Energy consumption, trade and GDP:

A Case Study for 5 South Asian countries

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CERTIFICATE

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To Mom(Late) and Dad

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Abstract

Energy consumption affects trade and GDP directly as well as indirectly. This study investigates the simultaneous linkages between energy consumption, trade and GDP of 5 South Asian countries, over the period of 1980 to 2009. To study the short run dynamics and long run linkages between energy consumption, trade and GDP; panel co-integration approach with dynamic OLS has been used. Granger causality test has also been used to find the direction of causality among the variables. Two separate models has been estimated one with exports and the other with imports as proxy variable for trade to study the long run relationship of trade and energy.

Results demonstrate that energy consumption, trade and GDP have a positive long run equilibrium relationship. The short run as well as long run panel Granger causality test show that bidirectional causality exists between energy and GDP and between energy and trade and this suggests that feedback hypothesis of energy hold in the South Asian region while findings also suggests that feedback relationship of energy consumption and trade also exists as theoretically expected. Moreover, there exists bidirectional causality between trade and GDP in the short run as well as in the long run. This suggests that trade play an important role to increase GDP and vice versa.

These findings have important implications for energy and trade policies of the South Asian region. Feedback relationship between trade and energy and between energy and GDP suggests that energy shortages due to any policy or non-policy reasons will not only reduce the trade but also impede the GDP increment in the region. Feedback relationship of trade and GDP suggests that protectionist policies of trade to reduce import or export are harmful for the GDP in the region. Moreover, reduction in trade due to energy shortage will further reduce the GDP in the South Asian region. Therefore, new means of energy production such as dams, wind power and tidal resources of energy should be developed to fulfill the demand of energy with trade liberalization policies to enhance the GDP in the region.

Chapter 1

Introduction

Acute shortage of energy sources in developing countries in general and South Asian countries in particular in recent years has proved that energy has become a binding input for any production process. Energy affects GDP indirectly as well as directly. Being a vital input almost; every production process involve a large amount of energy and increase in energy usage means an increase in GDP directly. Indirectly, availability of energy at reasonable cost improves competiveness of home products in international market and thus increases exports of the country. It is also noted that demand for heavy machinery and electrical equipment, which are the basic components for industrial growth, which are mainly operated by alternative energy resources, also depend on sufficient supply of energy.

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 and many other classical economists. They supported trade promotion on the basis of comparative advantage because it enhances economic welfare and adds to GDP growth. Many researchers and economists including Blassa (1978), Ram (1987), Kemel et al.(2002) Edwards (1998); many among others, favor trade promotion because 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, Awokuse (2008), Palley (2003) and Herrerais and Orts (2009);many among others, favor increase in imports as a long run source of growth because importing capital goods and intermediary goods from advanced countries in technological terms can be a source of technology transfer and competition to enhance production activity in the country. Moreover, imports can enhance the capital accumulation efficiently by importing cheaper capital goods from more advanced countries which spend a lot on R&D.

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 2012). Theoretically, it could be that energy consumption and trade (export or import) 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 vast studied area in energy economics (e.g. Lee, 2005; 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; Ekanayake, 1999). However, the simultaneous relationship among energy consumption, trade and GDP is relatively less studied area of economics in recent years. 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 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.

Though the relationship between energy consumption and GDP using a multivariate frame work with labor and capital for Asian countries (including Pakistan, Bangladesh, India, Sri Lanka and Nepal) has been studied by many researchers (e.g. Khan and Qayyum, 2005; Noor and Siddiqi, 2010) and relationship between trade and GDP using a production function framework with labor and capital has also been investigated for Asian countries by many researchers (e.g. Kemel et al,2002; Din, 2004). Yet there is no study which simultaneously investigates the long run linkages among energy consumption, GDP and trade for South Asian countries.

This study is different from previous studies in following ways. Firstly, 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, output and energy consumption. Secondly, this examination is for the five South Asian economies (Pakistan, India, Bangladesh, Nepal and Sri Lanka) and through this study, a better understanding can be developed for economic growth and welfare of these countries by looking the simultaneous relationship between the variables selected. Thirdly, like most of the previous studies, this study uses exports as a proxy variable for trade and in addition, our analysis also uses imports as proxy for trade because Awokuse (2008) noted that focusing only on the role of export and ignoring the role of import would be misleading to analyze trade-GDP relationship. Fourthly, 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.

1.1 Scope of the Study:

There are many studies on the relationship of energy - GDP and export-GDP for South Asian countries. But, according to best of our information, long run linkages among energy consumption, GDP and trade is not a well-researched area for the 5 selected South Asian economies. On the other hand; some studies (Sadorsky, 2011, 2012; Lean & Smyth 2010a, 2010b; and Narayan & Smyth, 2009) emphasized for investigating the dynamic relationship between energy consumption, GDP and trade for non-South Asian economies.

The relationship between trade, energy consumption and output is a motivational topic for research for 5 South Asian countries (Pakistan, Bangladesh, India, Nepal, and Sri Lanka) to know the level of a key insight towards energy and trade linkages that could be developed by examining the empirical results of study. The empirical findings of this study might provide a new direction to understanding and developing new policies for trade and energy in the region.

1.2 Objective of the Study:

The objectives of the study in specific are as follows:

- To examine the long run relationship between trade, output and energy consumption for the panel of 5 South Asian countries.
- To identify the short run and long run Granger causality direction between energy consumption and GDP and between trade and GDP and between trade and energy consumption.
- To identify the long run estimates of the model.

1.3 Plan of the Study:

The roadmap for the remainder of this study is as follow. 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.

Chapter 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.

2.1 energy consumption and GDP:

The relationship between energy consumption and GDP is a vast studied area in the literature of energy economics today. The neo-classical growth theories consider labor and capital as important factor of production and energy is not considered important in this regard. After the energy crisis of 1974, the importance was given to the energy and GDP growth relationship. Kraft and Kraft (1978) are considered the pioneers of the study of energy-GNP causality relationship. Since then there are 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:

1) Neutrality hypothesis which suggests that there is no significant causal relationship between energy consumption and GDP.
2) Conservation hypothesis which suggests that there is a one-way causality relationship running from GDP to energy consumption.
3) Feedback hypothesis which suggests that there is a two-way causality relationship between energy consumption and GDP.

4) Growth hypothesis suggests there is a one-way causality relationship running from energy consumption to GDP.

If neutrality or conservation hypothesis is found to be true by empirical examination of the data set of different countries then it would mean that energy conservation policies have no effect on GDP and these policies can be implemented without any reluctance. On the contrary if feedback hypothesis is found to be true by empirical investigation of the data set of the different countries then the energy conservation policies can have a negative effect on GDP and these policies needs to be revised again in this situation. In the case of feedback relationship between energy consumption and GDP, any decrease in energy supplies can decrease GDP directly and vice versa and the energy policies should be design in such a way that energy can be used in a more efficient manner and the amount of energy wasted is reduced. This is also applicable for the growth hypothesis because energy will be impetus for growth for energy-dependent countries.

There is a contradiction that which of the hypothesis stated above proved to be applicable in real world. There are a lot of studies both for developed and developing countries which suggests that feedback or growth hypothesis is right while there are also contradictory empirical findings which are in favor of conservation or neutrality hypothesis

The difference in findings of different studies is mostly due to different variables used for estimation, different econometric techniques used and difference in selection of the time period and countries as well.

