Energy Conservation Policies may affect Trade Performance in Pakistan: Confirmation of Feedback Hypothesis

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Abstract

This study investigates the relationship between energy consumption and trade performance in Pakistan by using the annual time series data from the period of 1973-2011. The cointegration results confirm the valid long run relationship between energy consumption and trade performance. Our results indicate that gross domestic product, exports and imports have positive impact on energy consumption. The findings of Generalized forecast error variance decomposition method under vector autoregressive (VAR) system suggest the bidirectional causal relationship of gross domestic product, exports and imports with energy consumption. This confirms the presence of feedback hypothesis in Pakistan. We note that energy conservation policies will reduce the trade performance which leads to decline in economic growth in Pakistan. The present study may guide policy makers in formulating a conclusive energy and trade policies for sustainable growth for long span of time.

Keywords: Energy, Trade, Growth, Pakistan

JEL Classification: Q43, F10, F43, C22

1. Introduction

Over the last four decades, many developing economies have experienced the rapid increase in exports, imports, income per capita and energy consumption to promote economic growth. Since the oil shocks of 1970's many studies have been conducted to analyze the relationship between energy consumption and economic growth (Yu and Choi, 1985; Ramcharran, 1990; Ebohon, 1996; cheng, 1999; Yang, 2000; Wolde-Rufael, 2004; Lee and Chang, 2005; Altinay and Karagol, 2005; Lee, 2006; Chen et al., 2007; Ciarreta and Zarraga, 2008; Apergis and Payne, 2009; Wolde-Rufael, 2009; Ozturk, 2010; Payne, 2010; Shahbaz and Feridun, 2012; Shahbaz and Lean, 2012a,b,). There are also a separate and comparatively large literature is available on the relationship between trade and economic growth (Culem, 1988; Ozawa, 1992; Black and Pain, 1994; Pain and Wakelin, 1998; Sun, 2001; Katerina et al., 2004; Yousuf et al., 2008; Ahmadi and Ghanbarzadeh, 2011; Tabassum et al., 2012). However, there are very few studies have been conducted to analyze the relationship between energy consumption and trade performance.

The relationship between energy consumption and trade performance is an important topic to study because of many reasons. If causal relationship runs from energy consumption to trade or there is feedback relationship existed between energy consumption and trade (exports and imports), then energy conservation policies will reduce the trade performance which leads to decline in economic growth. Evidence of Granger causality running from trade to energy or evidence of no Granger causality in either direction means that energy conservation policies can be implemented without affecting trade.

There are very few studies have been conducted to analyze the relationship between energy consumption and trade performance. In many studies mentioned in section 2.2, cross country data have been used to analyze the relationship between energy consumption and trade performance (Narayan and Smyth, 2009; Sadorsky, 2011; Hossain, 2012; Dedeoglu and Kaya, 2013). The usage of panel data may be suitable for answering greater question on average. It only provides the aggregate average results of sample but it fails to explain the effect on each individual country to formulate and manage domestic policies. This paper make a unique contribution to the literature with reference to Pakistan, being a pioneering attempt to investigate the relationship between energy consumption and trade performance by using the long annual time series data from the period of 1973-2011 and by applying more rigorous econometric techniques.

The main contribution of this study is that we have not restricted our study on any particular econometric technique at any stage to estimate the relationship between energy consumption and trade performance, which is mostly done in the past studies. In this study, to ascertain the robustness of the results of relationship, we use different sensitivity analyses (estimations techniques) to check the robustness of initial results. We use three different econometric techniques in each step of estimations of unit root test, long run cointegration and long run elasticities to analyze the robustness of relationship in between energy consumption and trade performance in Pakistan.

Economic Growth, Energy Consumption and Trade Performance in Pakistan

Pakistan is the 2nd largest country in South Asia in terms of population and gross domestic product. Table-1.1 presents the different trends of gross domestic product, exports, imports and energy consumption in Pakistan. The average annual gross domestic product of Pakistan was 1048 billion in 1970's, 1922 billion in 1980's, 3171 billion in 1990's and 4738 billion in 2000's. However the gross domestic product of Pakistan was increased in last four decades but these increases was with declining growth rate. There was a growth in gross domestic product of 83% from 1970’s to 1980’s, 65% from 1980’s to 1990’s and 49% from 1990’s to 2000’s.

<Insert Table-1.1here>

The average annual exports of Pakistan was 114 billion in 1970’s, 229 billion in 1980’s, 471 billion in 1990’s and 801 billion in 2000’s. The average annual exports of Pakistan was increased with increasing growth rate in 1980’s and 1990’s with more than 100 percent growth rate. The reason of such increasing exports was the industrial development in 1990’s. But this growth rate has failed sharply to 70% in 2000’s. The average annual imports of Pakistan was 322 billion in 1970’s, 421 billion in 1980’s, 572 billion in 1990’s and 766 billion in 2000’s. The growth rate in imports has remained very constant in last four decades of around 30% to 35%. The energy consumption in Pakistan is also increased very significantly in last four decades. The average annual energy consumption is 20077 kilo tonne in 1970’s, 32256 kilo tonne in 1980’s, 52214 kilo tonne in 1990’s and 73753 kilo tonne in 2000’s.

