84
Δe	3.18	0.85	1.31		1.65
prob.	0.00	0.39	0.19		0.10
Δx	2.47	-0.20	-0.10	1.64	
prob.	0.01	0.92	0.84	0.10	
μ_{t-1}	-4.43	1.50	-0.91	2.26	0.15
prob.	0.00	0.13	0.36	0.02	0.87
Speed of adjustment	-.445133	.803	-.075	.326	.1207

The Table (5.) contains t-statistics with their p-values for all variables including error correction term and coefficients of lagged error terms which show speed of adjustment towards long run equilibrium after a shock, are also reported below the p-value of lagged error terms.

For the interpretation and discussion of the results, a level of 1%, 5% and 10% are used respectively. The short run Granger causality test show that there exists a feedback relationship between energy and GDP at all level of significance while there exists a feedback relationship between energy and exports at 10% level of significance. For trade-GDP relationship the Granger causality test shows a bidirectional feedback relationship between exports and GDP at all level of significance. There also exists short run feedback relationship between capital and GDP at all level of significance. There are no other statistically significant Granger causality relationships for other variables.

For the purpose of long run Granger causality relationship, significance of the coefficients of lagged error term is necessary. For equation (4.5a) with GDP as dependent variable, the coefficient of the lagged error term has a value of -0.44 and it is highly statistically significant at 1% level of significance. By this error correction term, short run variations are driven by adjustment back to long run equilibrium and 44% of the error is corrected in first year and 44% of the remaining of error is corrected in the next year and so on. The other coefficients of lagged error terms are not significant except for the equation with energy on left hand side. So there is evidence of long run Granger causality from capital, labor, energy and exports to GDP and long run causality from capital, labor, GDP and exports to energy. The significance of these two lagged error terms shows that long run adjustment to equilibrium is essential in explaining short run dynamics in GDP and energy. The feedback relationship between exports and GDP suggest that exports play a significant role to enhance the GDP growth and vice versa in short run and unidirectional relationship running from export to GDP in the long run. This supports both the export-led growth in short as well as in long run and the growth-led export hypothesis in short run for the South Asian region. This finding has resemblance with findings of Kemel et al. (2002) who studies same five South Asian countries for export-GDP relationship. The feedback relationship between capital and GDP also supports the idea that changes in capital formation are important in explaining changes in GDP in short run and vice versa. Further evidence of feedback relationship between energy and GDP suggests that energy is a limiting factor to GDP growth in South Asian countries and changes in GDP are also important in explaining changes in energy consumption both in the short run and in the long run. This finding resembles with the finding of Khan and Qayyum (2006) which suggests that any energy shortfall can retard the GDP growth in the South Asian region.

Result of long run elasticities with Dynamic OLS:

Finally, we proceed with the estimation of long run elasticities table below contains the results of long run elasticities for the model with exports.

Table 5.3.1			
DOLS results			
Dependent variable = y			
	Coefficient	t	P - value
k	.11372	2.31	0.021
l	.5148357	2.04	0.041
e	.3289455	1.30	0.202
x	.2701083	5.57	0.000

For the purpose of interpretation and discussion for the empirical findings, 10% level of significance is used. The dynamic OLS result shows that capital, labor and exports have the coefficients which are statistically significant at the level of 5% while coefficients of energy is insignificant even at the significance level of 10%. This means that a 1% increase in capital increases GDP by 0.11% and 1% increase in labor increases GDP by 0.51% and similarly a 1% increase in exports increases GDP by 0.27%.

The results of dynamic OLS suggest that energy contributes significantly in explaining GDP in the long run. These findings are in contrast to the findings of Noor and Siddiqi (2010) who found a negative relationship between energy and GDP for the South Asian countries. This contradiction may be due to the inclusion of trade variable in the model.

6. **Conclusion and policy implication**

The purpose of present study has been to investigate the long run dynamic linkages between energy consumption, trade and GDP for a panel of South Asian economies over the period 1980-2009 using panel co-integration approach with dynamic OLS. The findings support the feedback relationship between energy consumption and GDP, between trade and GDP, and between energy consumption and exports in the short run. In the long run, the feedback relation between energy and GDP holds while in the case of export and energy the relationship is unidirectional. The unidirectional causality runs from export to energy.

The feedback relationship between trade and energy consumption suggests that any shortage of energy supplies or energy reduction policy to decrease the energy consumption will lessen the trade. This reductions in trade will lessen the benefits of trade in the region by impeding GDP growth as benefits of export promotion also includes the wealth creation in the country by employing more of factor of production in the exportable sector to meet the international demand with increments in the income levels of the countries. Thus feedback hypothesis of energy holds in South Asian countries in the short as well as in the long run. The feedback relationship between export and GDP also support the export-led growth and growth-led exports hypothesis in the South Asian countries and thus suggests that any reduction in export due to some kind of restriction can hinder the GDP enhancement and decrease in GDP can also reduce the export of the South Asian economies in the short run.

The results of long run elasticities with the model of exports show that capital, labor and exports play a significant role in promoting GDP growth in the South Asian region. The coefficient of energy consumption suggests that GDP is inelastic to energy consumption. A 1% increase in capital increases GDP by 0.11% and 1% increase in labor increases GDP by 0.51% and similarly a 1% increase in exports increases GDP by 0.27% in the South Asian countries. These finding supports the idea that exports are essential in promoting GDP.

The policy implications are that any energy conservative policy to reduce energy consumption will harm the GDP growth in short as well as in the long run for South Asian region. Further the use of protectionist policies for trade will also hamper GDP growth of the region. Any reduction in energy supplies will reduce trade and GDP directly and this reduction in trade due to energy shortage will further reduce the GDP growth in the South Asian region indirectly. Trade liberalization policies are beneficial for the South Asian countries with development of new resources of energy production such as construction of dams and wind power or tidal resources of energy, to fulfill the demand of energy to increase trade and to enhance the GDP growth in the region.

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