Ozturk et al. (2010) have investigated the long run and causality relationship between energy consumption and GDP growth. A panel data of 51 countries is used from the year 1971 to2005 and further the countries are divided into low income class(Pakistan, Bangladesh, Ghana ,Sudan, Nigeria etc.) ,lower middle income (China, Colombia, Iran, Sri-lanka, Thailand etc.) and upper middle income class (Argentina, Malaysia, South Africa, Turkey etc.) .Pedroni panel co-integration technique (1999) and Pedroni method (2001) were used to estimate long run relationship and causality between energy and GDP. The findings of the study are that there is long run co-integrating relationship exists between energy consumption and GDP growth for all three income classes of the countries. There is found one way causality relationship running from energy consumption to GDP for low income countries and a two way causality relationship between energy consumption and GDP is found for both lower middle income and upper middle income countries. The estimated co-integration factor is found to be not equal to 1, which suggests that there is no strong relationship between energy consumption and GDP growth for all income classes included in the investigation and energy conservation hypothesis is applicable on these countries with some exceptions there.

Mahadevan et al. (2007) suggest that many studies for the causality between energy consumption and GDP growth are in support of conservation hypothesis because they do not include other economic and non-economic factors such as energy supply infrastructure and institutional constraints etc. Their findings are based on panel ECM with 20 countries which were divided into net importer or exporter of energy and the data is used from1971 to 2002.

Apergis and Payne (2010) suggest that the growth hypothesis is found to be true for 9 south American countries using annual data from the period 1980-2005.They also found a long-run co-integration relationship between energy consumption, GDP, gross fixed capital formation and labor -force. Energy is found to be an exogenous variable in the model. These findings were based on panel co-integration approach. This finding confirms the importance of energy for the economic growth.

According to Lee and chang (2008) there is a long run relationship between energy consumption, GDP, capital stock and labor using Cob-Douglas type production function. These findings are obtained by using panel co-integration technique on the data of 16 Asian countries from 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) are of the view 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 1980-2006.They found a long-run relationship between energy and GDP for Asia, western Europe ,Africa, Latin America and globe which include all countries. The value of point estimates was zero or near to zero for Asia, Africa and globe although there was found a positive sign for the co-integrating relationship of the variables.

Stern (2000) is of the view that energy is a key factor in economic growth as it can be used directly to produce a final product. He found a long run Granger causality running from energy to GDP by using a production function with labor and capital.

Pokrovski (2003) pointed out that value of production should be judged from capital, labor and productive energy in those cases where energy driven equipment are used in place of manual labor and used like a factor of production. Further in many technological processes, energy has been used as an external source to substitute for labor.

Noor and Siddiqi (2010) suggest that energy conservation policies can be implemented in south Asian countries (Pakistan, Bangladesh, Nepal, Sri-lanka and India) as there is found a negative long run relationship between energy and GDP both in per capita terms with labor and capital by using panel co-integration and FMOLS method. And there is unidirectional causality running from Energy to GDP were found in the short run.

Lee (2005) suggests that energy conservation policies are harmful in 18 developing countries selected 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 by using annual data from 1975-2001.His results support long run relationship between these two variables after allowing for individual county effects and energy is impetus for GDP growth in these countries.

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.

Masih and Masih (1996) suggest that energy and GDP are co-integrated for Pakistan, Malaysia and India and a bi-directional causality was found for Pakistan while a one way causality running from GDP to energy was found for Malaysia and reverse was true for India. Their findings were based on annual data of six Asian countries by using co-integration and VECM to check for long run relationship and causality direction between energy and GDP.

Khan and Qayyum (2005) are of the view 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 in these 4 south Asian countries. Their findings are based on annual data of energy, GDP, labor and capital formation from the period 1972-2004.They used ARDL approach to investigate the long run relationship between these variables.

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 from the period 1980-2008. The panel VECM is used to investigate the causality relationship between the two variables and there 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.

Cheng (1997) has investigated the causality relationship between energy consumption and GDP growth for 3 Latin countries (Brazil, Mexico and Venezuela). There is found no causality relationship between the two variables for Mexico and Venezuela but for Brazil energy causes GDP in Granger sense. Overall there was no consistent pattern detected for the energy-GDP relationship for these countries.

Lee et al. (2008) suggest that there exists a long run equilibrium relationship between energy, capital and GDP and contribution of capital in promoting economic growth is four times more than that of energy consumption. They have investigated the relationship between these variables for 22 OECD countries for the period 1960-2001 by using an aggregate production function. They have used panel co-integration technique and panel VECM to study the long run dynamics and causality relationship among the three variables in per capita terms. They also showed that the co-integrating relation is found to be weak if the capital is dropped from the model and effect of energy consumption on GDP is overestimated due to excluding capital. They found that there exists a two way causality relationship among the three variables studied.

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.

According to Chotanwat et al. (2008) causality running from energy to GDP is more prevalent in OECD countries as compare to developing countries. They have used consistent data set and methodology to study the relationship between the two variables for 30 OECD and 78 non-OECD countries. They refute the neutrality hypothesis in case the of OECD countries.

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.

2.2 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. There is a plethora of studies which supports export-led growth hypothesis while others are in favor of growth-led export hypothesis. There is another group of economists who argues that imports play a vital role in transferring technology and innovation in the country so growth is basically import-led rather vice versa. The supporter of export-led growth favor export promotion because exports can enhance economic growth process by increasing local market size, allocating resources efficiently, improving economies of scale and capacity utilization. on the contrary, supporters of import-led growth hypothesis including Awokuse (2008),Palley (2003) and Herrerais and Orts (2009);many among others, favor imports as a long run source of growth because importing capital goods and intermediary goods from advanced countries in technological terms can be a source of technology transfer and competition to enhance production activity in the country. Further imports can enhance the capital accumulation efficiently by importing cheaper capital goods from more advanced countries which spend a lot on R&D.

The results of different empirical studies is as follow;

Blassa (1978) is of the view that export orientation is important factor in explaining inter-country differences in income's growth with labor and domestic and foreign investment and cost of raising income is low in term of investment for the countries following export promotion policies. The findings were based on cross sectional data of 11 developing countries and separate consideration was given to manufactured and total production.

According to Bahmani-Oskooee et al. (1991) export led growth hypothesis is found to exists for 4 out of 20 LDC's selected while for remaining countries there is no clear results in favor of this hypothesis as most of these countries were using import substitution policies. They support the export led growth hypothesis although the overall results were not consistent in evaluating competing hypothesis.

Awokuse (2008) has investigated the prevalence of export-led and import-led growth hypothesis in 3 Latin American countries (Peru, Colombia, Argentina) by using a neoclassical production function and estimating it by multivariate co-integrating VAR. the impulse response function was also used. 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. These results suggest that exclusion of imports and focusing only on role of exports to enhance economic growth will be misleading and inadequate.

Ram (1987) suggested that it will better to use both cross section and time series data to check the export-growth nexus and there is a positive and significant relationship was found between exports and GDP growth by using a production function in investment and labor. The data of 88 developing countries was used to investigate the relationship of export and GDP. Further Govt. expenditure were also used as an explanatory variable to find its effect on GDP growth and exports but the coefficient of exports was found robust against the inclusion or exclusion of Govt. expenditures.