The rest of the paper is organized as follows: following introduction section 2 review some selected theoretical and empirical literature on the relationship of energy consumption, economic growth and trade performance, section 3 discuss empirical strategy, section 4 shows estimations and results, section 5 shows results of rolling window estimation, section 6 discuss the results of cumulative sum and cumulative sum of square estimations, section 7 shows the results of causal relationship and the final section conclude the study and provide some policy implications.

2. Literature Review

This section reviews some theoretical and selected cross country as well as time series empirical studies.

2.1 Theoretical Underpinning

The relationship between energy consumption and trade performance is an important topic to study because of many reasons. If causal relationship runs from energy consumption to trade or there is the feedback relationship exists between energy consumption and trade, then energy conservation policies will reduce the trade performance which leads to decline in economic growth. Evidence of Granger causality running from trade to energy or evidence of no Granger causality in either direction means that energy conservation policies can be implemented without affecting trade. The possible mechanisms that show the relationship between energy consumption and trade performance are given below:

For an increase in exports to take place, machinery and equipment must be used to load and transport the exports to seaports, airports or other docking stations where the exports are then offloaded and re-loaded for voyages abroad. The machinery and equipment used in the process of producing and transporting goods for export requires energy to operate. An increase in exports represents an increase in economic activity and this should increase the demand for energy. It is also possible for changes in energy to affect exports because energy is an important input into the production and transportation of goods destined for exports (Sadorsky, 2011).

As discussed in the previous paragraph, exporting manufactured goods or raw materials requires energy to fuel transportation. Without adequate energy to fuel transportation, export expansion will falter. Consequently, energy is an important input into export expansion and adequate usage of energy is essential to expanding exports. A dramatic decrease in energy consumption, resulting from say an energy conservation program, could affect the ability to produce and transport exports. The exports-led energy hypothesis, discussed in the previous paragraph, posits that change in exports impact changes in energy. The energy led export hypothesis, discussed in this present paragraph, posits that change in energy impact changes in exports. It is also possible that the feedback relationship exists between energy and exports whereby energy is important for explaining movements in exports and exports are important for explaining movements in energy demand and changes in economic growth. It is also possible for the relationship between energy and exports to be neutral. In this case, the correlation between energy and exports is so negligible that it does not show up as a statistically significant relationship at conventional tests levels (Sadorsky, 2011).

For completeness, this present paper also investigates the relationship between energy consumption and imports. If Granger causality runs from energy to imports or if there is the feedback between energy and imports, then reducing energy use, say through energy conservation policies will reduce imports. This could have very undesirable impacts on Pakistan's economy if imports consist of machinery, equipment and new technology products desirable for their ability to boost productivity and create economic wealth. Evidence of Granger causality running from imports to energy or evidence of no Granger causality in either direction means that energy conservation policies can be implemented without affecting imports (Sadorsky, 2012).

Theoretically, changes in imports can affect energy consumption in two ways. In the first way, the distribution of imported goods into a country requires a transportation network to distribute the imports and this transportation network is fueled by energy. Imported goods can also affect energy consumption in a second way that depends upon the mix of imported goods.

Durable imported goods like automobiles, air conditioners, refrigerators, etc. are big users of energy and an increase in these types of imported goods will increase the demand for energy.

Since energy is an essential input into the transportation process that facilitates imports, changes in energy use can impact imports. Inadequate use of energy will make it difficult to distribute imported goods and also make it less likely that durable energy intensive goods will be imported. It is also possible that there is the feedback relationship between energy and imports or that there is no statistically significant relationship between energy and imports.

2.2 Empirical Studies

In this section, some related empirical literature has been studied regarding the relationship in between energy consumption, economic growth and trade performance.

2.2.1Energy Consumption and Economic Growth

Since the oil shocks of 1970's many studies have been conducted to analyze the relationship between energy consumption and economic growth. Large numbers of studies have been done to find causal relationship between energy consumption and economic growth.

Yu and Choi (1985), Ramcharran (1990), Masih and Masih (1996), cheng (1999), Morimoto and Hope (2004), Wolde-Rufael (2004), Lee and Chang (2005), Hatemi and Irandoust (2005), Altinay and Karagol (2005), Lee (2006), Ciarreta and Zarraga (2008) and Apergis and Payne (2009) show the unidirectional causality run from energy consumption to economic growth. On the other hand, Akarca and Long (1980), Cheng and Lai (1997), Ghosh (2002), Soytas and Sari (2003), Yoo and Kim (2006), Yoo (2006), Halicioglu (2007) and Hu and Lin (2008) note the unidirectional causality run from economic growth to energy consumption. In contrast, Ebohon (1996), Murray and Nan (1996), Yang (2000), Hondroyiannis et al., (2002), Yoo (2005), Zachariadis and Pashourtidou (2007), Wolde-Rufael (2006), Squalli (2007), Chen et al., (2007), Akinlo (2008), Narayan and Smyth (2009) and Wolde-Rufael (2009) provide evidence of the bidirectional causality between energy consumption and economic growth.