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 data of 62 developing countries from the period 1960-1999 and estimating it by panel co-integration technique. Further they found that economic growth will also encourage capital formation and higher imports as these were also co-integrated as a dependent variable.

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.

Ekanayake (1999) has found that the export-led growth hypothesis exist in 7 out of 8 LDC (Pakistan, Malaysia, Sri Lanka, Philippines, Thailand, India, Indonesia and Korea) and short run causality running from GDP growth to Exports growth was found for all countries except for Sri lanka.Johansen co-integration and ECM were used to investigate the relationship between the two variables and Granger causality test was used to find the direction of causation between the exports and GDP.

Palley (2003) suggests that for sustainable development the import-substitution policies with competitive pressure on producers and with a limit to non-productive rent seeking by the governance will be better as compare to export promotion policies. The findings of the study were based for the US imports from 4 Asian Tigers that was replaced by china and Japan's exports that were crowded out by Mexico so author suggests that if export promotion policies are adopted globally then the growth may turn into a zero-sum game.

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 suggests that there is long run relationship among the GDP, exports and imports for Pakistan and Bangladesh while a short run bi-directional 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.

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.

Anwar and Sampath (1997) over-whemingly rejected the export-led growth hypothesis as they found only 9 out of 96 countries having a positive relationship between exports and GDP using data from the period 1960-1992.They also found that 35 countries were having different order of integration and 30 out of remaining 61 were not co-integrated and unidirectional long run causality running from GDP to exports was detected for 12 out of 20 co-integrated countries.

Herrerais and Orts (2009) has investigated the import-led growth hypothesis for China using the data from the period 1964-2000.The findings of the study were in favor of the hypothesis and further imports and investment were found to enhance labor productivity and GDP growth but they were not causing each other.

2.3 Energy consumption, GDP and Trade:

The relationship between energy-GDP is a well-studied area in energy economics while a plethora of research is available on the relationship between export-GDP in international economics. However there is very little empirical evidence for the investigation of the dynamic relationship between the energy consumption and trade. There are very few studies that investigated the ties among energy consumption, GDP and trade. 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 (2011) 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 (2012) 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 the above studies it is clear that energy consumption and trade (either import or export) are inter-correlated and most of the studies described above favor a feedback relationship between the energy and trade in short run as well as in the long run. The objective of the present study is also to investigate the dynamic linkages between trade and energy in the output framework for the South Asian economies as there is little or no empirical investigation on this topic for this region.

Chapter 3

Analytical Framework and Descriptive analysis

The neo-classical theory suggests that trade plays a very significant role in economic growth process. Theoretically it is possible that energy use has a long run equilibrium relationship with trade but there is very little empirical evidence investigating the dynamic linkages between energy use, trade and GDP simultaneously in a model. Specifically, Lean and Smyth(2010b)and Sadorsky (2012),modeled the relationship between trade ,GDP and energy consumption by using a production framework with labor, capital formation, energy consumption and augmenting it by a trade openness variable (export and imports) for Malaysia and seven South American economies, respectively. The present study also uses the same model to estimate the long run linkages among energy use, trade and GDP for 5 South Asian economies.

3.1 Theoretical Model:

We shall consider simple model and assume that output (Y) depends on labor (L) and capital (K) as outlined by the following equation:

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

The neo-classical models consider capital and labor as fundamental factors of production. However, there are many researchers including Khan and Qayyum (2005), Noor and Siddiqi (2010), Lee (2008) and Apergis and Payne (2010); many among others, who added energy in the production function as a third factor of production. Energy is considered a key and limiting factor to explain GDP growth (Stern, 2000; Ghali and El-sakka, 2004). Further Pokrovski (2003) pointed out that in many technological processes; energy has been used as an external source to substitute for labor. Following the literature and keeping the above arguments in mind; it is justified to add energy (E) in our model as a third factor of production and equation 3.1 can be written as:

$$Y= f(K, L, E) \quad (3.2)$$

Export and import are the part of GDP. Although, technically they are not the arguments of the production function because they are not factor of production in classical approach yet they can be used as an input in the production function to estimate the impact of trade on GDP. The usage of output framework with labor and capital and augmenting it with export (import) to estimate the effect of trade openness on economic growth has been done by many researchers including Blassa (1978), Ram (1987), Din (2004), Bahmani-Oskee et al.(2005) and Awokuse (2008) with many among others.

Imports can enhance the capital formation efficiently by importing cheaper capital goods and raw material (to be used in production activity) and increased export demand will also directly increase production in the economy. Exports can make major contribution toward GDP growth in many ways such as; by increasing efficiency of resource allocation which can enhance comparative advantage, by economies of scale which comes from expanding of domestic market size, by improvement in capacity and resources utilization and by increased demand of domestic goods and services through which income and employment in exportable sector rises. In pursuance of the above arguments and following Sadrosky (2012), the relationship between GDP, energy use and trade with country specific variable (S) can be written in the functional form as:

$$Y= f(K, L, E, T, S) \quad (3.3)$$

Taking natural logarithms of above function after parameterization and adding an error term in it, equation (3.3) can be written as.

$$y_{it} = \alpha_1 k_{it} + \alpha_2 l_{it} + \alpha_3 e_{it} + \alpha_4 t_{it} + s_i + \varepsilon_{it} \qquad (3.4)$$

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 have positive value theoretically as mentioned before. There is also a selection to be made for the pooling of the panel data (Harris and Sollis, 2003). Pooling is of two types; pooling along within dimension and pooling along between dimensions. The above specification of equation (3.4) is consistent with within-dimension pooling of data.

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	Real import
Bangladesh	4.472259739	4.740199304	7.781782842	2.725675323	13.20962832	8.877238179
India	4.207516017	6.08846928	8.55492917	2.625724838	14.36076241	13.64729746
Pakistan	4.378186429	4.985839842	4.327417544	3.248734042	8.874416989	8.691521038
Sri-Lanka	2.56055973	4.76591611	4.399257597	1.180351229	7.667946868	6.666766391
Nepal	2.736395369	4.56373306	0.845101381	2.903873765	9.277615628	10.9998808

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. Average growth rate of imports and exports are much faster than the energy or GDP growth rates for each and every country. Bangladesh and India are the countries having the positive double digit average annual growth rate in exports while India and Nepal have recorded double digit average annual growth rate in imports. 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	Δm
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	0.353215	0.373981	-0.005875	0.144832	0.532809	1