Few studies have been conducted to find the long run relationship between energy consumption and economic growth.

Squalli and Wilson (2006) investigate electricity consumption-income growth hypothesis by using time series data from1980 to 2003 for six member countries of GCC. The ARDL bounds testing approach and Toda-Yamamoto causality test have been used to find the long run relationship and direction of causation respectively. Their results suggest that positive long run relationship exists between electricity consumption and economic growth. The causality analysis suggests the bidirectional causality between electricity consumption and economic growth in Bahrain, Qatar and KSA. The unidirectional causality exists running from economic growth to electricity consumption in Kuwait and no causal relationship exists in UAE.

Ho and Sui (2006) suggest the long run relationship between energy consumption and economic growth. Squalli (2007) investigates the long run relationship between electricity consumption and economic growth. The results of ARDL bounds testing approach suggest the long run relationship between electricity consumption and economic growth.

Pao (2009) has empirically examined the relationship between electricity consumption and economic growth of Taiwan from 1980 to 2007. The cointegration and error correction model have been used. The empirical evidence notes the long run relationship between electricity consumption and economic growth. Lean and Smyth (2009) investigate the relationship between emissions of carbon dioxide, electricity consumption and economic growth by using panel data from 1980 to 2006 and employing vector error correction model for five ASEAN countries. Their results suggest the positive long run relationship between electricity consumption and emissions and, emissions and real output. The results of Granger causality suggest the unidirectional causality running from emissions and electricity consumption to economic growth.

Chandran et al., (2009) prove the long run relationship between electricity consumption and economic growth in Malaysia. Akinlo (2009) examine the relationship between electricity consumption and economic growth in Nigeria and found long run relationship. Ozturk and Acaravci (2010) examine the relationship between energy consumption and economic growth of four South African economies namely: Albania, Bulgaria, Hungary and Romania. Results suggest long run relationship exist between energy consumption and economic growth in Hungary.

Shahbaz et al., (2012) discuss the nexus between electricity consumption and economic growth in Portugal by using the data from the period of 1971 to 2009. Results of granger causality confirm the bidirectional causal relationship in long run while, the unidirectional causality runs from economic growth to electricity consumption is found in short run. Shahbaz et al., (2012) analyze the relationship between energy consumption and economic growth in Pakistan by using the time series data from the 1972 to 2011. The empirical results confirm the long run positive relationship between energy consumption and economic growth. Results of Granger causality also confirm the existence of bidirectional causality in between energy consumption and economic growth in Pakistan.

Shahbaz and Feridun (2012) verify the relationship between electricity consumption and economic growth in Pakistan by using the annual data from 1971 to 2008. Results of ARDL cointegration confirm the long run relationship between energy consumption and economic growth in Pakistan. Shahbaz and Lean (2012) prove the relationship between electricity consumption and economic growth in Pakistan by controlling the effect of two major production functions i.e. labour and capital. Results confirm the long run positive and bidirectional causal relationship between energy consumption and economic growth. Shahbaz et al., (2013) also provide evidence of positive long run relationship between energy consumption and economic growth in China by using the annual data from the period of 1971 to 2011.

Farhani et al., (2014) analyze the relationship between natural gas consumption and trade in Tunisia by using the data from the period of 1980 to 2010. Results of ARDL cointegration confirm the long run relationship among variables. Results of Toda and Yamamoto causality analysis prove the bidirectional causality between trade and natural gas consumption in Tunisia. Shahbaz et al., (2014) also confirm the positive relationship between natural gas consumption and economic growth in long run as well as in short run in Pakistan. Results of causality analysis also confirm the bidirectional causality in between natural gas consumption and economic growth.

2.2.2 Energy Consumption and Trade

There are very few studies have been done to analyze the relationship between energy consumption and trade performance. Narayan and Smyth (2009) investigate the causal relationship between energy consumption and export in seven Middle Eastern countries by using the multivariate Granger causality approach. Their findings show no causal relationship between energy consumption and exports. Erkan et al. (2010) apply the Johansen Juselius cointegration approach and vector error correction model based Granger causality approach to examine the relationship between energy consumption and exports in Turkey. They valid the long run relationship between energy consumption and exports. The results of causality test confirm the unidirectional causality runs from energy consumption to exports.

Lean and Smyth (2010a) analyze the causal relationship between energy consumption and exports in Malaysia and suggest the unidirectional causality runs from energy consumption to exports. But in another study of Lean and Smyth (2010b) they do not find any evidence of causal relationship between energy consumption and exports in Malaysia. The results of both studies conclude that no causal relationship exists between energy consumption and exports in Malaysia. Sami (2011) also analyzes the causal relationship between energy consumption and exports in Japan. The empirical exercise validates the long run relationship between energy consumption and exports and exports Granger cause energy consumption.

Halicioglu (2011) analyze the long run and causal relationship between energy consumption and export in Turkey. The results conclude the long run relationship between considered variables and the unidirectional causality from exports to energy consumption. Sadorsky (2011) analyze the relationship between energy consumption, exports and imports in eight Middle Eastern countries by using the panel cointegration and Granger causality estimation procedures. The results suggest the valid long run relationship between considered variables and the positive and significant impact of both exports and imports on energy consumption in long run is found. The results of short run Granger causality test suggest the unidirectional causality from exports to energy consumption and bidirectional causality in between imports and energy consumption.

Hossain (2012) use the panel data of three SAARC countries to analyze the relationship between energy consumption and exports. The empirical evidence confirms the long run relationship between considered variables and also confirms the neutrality effect between energy consumption and exports. Sadorsky (2012) also analyze the relationship between energy consumption and trade in seven South American countries by using the three different indicators of trade namely, exports, imports and trade (exports plus imports). The empirical results indicate the bidirectional causal relationship between energy consumption and exports.

Dedeoglu and Kaya (2013) analyze the relationship among gross domestic product, trade and energy consumption in OECD countries. Their findings show the bidirectional causal relationship between energy use-imports, energy use-exports and energy use-output. Shahbaz et al., (2013) provide evidence of positive long run relationship between energy consumption and trade in China by using the annual data from the period of 1971 to 2011. Results of Granger causality confirm the presence of feedback hypotheses in China which means that there is bidirectional causal relationship exist between energy consumption and trade.

Farhani et al., (2014) analyze the relationship between natural gas consumption and trade in Tunisia by using the data from the period of 1980 to 2010. Results of ARDL cointegration confirm the long run relationship among variables. Results of Toda and Yamamoto causality analysis prove the unidirectional causality from trade to natural gas consumption in Tunisia. Sbia et al., (2014) analyze the relationship between trade openness and energy demand in UAE by using the data from the period of first quarter of 1975 to fourth quarter of 2011. They conclude that trade openness decline the energy demand in UAE. Shahbaz et al., (2014) prove the relationship between energy consumption and trade openness in 91 high, middle and low income countries by using the data from the period of 1980 to 2010. The overall results expose that the feedback effect (bidirectional causality) exists between trade openness and energy consumption.

3. Empirical Framework

After reviewing the theoretical and empirical work, the model to examine the relationship between energy consumption and trade performance is derived using the following framework:

$$ENC_t = \beta_0 + \beta_1 GDP_t + \beta_2 EXP_t + \beta_3 IMP_t + \varepsilon_t$$

Where, ε_t is the error term, *ENC* is the energy consumption which is measured by energy use in kilo tonne of oil equivalent, *GDP* is real gross domestic product as a proxy of economic growth, *EXP* is real value of exports of goods and services and *IMP* is real value of imports of goods and services. All variables are used in the log linear form. The expected sign for *GDP* is positive while, the sign of *EXP* and *IMP* are to be determined. In our basic model we also consider GDP to control the effects of economic growth in the model. Annual long time series data is used from the period of 1973 to 2011. All data are gathered from DataStream and different issues of economic surveys of Pakistan.

3.1 Unit Root Analyses

Augmented Dickey Fuller (*ADF*) and Phillip Perron (*PP*) unit root tests are used to examine the stationary properties for long run relationship of time series variables. Augmented Dickey Fuller (*ADF*)[1] test is based on equation given below:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t$$

Where ε_t is pure white noise error term, Δ is first difference operator, Y_t is a time series, α_0 is the constant and *k* is the optimum numbers of lags of the dependent variable. Augmented Dickey Fuller (*ADF*) test determines whether the estimates of coefficients are equal to zero. ADF test provide cumulative distribution of ADF statistics. The variable is said to stationary, if the value of the coefficient δ is less than critical values from fuller table. Phillip and Perron (PP)[2] unit root test equation is given below:

$$\Delta Y_t = \alpha + \rho^* Y_{t-1} + \varepsilon_t$$

[1] See, Dickey and Fuller (1979)
[2] See, Phillips and Perron (1988)

The Phillip and Perron unit root test is also based on t-statistics that is associated with estimated coefficients of ρ^*. In literature there are some conflicting evidences are available against the ADF and PP unit root tests. Researches argue that these unit root tests provide misleading results due to their low size and power. These tests also failed to provide any information about the structural breaks stemming in the series. Therefore, to ascertain the results of unit root properties we also use Zivot and Andrews (1992) structural break unit root test to identify the structural breaks in the series.