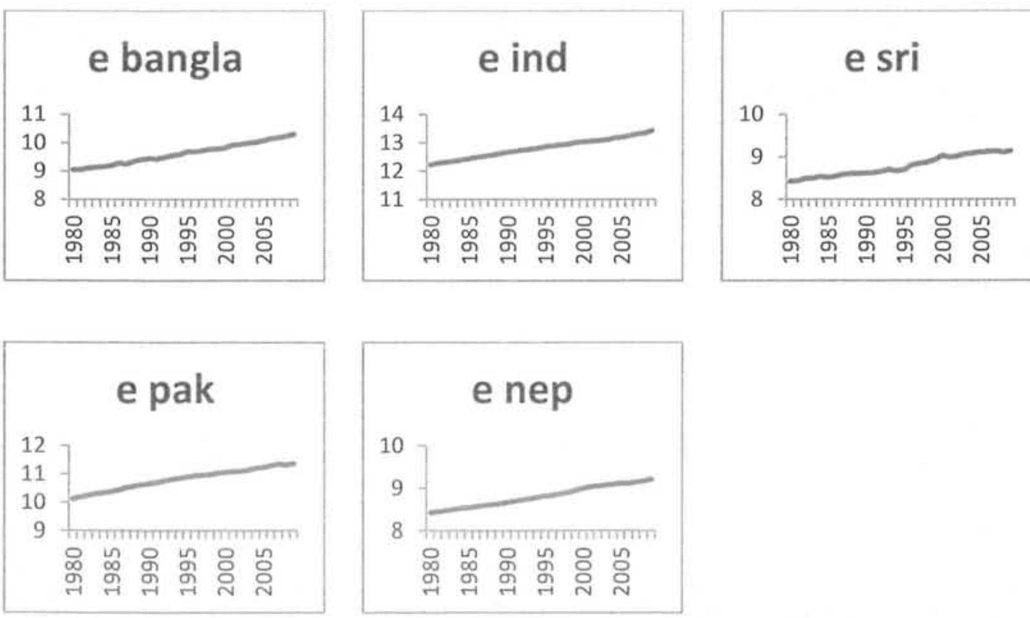
Observation=150

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 energy consumption is more correlated with the growth rate of exports as compared to the growth rates of imports. This suggests that energy is important in export sector and its usage is intensive in exportable sector relative to import sector. The growth rate in GDP shows a highest correlation with the growth rate of capital formulation and after it with the growth rate of imports. This suggests that capital formation play significant role to enhance GDP growth and imports which include cheaper capital goods also have positive impact on GDP growth. Most of the correlations are positive which supports our theoretical model. Labor growth is negatively correlated with the GDP growth, exports growth and imports growth. Imports growth and exports growth are positively correlated. Output and energy growth rates are also having a positive correlation which suggests that increase in GDP also increase energy consumption. All the correlations supports our theoretical model.

3.3 Graphical analysis of the trend of the variables:

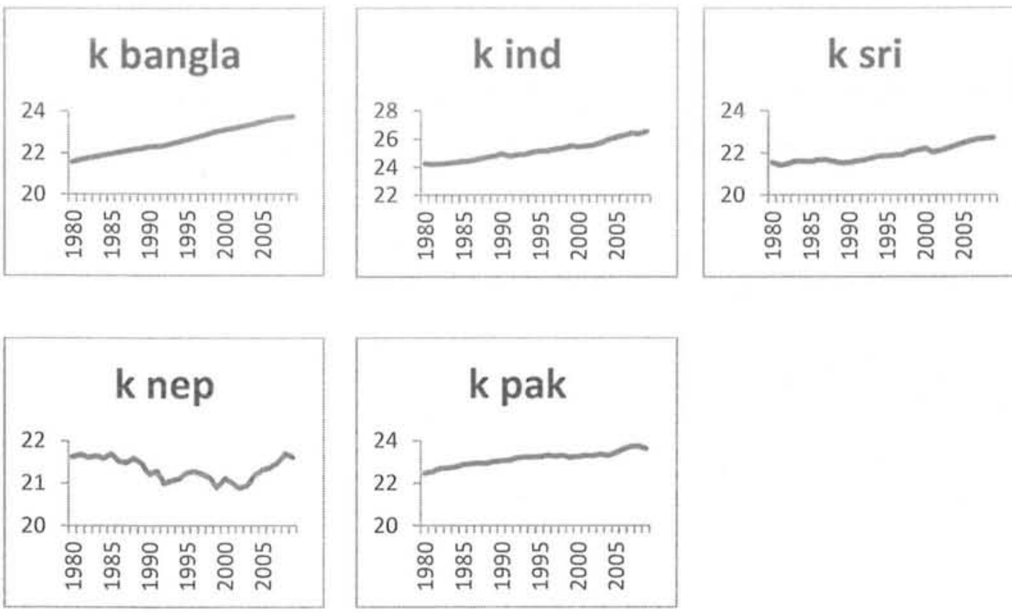
To analyze the trend and long run behavior of the variables under analysis we have done graphical analysis.

Figure 1) Natural log of energy consumption.



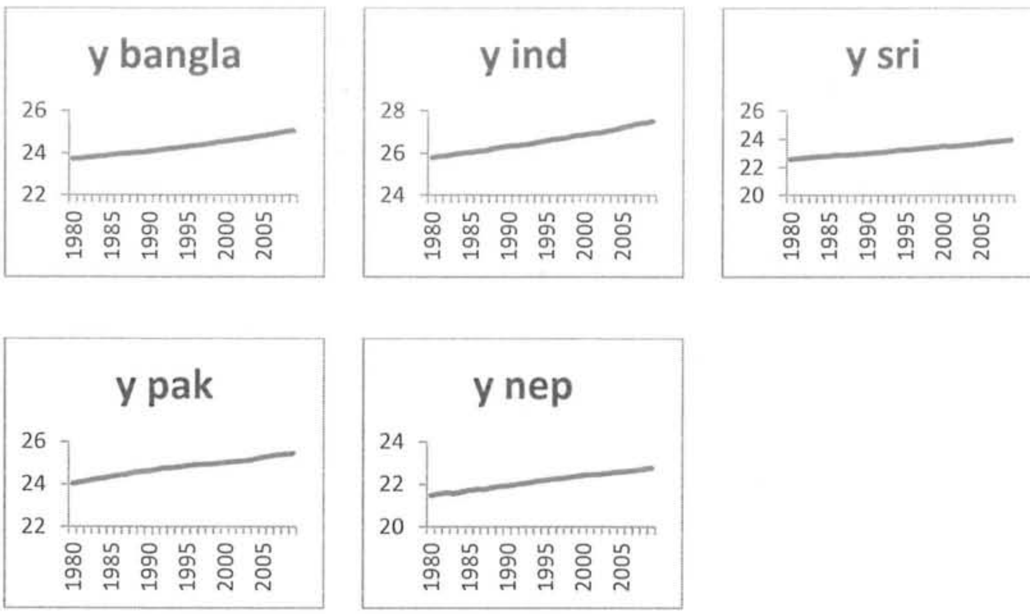
The above figure (1) contains the time series graph of natural log of energy consumption for each country of the South Asian region. All the countries have a positive trend across time, although the trend varies by the countries. The largest energy consumer country is India with Pakistan standing at second position in this regard. Bangladesh is the third largest energy consumer of the South Asian region while Nepal and Sri Lanka stands 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) Natural log of fixed capital formation.



The above figure (2) contains the time series graph of natural log of real fixed capital formation for each country of the South Asian region. All the countries have a positive trend across time, although the upward trend varies by the countries except for Nepal where the trend is decreasing or constant till year 2000 and then starts rising. India is the biggest country among the South Asian countries that contains largest fixed capital formation while Bangladesh have an upward trend which is greater in strength as compare to other countries of the panel. Pakistan stands at third position while Sri Lanka stands at fourth in this regard.