3.2 Cointegration Analyses

The Auto Regressive Distributed Lag (ARDL) method of cointegration developed by Pesaran and Pesaran (1997), Pesaran and Shin (1999) Pesaran *et al.* (2000, 2001) is used with the help of unrestricted vector error correction model to investigate the long run relationship between energy consumption and trade performance. The ARDL approach has several advantages upon other cointegraion methods. ARDL approach may applies irrespective of whether underlying variables are purely *I(0)*, *I(1)* or mutually co-integrated.[3] ARDL approach has estimated better small sample properties.[4] In ARDL procedure the estimations of results is even possible if the explanatory variable are endogenous.[5] The ARDL model is developed for estimations as follow:

$$\Delta \mathrm{ENC}_t = \psi_0 + \psi_1 \sum_{i=1}^{p} \Delta \mathrm{ENC}_{t-1} + \psi_2 \sum_{i=1}^{p} \Delta \mathrm{GDP}_{t-1} + \psi_3 \sum_{i=1}^{p} \Delta \mathrm{EXP}_{t-1}$$

$$+ \psi_4 \sum_{i=1}^{p} \Delta \mathrm{IMP}_{t-1} + \gamma_1 \mathrm{ENC}_{t-1} + \gamma_2 \mathrm{GDP}_{t-1} + \gamma_3 \mathrm{EXP}_{t-1} + \gamma_4 \mathrm{IMP}_{t-1} + \mu_t$$

[3] Pesaran and Shin (1999)
[4] Haug (2002)
[5] Pesaran and Shin (1999) and Pesaran et al. (2001)

Where ψ_0 is constant and μ_t is white noise error term, the error correction dynamics is denoted by summation sign while the second part of the equation corresponds to long run relationship. Schwarz Bayesian Criteria (*SBC*) is used to identify the optimum lag of model and each series. In ARDL model we first estimate the *F*-statistics value by using the appropriate ARDL models. Secondly, the Wald (*F*-statistics) test is used to investigate the long run relationship among the series. The null hypothesis of no cointegration is rejected if the calculated *F*-test statistics exceeds the upper critical bound (UCB) value. The results are said to be inconclusive if the *F*-test statistics falls between the upper and lower critical bound. Lastly, the null hypothesis of no cointegration is accepted if the *F*-statistics is below the lower critical bound. If long run relationship between energy consumption and trade performance is found then we estimate the long run coefficients. The following model will be use to estimate the long run coefficients:

$$\mathrm{ENC}_t = \zeta_0 + \zeta_1 \sum_{i=1}^{p} \mathrm{ENC}_{t-1} + \zeta_2 \sum_{i=1}^{p} \mathrm{GDP}_{t-1} + \zeta_3 \sum_{i=1}^{p} \mathrm{EXP}_{t-1} + \zeta_4 \sum_{i=1}^{p} \mathrm{IMP}_{t-1} + \mu_t$$

If we find evidence of long run relationship between energy consumption and trade performance then we estimate the short run coefficients by employing the following model:

$$\Delta\mathrm{ENC}_t = \varphi_0 + \varphi_1 \sum_{i=1}^{p} \Delta\mathrm{ENC}_{t-1} + \varphi_2 \sum_{i=1}^{p} \Delta\mathrm{GDP}_{t-1} + \varphi_3 \sum_{i=1}^{p} \Delta\mathrm{EXP}_{t-1} + \varphi_4 \sum_{i=1}^{p} \Delta\mathrm{IMP}_{t-1} + \mathrm{nECT}_{t-1} + \mu_t$$

The error correction model shows the speed of adjustment needed to restore the long run equilibrium following a short run shock. The n is the coefficient of error correction term in the model that indicates the speed of adjustment.

Johansen and Jeuuselius J. J. (1990) cointegration technique is also used to analyze the existence of long run relationship between energy consumption and trade performance in Pakistan. The J. J. cointegration test is based on λ_{trace} and $\lambda_{\max}$ statistics. First "trace test" cointegration rank '*r'* is as follow:

$$\lambda_{trace} = -T \sum_{j=r+1}^{n} In(1-\lambda_j)$$

Second, $\lambda_{\max}$ maximum number of cointegrating vectors against $r + 1$ is presented in following way:

$$\lambda_{\max}(r, r+1) = -T\ In(1-\lambda_j)$$

The null hypothesis of the J. J. cointegration is that there is no long run cointegration among the variables. If null hypothesis is rejected that's mean there is a significant long run relationship among the series of variables and vice versa.

In literature there are some conflicting evidences are available against the J. J. and ARDL cointegration methods. Researches argue that these cointegation approaches failed to provide any information about the structural breaks stemming in the series and may provide doubtful results of long run relationship among considered variables. Therefore, to ascertain the results of long run relationship between energy consumption and trade we also use Gregory and Hansen (1996) structural break cointegration approach to identify the structural breaks in the series.

3.3 Long Run Stability and Elasticity

In this study we use four different estimation approaches to analyze the long run coefficients and stability of model to ascertain the robustness of long run relationship between energy consumption and trade performance in Pakistan. First by using ARDL based coefficients method, second by using fully modified ordinary least square method (FMOLS) method, third by using dynamic ordinary least square (DOLS) method and fourth by using rolling window analysis procedure.

3.4 Causal Relationship

In this study we use more advance econometric technique variance decomposition method to analyze the causal relationship between considered variables. The variance decomposition method has several advantages upon other methods of causal relationships of time series data. The results of other causality tests weaken their reliability because they cannot analyze the strength of causal relationship beyond the selected time period. The variance decomposition method provides the magnitude of the predicted error variance for a series accounted for by innovations from each of the independent variable over different time period.[6] This ensures that our conclusions regarding the causal relationship of energy consumption and trade are accurate and more reliable as compare to past studies.