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 (4) contains the time series graph of natural log of real imports 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 importer while Nepal is the smallest importer of the South Asian region. Pakistan is also a largest importer and stands at second position in this regard. Bangladesh and Sri Lanka stands at third and fourth position respectively. For each country, imports and fixed capital formation show almost same patterns which suggests that fixed capital formation and imports are interconnected in such a way that imports also includes capital goods which accumulate capital in the each country.

Figure 4) Natural log of real imports.

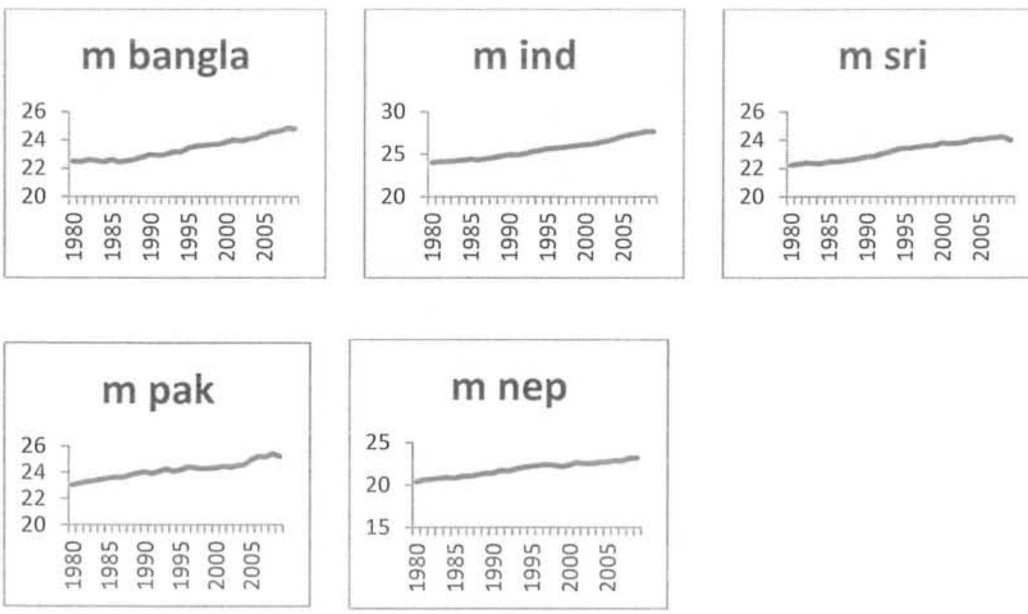
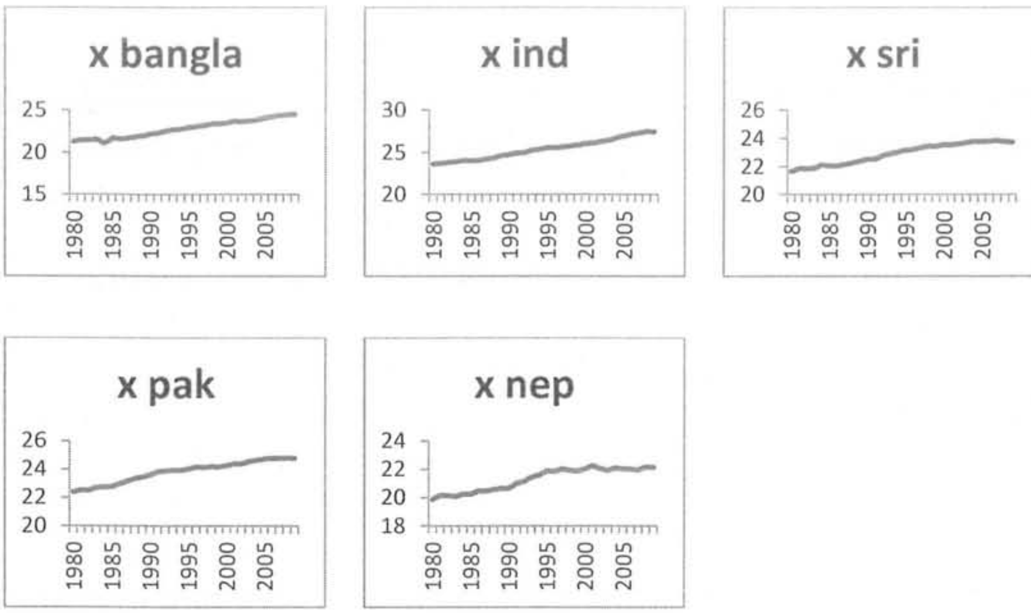


Figure (5) contains the time series graph of natural log of real exports for each country of the South Asian region. All the countries have a positive trend across time, although the trend varies by the countries. India is the largest exporter while Pakistan is the second largest exporter of the panel. Nepal is the smallest exporter with a varying trend.

For each of the country, imports and exports have similar patterns which suggest that both of them move together across time. This is also supported by correlation analysis of the imports and exports for the panel as a whole as there is evidence of a high correlation between the two variables in level form with a correlation coefficient of 0.9.

Figure 5) Natural log of real exports.



The trend of all the variables is positives which suggest that there could be a long run relationship among these variables and this is consistent with our specification of equation (3.4).

Chapter 4

Methodology and data construction

To estimate the simultaneous linkages among energy consumption, trade and GDP for the panel of South Asian economies, econometric methodology is discussed in this section.

4.1. Econometric model and Technique:

The panel co-integration technique developed by Pedroni, (1999, 2004) is used to investigate the relationship between trade and energy consumption. The following sections will elaborate panel co-integration approach.

4.2 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.

(i)Levin and Lin Test:

Levin et al (2002), proposed a test to check the non-stationarity of the variables in a panel data set. This test can be considered as an extension of the DF Unit Root Test which is used in a time series analysis frame work. They estimate the following model.

$$\Delta Z_{it} = \alpha_i + \rho Z_{i,t-1} + \sum_{j=1}^{n} \gamma j \, \Delta Z_{i,t-j} + \delta_i t + \theta_t + \omega_{it} \qquad (4.1)$$

Here, α_i is unit specific fixed affect and θ_t is a unit specific time trend so the above model allows for these two way fixed affect. The coefficient of the lagged Z_{it} is restricted to be homogeneous while unit specific fixed affect are allowed to be heterogeneous across all units of the panel. The null hypothesis of this test is that there is a unit root while the alternative hypothesis is that there is no unit root.

Ho: $\rho = 0$, i.e. series is non-stationary

Ho: $\rho < 0$, i.e. series is weakly trend stationary

This test assumes that there is common unit root process across all the cross section and cross sectional independence for the individual processes.

(ii)The Im, Pesaran and Shin (IPS) test:

The problem associated with the LL test is that it puts a restriction of the homogeneity of the, ρ, coffiecient of the lagged Z_{it} across all cross section. Im, Pesaran and Shin (1997), modified the LL test by allowing the coefficient of the lagged Z_{it} variable to be heterogeneous. They proposed a test based on the average of single unit root test statistics. Further they gave individual estimations for each cross section which allows different specification of the value of parameter, lag length and variance. Their model takes the following form:

$$\Delta Z_{it} = \alpha_i + \rho_i Z_{i,t-1} + \sum_{j=1}^{n} \gamma j \, \Delta Z_{i,t-j} + \delta_i t + \omega_{it} \qquad (4.2)$$

Now the formulation of the null and alternative hypothesis is

Ho: $\rho_i = 0$ for all i

Ho: $\rho_i < 0$ for at least one i

The null hypothesis is that all the series are non-stationary or integrated of order one while under the alternative hypothesis it is assumed that some of the series of the cross sections do not integrated of order one that is they are stationary. IPS test is different from LL test with respect to the alternative hypothesis as LL test assumes that all series are stationary.