4. Estimations and Results

To check the stationary properties we use Augmented Dickey Fuller (*ADF*) and Phillip Perron (*PP*) unit root tests. Table 4.1 represents the results of stationary tests. First, these tests are applied on level of variables then on their first difference.

<Insert table 4.1 here>

Results of table 4.1 show that all variables are stationary and integrated at first difference. This implies that the series of variables may use for further long run estimations. In past studies some researches argue that ADF and PP unit root tests provide misleading results due to their low size and power. These tests also failed to provide any information about the structural breaks

[6] Wong (2010) and Raza & Jawaid (2012)

stemming in the series. Therefore, to ascertain the results of unit root properties we also use Zivot and Andrews (1992) structural break unit root test to identify the structural breaks in the series. Table 4.2 represents the results of Zivot and Andrews structural break unit root test.

<Insert table 4.2 here>

Results of table 4.2 show that all variables are non-stationary at level with intercept and trend but variables are found to be stationary at first difference. This confirms that series of all variables are cointegrated at I(1). Results of all three unit root tests confirm the robustness of results that all variables are cointegrated at I(1) and we can use these series for further long run estimation procedures.

Autoregressive distributed lag method for cointegration is used to estimate the long run relationship between energy consumption and trade performance. The first step is to determine the optimal lag length of the variables. The order of optimal lag length is decided by using the Schwarz Bayesian Criterion. Table 4.3 shows the results of ARDL cointegration method.

<Insert table 4.3 here>

The ARDL results suggest the rejection of null hypothesis of no cointegration in model because the value of the *F*- statistics is greater than upper bound critical value at 1% level of significance in favor of alternative hypothesis that the valid long run relationship is exist between energy consumption and trade performance in Pakistan.

<Insert table 4.4 here>

Johansen and Jeuuselius (1990) cointegration method is also used to estimate the long run relationship. Table 4.4 represents the calculated and critical values of Trace statistics and Maximum Eigen value statistics of Johansen and Jeuuselius (1990) cointegration method. Results indicate the rejection of null hypothesis of no cointegration in model at significance level of 5 percent in favor of alternative hypothesis that is the existence of one or more cointegrating vectors. The findings confirm the existence of long run relationship between energy consumption and trade performance in Pakistan.

<Insert table 4.5 here>

In past studies some researches argue that ARDL and J. J. cointegration methods provide doubtful and misleading results due to presence of structural break in a series. Therefore, to ascertain the results of long run relationship we also use Gregory and Hansen (1996) structural break cointegration approach. Table 4.5 represents the results of Gregory and Hansen cointegration approach. Results confirm the valid long run relationship between variables. Results of all three cointegration tests confirm the robustness of results that valid long run relationship exists between considered variables. After having the valid evidence of long run relationship between energy consumption and trade performance now we apply the ARDL method to estimate the long run and short run coefficients.

Now we estimate the lag length order of the all variables through unrestricted vector auto regression method. The decision criterion is based on minimum value of Schwarz Bayesian Criterion.

<Insert table 4.6 here>

Table 4.6 represents the results of lag length order of all variables. Results of Schwarz Bayesian Criterion indicate that the variables of energy consumption, gross domestic product and exports should be include in model at 1^{st} lag while the variable of imports should be include in model at 2^{nd} lag. The model for long run coefficients as follow:

$$ENC_t = \zeta_0 + \zeta_1 \sum_{i=1}^{p} ENC_{t-1} + \zeta_2 \sum_{i=1}^{p} GDP_t + \zeta_3 \sum_{i=1}^{p} GDP_{t-1}$$
$$+ \zeta_4 \sum_{i=1}^{p} EXP_t + \zeta_5 \sum_{i=1}^{p} EXP_{t-1} + \zeta_6 \sum_{i=1}^{p} IMP_t + \zeta_7 \sum_{i=1}^{p} IMP_{t-1} + \zeta_8 \sum_{i=1}^{p} IMP_{t-2} + \mu_t$$

<Insert table 4.7 here>

Table 4.7 shows the results of long run ARDL estimations. Results suggest that all three variables economic growth, exports and imports are the major sources to increase energy consumption in Pakistan. Results indicate the positive and significant effect of exports and import on energy consumption in Pakistan. The coefficient of exports is showing that the 1% increase in exports causes the increase in the energy consumption by 0.283%. On the other side, the coefficient of imports is showing that the 1% increase in imports causes the increase in the energy consumption by 0.237%. It is concluded that the exports and imports are the important factors to increase energy consumption in Pakistan. The findings of this study are consistent with the earlier available literature which is mostly showing the positive relationship between trade and energy consumption. Following model is used to check the short run relationship among the considered variables with the different lag length.