(iii)The Maddala and Wu (MW) test:

The main drawback associated with the IPS test previously stated, is that it requires a balanced panel to compute test statistic for the series. Maddala and Wu (1999) proposed a model which can be estimated with an unbalanced panel and they also prefer heterogeneous alternative. The usage of average ADF statistics is not considered a good way to evaluate the non-stationarity of the series rather they assume N unit root tests and it has following form:

$$\prod = -2\sum_{j=1}^{N} ln\,\pi_i \qquad (4.3)$$

Here, π_i refers to probability limit value from regular ADF or PP unit root test for each cross sectional unit. The above statistics follows a χ^2 distribution with 2N degrees of freedom as $T \rightarrow \infty$ for finite N. The value of π_i are computed by the bootstrap procedure by considering the cross section dependence, as correlation among different groups can bring substantial size distortion for the test. 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 (say y) but reject the null hypothesis for the same variable (y) in the difference form then this variable (y) would be declared as non-stationary or integrated of order one i.e. I(1).

4.3 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 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 section 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. For the above procedure, a priory restriction of a unique co-integrating vector is assumed. The test of panel co-integration suggested by Pedroni has many good features as it allow including multiple regressors and the co-integration vector is allowed to vary across the different cross section of the panel. Further error terms across the cross sections are allowed to have heterogeneity.

4.4 Dynamic OLS:

In case of the above panel co-integration test, if there is an indication for a significant co-integrating relationship then equation (3.4) 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 (DOLS) proposed by Kao and Chiang (1997) and modified for group-mean or between-dimension setting by Pedroni (2001) are 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:

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

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

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

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

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

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 or real imports) 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 (3.4) 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.

4.7 Data and Variable construction:

We are interested in estimating the dynamic linkages between trade, energy consumption and GDP growth for the 5 South Asian economies. Panel data approach is preferable when sample size of each cross section is relatively small and by combining different cross sections in a panel increases the sample size. Further, degree of freedom also increases with panel data analysis so estimates obtained will be more accurate as compare to estimates obtained from each cross section individually. In this present study we are estimating the long run relationship among energy consumption, trade and GDP using output framework.

Panel data is more advantageous as compare to individual cross section data or time series data. Baltagi (2005) noted that:

- In panel data, pooling of the cross section unit is done over the time periods. There may be heterogeneity issue among the different individual units and panel data can handle this issue easily by incorporating individual country specific variable or by a dummy variable.
- Panel data is more informative as it is pooling of cross section and time series units; hence it provide less co linearity among the variables, more degrees of freedom yielding more precise parameters and more dynamics of variables. Further pooling of the data causes the sample size to increase so estimation yields unbiased and efficient parameters.

On the basis of above arguments, our study also use data set of balanced panel of 5 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.

4.7.1 Variable construction:

This study is estimating the long run linkages among energy consumption, GDP and trade (using export or import as proxy to trade) by using an output framework with labor and capital. The subsequent subsections have a detailed discussion of construction of the different variables used.

4.7.2 Gross Domestic Product

We have used natural log of real GDP to measure the economic growth of the South Asian economies. Most of the standard studies have used real GDP to investigate the energy-GDP or export-GDP relationship. It is better to use Data in level form as it explains GDP dynamics more accurately than data in growth rate form. Therefore, we used data of real GDP at 2000 constant

US dollar and it is obtained from world bank (CD-ROM 2012) World Development Indicator online data base.

4.7.3 Trade:

Trade plays a vital role in economic growth process and welfare increment of the countries. Trade can be measured by using export or import as a proxy to trade. Exports can enhance economic growth process by increasing local market size, allocating resources efficiently, and improving economies of scale and capacity utilization. Many studies have investigated the impact of trade on economic growth for example, Blassa, Bahmani-Oskee et al., Giles and Williams, Din and Kemel et al.(1978, 2005, 2000, 2004, 2002 respectively).While there are some other studies which suggest that using only export and ignoring import for testing trade impact on economy, can be misleading and further import can be a source of long run growth as importing cheaper capital goods from advanced countries can be a source of technology transfer and competition to enhance production in the counrty (Palley, Awokuse and Din;2003, 2008,2004). Keeping the above arguments in mind and following the work of Sadorsky (2012), our study uses export and import separately in the model to capture their impact on GDP. The data of export and import were taken from World Bank (CD-ROM 2012) World Development Indicator online data base. Export (import) 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).

4.7.4 Labor:

Labor is considered a major factor of production. Data of total labor force is used to measure labor. Total labor force includes the people of age 15 or above who are in accord with the definition of International Labor organization of economically active population; who are willing to work and actively participate in the production of goods and services during a specific time period. Labor force includes both employed and unemployed workers. Labor force data is obtained from World Bank data source (World Bank CD-ROM 2012).

4.7.5 Capital:

Capital plays a fundamental role in production. Data of gross fixed capital formation is used to measure capital stock of the countries and this was done by following Sadorsky (2012), Apergis and Payne (2010a, 2010b) and Khan and Qayyum (2005). Gross capital formation includes outlays on addition to fixed assets of the country with net changes in level of inventories. Lee (2008) pointed out that contribution of capital is four times more in promoting GDP growth than that of energy and co-integrating relation becomes weak if capital is dropped and effect of energy on GDP is over estimated. We obtained data of gross capital formation at constant 2000 US dollar from World Bank data source (CD-ROM 2012) which is the world development indicator. Data for capital formation at constant 2000 US dollar was not available for Nepal so for real capital formation, we take ratio of total fixed capital formation to GDP deflator. Data for GDP deflator were also obtained from World Bank (CD-ROM 2012).

4.7.6 Energy use:

Energy is considered a key and limiting factor to explain GDP growth (Stern,2000; Ghali and El-sakka, 2004).Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (World Bank, 2012).we obtained the data of energy consumption in kilo tons of oil equivalent from the World Bank (CD-ROM 2012) World development indicator online data base.

Chapter 5

Empirical Results and Discussion

The prime emphasis of this study is to investigate the simultaneous linkages among energy consumption, GDP and trade openness for the South Asian region. The data for 5 South Asian countries (Pakistan, India, Bangladesh, Sri-Lanka and Nepal) from the period of 1980 to 2009 is used to accomplish the task. We use the panel co-integration approach of Pedroni (1999, 2004) to estimate the long run equilibrium relationship and its short run dynamics between the concerned variables. This chapter contains a very detailed discussion on the empirical findings of the study.

5.1 Results of Panel Unit Root Tests:

For the analysis of non-stationarity properties of the variables of the panel, we apply the panel unit root tests outlined in section (4.2). The values of the each test statistics and their corresponding p-values are reported in Table (5.1). The test regression for the variables in level form (y, k, l, e, x, m) and in first difference form ($\Delta y, \Delta k, \Delta l, \Delta e, \Delta x, \Delta m$) contain an intercept only. The lag lengths were selected according to the Schwartz information criterion for all the 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. This is in accord with the notion, noted by Nellsor and Plosser (1982), that most of macroeconomic variables are non-stationary. 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.