$$\Delta ENC_t = \varphi_0 + \varphi_1 \sum_{i=1}^{p} \Delta ENC_{t-1} + \varphi_2 \sum_{i=1}^{p} \Delta GDP_t + \varphi_3 \sum_{i=1}^{p} \Delta GDP_{t-1}$$
$$+ \varphi_4 \sum_{i=1}^{p} \Delta EXP_t + \varphi_5 \sum_{i=1}^{p} \Delta EXP_{t-1} + \varphi_6 \sum_{i=1}^{p} \Delta IMP_t$$
$$+ \varphi_7 \sum_{i=1}^{p} \Delta IMP_{t-1} + \varphi_8 \sum_{i=1}^{p} \Delta IMP_{t-2} + nECT_{t-1} + \mu_t$$

<Insert table 4.8 here>

Table 4.8 represents the short run relationship between energy consumption and trade. Results indicate that the lagged error correction term for the estimated energy consumption equation is both negative and statistically significant. This confirms a valid short run relationship between energy consumption and trade in Pakistan. The coefficient of error term is showing the value of -0.122 suggest that about 12 % of disequilibrium is corrected in the current year. Results indicate the positive and significant effect of economic growth, exports and imports on energy consumption in short run as well.

Sensitivity Analysis of Long run Coefficients

In this section to check the robustness of initial results of long run coefficients two different sensitivity analyses have been performed namely; dynamic ordinary least square (*DOLS*) and fully modified ordinary least square (*FMOLS*).

<Insert table 4.9 here>

Dynamic Ordinary Least Square

The robustness of the relationship between dependent variable and explanatory variables is also tested through Dynamic Ordinary Least Square (*DOLS*) technique developed by Stock and Watson (1993). This method involves estimating the dependent variable on explanatory variable by using the levels, leads and lags of the explanatory variable. This method resolves the issues of small sample bias, endogeneity and serial correlation problems by adding the leads or lags of explanatory variable (Stock and Watson, 1993).

Table 4.9 also represents the results of dynamic ordinary least square of energy consumption model. We have run our model of *DOLS* by taking the lead and lag of 2. Results confirm that the coefficients of all determinants remain same sign and significance after taking the different lag and lead in the model. The coefficients of all determinants are also almost same as in the ARDL based coefficients model.

Fully Modified Ordinary Least Square (*FMOLS*)

The fully modified ordinary least square technique developed by Philips and Hansen (1991) is also used to analyze the robustness of our initial results of ARDL based coefficients model. *FMOLS* provides the optimal estimates of the cointegration equation.[7] The *FMOLS* modifies the *OLS* to control the problems of serial correlation and endogeneity in the regressors that results from the existence of a cointegrating relationship.[8] Results of *FMOLS* are also presented in table 4.9. Results of *FMOLS* confirm that the coefficients of all determinants remain same sign and significance as in the ARDL based coefficients model.

Results of both sensitivity analyses show that the coefficient of all considered variables have remain same sign and significance even magnitude is also almost same as in ARDL based coefficients model. These findings confirm that the initial results are robust.

5. Stability of Long run Model: A Rolling Window Analysis

The stability of coefficients of the long run model in the sample size is evaluated by using the rolling window estimation method. Figure 5.1, 5.2, 5.3 and table 5.1 represent the coefficients of each year of gross domestic product, exports and imports throughout the sample by using the rolling window estimation method. Two standard deviation bands show the upper and lower bounds.

<Insert figure 5.1, 5.2, and 5.3 here>

<Insert table 5.1 here>

Results indicate that the gross domestic product is having positive coefficient throughout the sample except for the years from 1994 to 1998. The coefficient of GDP is continuously increasing from 2006. The exports is also having positive coefficient throughout the sample

[7] Bum and Jeon (2005)
[8] See, Philips and Hansen (1990), and Hansen (1995)

except for the years from 1984 to 1986. The coefficients of imports are showing very mix results throughout the sample period. The imports are having the negative coefficient in the year of 1987, 1988, 1996, 1997, 2001, 2002, 2006 and 2009 while in rest of the years the coefficient of imports remain negative.

6. Stability of Short run Model

The stability of short run model in the sample size is evaluated by using the cumulative sum (CUSUM) and CUSUM of square test on the recursive residuals. CUSUM test detects systematic changes from the coefficients of regression, while, CUSUM of square test is able to detects the sudden changes from constancy of regression coefficients [Brown et al. (1975)].

<Insert figures 6.1 & 6.2 here>

Figure 6.1 and 6.2 represents the results of CUSUM and CUSUM of square tests respectively. Results indicate that the statistics of both CUSUM and CUSUM of square test are lie within the interval bands at 5% confidence interval. Results suggest that there is no structural instability in the residuals of equation of energy consumption.

7. Causality Analysis: Variance Decomposition Analysis

Generalized forecast error variance decomposition method under vector autoregressive (VAR) system is used to analyze the strength of the causal relationship of energy consumption and trade. The variance decomposition method provides the magnitude of the predicted error variance for a series accounted for by innovations from each of the independent variable over different time period. Wong (2010), and Raza and Jawaid (2013) have used this approach to find causal relationship among considered variables. Table 7.1 represents the results of variance decomposition analysis.