Table 5.1:Results of Panel Unit Root Test

Method	y		Δy		k		Δk		l		Δl	
	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	3.95735	1.0000	-3.74943	0.0001	0.92496	0.8225	-3.43218	0.0003	2.43880	0.9926	-2.33238	0.0098
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	6.33861	1.0000	-4.73293	0.0000	3.08996	0.9990	-4.48722	0.0000	3.52458	0.9998	-3.5514	0.0002
ADF - Fisher Chi-square	1.37880	0.9993	42.9989	0.0000	3.15604	0.9775	38.5780	0.0000	5.17255	0.8794	32.9219	0.0003
PP - Fisher Chi-square	7.62779	0.6651	67.7741	0.0000	3.11752	0.9785	76.1611	0.0000	24.1101	0.0073	73.3790	0.0000

Method	e		Δe		x		Δx		m		Δm	
	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	-0.06671	0.4734	-5.3693	0.0000	-0.77177	0.2201	-2.37443	0.0088	1.28425	0.9005	-1.29359	0.0979
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	3.12794	0.9991	-5.60101	0.0000	1.95321	0.9746	-4.16538	0.0000	3.75990	0.9999	-4.82313	0.0000
ADF - Fisher Chi-square	4.38570	0.9283	50.6950	0.0000	4.77339	0.9058	37.0045	0.0001	1.25697	0.9995	43.1057	0.0000
PP - Fisher Chi-square	13.4536	0.1994	92.4792	0.0000	7.21563	0.7049	101.488	0.0000	1.82321	0.9975	85.6173	0.0000

* Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

All unit root test were performed with intercept only with user specified lags at:1.

5.2 Result of panel co-integration test:

After checking the order of integration of the variables in level as well as in difference form, we can now test for the co-integration relationship between the variables by the Pedroni co-integration technique outlined in section (4.3). The results of panel co-integration test for the data set with exports are given in Table (5.2.1)

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 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.

Table 5.2.2: Result of panel co-integration test for the model with imports.

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

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.798136	0.0361	0.270134	0.3935
Panel rho-Statistic	0.626799	0.7346	0.165886	0.5659
Panel PP-Statistic	-1.023819	0.1530	-2.067607	0.0193
Panel ADF-Statistic	-0.541359	0.2941	-1.745976	0.0404

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

	Statistic	Prob.
Group rho-Statistic	1.184274	0.8818
Group PP-Statistic	-1.866570	0.0310
Group ADF-Statistic	-0.793693	0.2137

Null Hypothesis: No co-integration

Trend assumption: No deterministic trend

Lag selection: automatic SIC with a maximum at lag 5

As exports and imports have a high correlation coefficient 0.9, so two separate models are estimated to avoid the problem of multi-collinearity. The results of panel co-integration test for model with imports are reported in Table (5.2.2).

The results of both the within and between dimension tests reported in the above table rejected the null of no co-integration at the 5% level of significance except for the Panel v-statistics,panel rho-statistics, Group rho-statistics and Group ADF-statistic which do not reject the null even at 10% level of significance. Hence, it is concluded that the residuals estimated from equation (3.4) with import as proxy to trade, are stationary and there is a long run panel equilibrium relationship between the real GDP, real fixed capital formation, labor, energy consumption and imports.

On the basis of above co-integrations, it is confirmed that in the long run the error will be corrected by the short run adjustments as the test indicates so to check for error corrections and Granger causality we go for VECM for the panel after long run elasticities of the model given next.

5.3 Result of long run elasticities with Dynamic OLS:

After establishing the co-integration relationship and before analyzing the direction of Granger Causality between the energy, trade and GDP, we proceed with the estimation of long run elasticities for the model with imports and with exports separately by using approach of Dynamic OLS outlined in section (4.4).The table 5.3.1 contains the results of long run elasticities for the model with exports.

Table 5.3.1			
DOLS results for model with export			
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, 1%, 5% and 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 the model estimated with the dynamics OLS are more reliable because this approach incorporates leads and lags of the differences of the variables on the right hand side of the equation to tackle the problem of endogeneity bias and serial correlation in the model.

To discuss and interpret the empirical of findings of the above table, level of significance at1%, 5% and 10% are used here. All the estimates obtained by using Dynamic OLS (DOLS) for the model with imports are highly statistically significant at the significance level of 1% only.

The table 5.3.2 contains the results of long run elasticities for the model with imports.

Table 5.3.1			
DOLS results for model with import			
Dependent variable = y			
	Coefficient	t	P - value
k	.3700	14.27	0.000
l	.4124	3.17	0.002
e	.2698	2.53	0.011
m	.2143	8.49	0.000

This means that all the explanatory variables explained the dependent variable significantly in the long run. The coefficient of the energy with the value of 0.26 shows that a 1% increase in energy consumption increases GDP by 0.26% and the coefficient of import with the value of 0.21 shows that a 1% increase in imports increases the GDP by 0.21%. Similarly, the coefficients of labor and capital show that a 1% increase in capital, increases GDP by 0.37% and a 1% increase in labor, increases GDP by 0.41%.

The results of dynamic OLS (DOLS) 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 the inclusion of trade variable in the model. The results of DOLS are more reliable due to the reason described before. This means that imports also play an important role in explaining GDP in the long run. Further capital and labor are also significant in explaining GDP in the long.

5.4: 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 used 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.

Table 5.4.1: Result of Granger causality For VECM with Imports.

From	To				
	Δy	Δk	Δl	Δe	Δm
Δy		3.13	-0.72	3.77	3.15
prob.		0.00	0.32	0.00	0.00
Δk	3.27		0.49	0.85	3.05
prob.	0.00		0.49	0.39	0.00
Δl	-0.72	0.49		1.20	-0.13
prob.	0.45	0.62		0.23	0.89
Δe	4.01	0.85	1.20		-0.03
prob.	0.00	0.46	0.19		-0.78
Δm	3.20	3.13	-0.13	-0.03	
prob.	0.00	0.00	0.91	0.78	
μ_{t-1}	-4.72	0.43	-0.30	2.97	1.82
prob.	0.00	0.66	0.76	0.02	0.06
Speed of adjustment	-.457	.222	-.023	.333	1.103

To check for the Granger Causality direction, there are two different models estimated one with exports and the other with imports. The results of the Granger Causality for VECM with imports are reported in Table given above.

The above table contains t-statistics with their p-values below them for all variables including error correction term and coefficients of lagged error terms which shows speed of adjustment towards long run equilibrium after a shock, are also reported below the p-value of lagged error terms. The significance of the coefficients of the lagged difference independent variables show the short run Granger Causality while for the long run Granger Causality relationship, significance of the coefficients of the lagged error terms are used. The two steps method of Engle and Granger (1987) is used to investigate the short run dynamics of the equation (3.4) with imports and exports separately. In the first step, equation (3.4) is estimated twice, one for import and the other for export and their residuals are saved. In the second step, equations (4.5a) to (4.5e) outlined in section (4.5) are estimated. For interpretation and discussion of the results we used 1%, 5% and 10% level of significance. The table (5.4.1) reports the results of the short run dynamics of the model for VECM with imports.

The short run Granger causality test show that bidirectional causality exists between energy consumption and GDP at all levels of significance while no causality between imports and energy consumption exist at any level of significance. There also exists a feedback relationship between GDP and imports at 1%, 5% and 10% levels of significance. There exists a short run feedback relationship between GDP and capital and between imports and capital. The other variables contain statistically insignificant relationship. The coefficient of lagged error term of equation (4.5a) is -0.45 and highly significant at the level of 1% and this show the speed of adjustment towards the long run equilibrium is significant and 45% of the error is corrected in one year and then 45% of the remaining is corrected in the next year and so on. The significance of all the lagged error terms is used to interpret the long run Granger causality. There exists long run Granger causality from capital, labor, energy and imports to GDP at all level of significance while there is also a Granger causality relationship from GDP, labor, capital and imports to energy consumption at 5% level of significant. The last long run causality relationship from GDP, labor, capital and energy to imports is noteworthy at 10% level of significance. No other significant long run causality is found for the other variables. The significance of these three lagged error terms show that long run adjustment to equilibrium is essential in explaining short run dynamics in GDP, energy and imports. Further evidence of a feedback relation between imports and capital shows that imports are the source of capital accumulation in the countries selected and a feedback relation between capital and GDP and between imports and GDP show that capital is important to increase GDP and this causes imports to rise as income level of people inhabiting the region rises. Imports also include cheaper capital goods from more advanced countries, so this can be a source of long run growth and technological transfer as suggested by Awokuse (2008). Energy and GDP have a feedback relationship both in short run and in long run which suggests that any decrease in energy consumption coming from its non-potential production and mismanagement will lead to decrease in GDP. Energy is impetus to GDP growth in the South Asian countries. This finding has resemblance with the findings of Ozturk et al. (2010); Lee (2005); Khan & Qayyum (2005); Dahmardeh et al. (2012) who consider energy as an important factor in explaining GDP.

To analyze the Granger causality directions between GDP, energy, labor, capital and exports, equation (3.4) is again 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 (5.4.2).

Table 5.4.2: 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 (5.4.2) contains t-statistics with their p-values for all variables including error correction term and coefficients of lagged error terms which shows 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 found to exist between the 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 level of 1%. 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 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 export 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 5 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 short run and in the long run. This finding resembles with the finding of Khan and Qayyum (2005) which suggests that any energy shortfall can retard the GDP growth in the South Asian region.

Chapter 6

Conclusion and policy implication

Energy consumption affects trade and GDP directly as well as indirectly and there is extensive literature that investigates the relationship between energy consumption and GDP growth and between trade and GDP growth separately for the Asian countries. In isolation with the previous pattern of investigation, the purpose of the present study is to investigate the simultaneous linkages among energy consumption, trade and GDP for a panel of South Asian economies which also have more or less similar socio-economic pattern.

To accomplish the task we used the panel data of 5 South Asian countries over the period of 1980-2009. To study the short run dynamics and long run linkages among energy consumption, trade and GDP, panel co-integration approach with dynamic OLS has been used. Further, a panel Granger causality test has been also used to find the direction of causality between the variables and two separate models were estimated one with exports and the other with imports as proxy for trade to study the long run relationship of energy consumption, trade and GDP.

The findings support the feedback relationship between energy consumption and GDP, between trade (export) and GDP, between capital and imports and between energy consumption and exports in the short run. In the long run, the feedback relationship between energy and import, between energy and GDP and between import and GDP are also significant. Further long run unidirectional causality running from export to energy was also significant. 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 and this reductions in trade will definitely lessen the benefits of trade in the region.

Further, reduction in export can impede GDP growth as benefits of export promotion also includes the wealth creation in the country by employment more of factor of production in the exportable sector to meet the international demand with increments in the income levels of the countries. The policies to control and manage energy consumption should incorporate the adverse effects of energy reduction on exports in the formulation and implementation of energy policies in the South Asian region. Moreover, the export promotion policies will also increase the demand of energy in the region so to forecast the energy demand, it will be necessary to incorporate exports in the models which make attempts to forecast the energy demand otherwise, the results may be underestimated for the energy demand in the region.

In the same way, a reduction in energy consumption can discourage imports as these two variable have a feedback relationship in the long run. As imports also includes cheaper capital goods and technology spillover effect from more advanced countries, a reduction of imports due to reduction in energy consumption which comes from energy conservative policies or any other measure to save energy supplies, can discourage capital formation and technology transfer in the region. So reduction in imports due to energy reduction can retard the GDP growth in the long run as this reduction will be an obstacle in the capital accumulation process and learning and implementing new technological methods of production. This implication is also supported by the feedback relationship between imports and capital in the short run and a feedback relationship between imports and GDP both in the short run as well as in the long run. So energy shortages will lead to impede the GDP as these will reduce imports which add to the capital formation in the region and due to reduction in capital formation, GDP further reduces.

GDP and energy consumption have a feedback relationship by both the models with import and with export. Thus feedback hypothesis of energy holds in South Asian countries in the short as well as in the long run. This suggests that any reduction in energy supplies can hamper the GDP growth 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. Similarly, a feedback relationship between import and GDP also support the import-led growth hypothesis and vice versa in the short as well as in the long run. Thus it is clear that the trade promotion policies including export promotion and removing barriers to imports can be source of long run GDP growth and increase in GDP also increases trade in the region. The use of protectionist policies for trade (import or export) will be an obstacle to GDP growth in the South Asian countries.

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 is insignificant and suggests that GDP is inelastic to energy consumption with the model of exports. Particularly, 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 growth. It has elaborated before that export can enhance economic growth process by increasing local market size, by enhancing efficiency of resource allocation, and by improving economies of scale and capacity utilization.

The empirical findings of long run elasticities with the model of imports show that capital, labor, energy and imports also play a significant role in promoting GDP growth of the South Asian region. The coefficient of the energy consumption with the value of 0.26 shows that a 1% increase in energy consumption increases GDP by 0.26% and the coefficient of import with the value of 0.21 shows that a 1% increase in imports increases the GDP by 0.21%. Similarly, the coefficients of labor and capital show that a 1% increase in capital, increases GDP by 0.37% and a 1% increase in labor, increases GDP by 0.41%. These findings suggest that energy is important and a limiting factor to GDP growth, as suggested by Stern (2000) and Ghali and El-Sakka (2004), also for the South Asian economies.

The policy implications are that any energy conservative policy to reduce energy consumption will definitely harm the GDP growth in the long run for South Asian region. Further the use of protectionist policies for trade (to reduce import or export) will also hamper GDP growth of the region. The feedback relationship between capital and imports also suggests that import are the source of capital formation in the South Asian region and any policy which reduces imports will also reduce the capital formation in 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.

Future prospects:

Different industries of export sector could have different intensities of energy consumption but our study could not use the energy at dis-aggregated level. Therefore, we suggest that future study should include energy consumption with respect to its intensity in different industries of the South Asian countries. Moreover, the inclusion of other important variables such as financial development or research and development or FDI etcetera with energy and trade to understand the long run linkages with economic growth of the region are also encouraged.

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