<Inset table 7. 1 here>

Results of table 7.1 show that in the first round the change in energy consumption is explained completely 100% by its own innovations. In the second period 82.88% explain by own innovation, 11.83% by gross domestic product, 2.77% by exports and 2.53% by imports. In period five the shocks in energy consumption explain 61.75% by own innovation, 22.72% by innovations of gross domestic product, 4.76% by innovations of exports and 10.77% by innovations of imports. In tenth period the shocks in energy consumption explain 22.76% by own shocks, while, 31.46% by innovations of gross domestic product, 23.46% by innovations of exports and 22.33% by innovations of imports.

The shocks in gross domestic product explain 29.88%, 37.76%, 37.40% and 36.31% by innovation of energy consumption in period 1, 2, 5 and 10 respectively. The shocks in exports explain 0.19%, 3.81%, 10.66% and 18.15% by innovation of energy consumption in period 1, 2, 5 and 10 respectively. The shocks in imports explain 9.56%, 6.51%, 15.58% and 23.56% by innovation of energy consumption in period 1, 2, 5 and 10 respectively. These findings suggest the bidirectional causal relationship of gross domestic product, exports and imports with energy consumption in Pakistan. These findings confirm the presence of feedback hypothesis in Pakistan and energy conservation policies will reduce the trade performance which leads to decline economic growth in Pakistan.

8. Conclusion and Recommendations

This study investigates the relationship between energy consumption and trade performance in Pakistan by using the annual time series data from the period of 1973 to 2011. The ARDL bound testing cointegration approach, Johansen and Jeuuselius cointegration approach and Gregory and Hansen structural break cointegration approach confirm the valid long run relationship between energy consumption and trade performance. Results of ARDL based coefficient model, fully modified ordinary least square method and dynamic ordinary least square method indicate that gross domestic product, exports and imports have positive and significant impact on energy consumption in long run. The same positive and significant relationship is also found in short run. Results of CUSUM and CUSUM of square test suggest that there is no structural instability in the residuals of equation of energy consumption.

Results of rolling window estimation method indicate that the gross domestic product is having positive coefficient throughout the sample except for the years from 1994 to 1998. The coefficient of GDP is continuously increasing from 2006. The exports is also having positive coefficient throughout the sample except for the years from 1984 to 1986. The coefficients of imports are showing very mix results throughout the sample period. The imports are having the negative coefficient in the year of 1987, 1988, 1996, 1997, 2001, 2002, 2006 and 2009 while in rest of the years the coefficient of imports remain negative. Results of Generalized forecast error variance decomposition method under vector autoregressive (VAR) system suggest the bidirectional causal relationship of gross domestic product, exports and imports with energy consumption in Pakistan.

Pakistan is a developing country and like most of the developing countries in current global financial crises Pakistan is also facing economic problems of high public debt, unemployment, high inflation, low savings, low investments and income inequality. The most appropriate way of dealing with these problems is to stimulate economic growth and increase international trade. In the favor of this argument, the results of bidirectional causal relationship of gross domestic product, exports and imports with energy consumption can have significant policy implications.

These findings confirm the presence of feedback hypothesis in between energy consumption-output, energy consumption-exports, energy consumption-imports in Pakistan and energy conservation policies will reduce the trade performance which leads to decline economic growth in Pakistan. Therefore, any energy or environment policy aiming at reducing energy consumption should be designed to do this through energy-intensity reduction to prevent output and trade decrease in Pakistan. Policy makers should make export promotion and economic growth related policies by considering the bidirectional positive causal relationship of energy consumption. This means that do not considering energy consumption while making policies for economic growth and trade expansion lead to demand shortages and supply interruptions.

There is a worldwide pressure on reducing the carbon dioxide CO_2 emissions, which are commonly accepted as a main source of global warming. In order to avoid falling behind the targets of CO_2 reduction without decreasing the economic growth and trade, Pakistan should rapidly invest in energy infrastructure that energy is produced from renewable sources such as hydroelectricity, wind power, hydropower, solar, biofuel etc. It is also recommended that Pakistan should implement a dual strategy of investment by investing in electricity infrastructure and by stepping up electricity conservation policies to avoid reduction in electricity consumption adversely affecting economic growth.

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Table 1.1: Trend of Gross domestic product, Exports, Imports and Energy Consumption in Pakistan

Time Period	Gross Domestic Product		Exports		Imports		Energy Consumption	
	Billion*	Growth	Billion*	Growth	Billion*	Growth	Kilo Tonne	Growth
1970s	1048.29	---	114.20	---	322.48	---	20077	---
1980s	1921.75	83.32%	229.46	100.93%	421.30	30.64%	32256	60.66%
1990s	3171.10	65.01%	471.32	105.41%	571.94	35.76%	52214	61.87%
2000s	4738.70	49.43%	801.46	70.05%	765.63	33.86%	73753	41.25%

Source: Ministry of Finance, Pakistan

Table 4.1: Stationary Test Results

Variables	Augmented Dickey-Fuller				Phillips-Perron			
	I(0)		I(1)		I(0)		I(1)	
	C	C&T	C	C&T	C	C&T	C	C&T
ENC	1.21	-2.72	-5.25	-5.41	1.06	-2.72	-5.32	-5.42
GDP	1.95	-0.95	-3.99	-3.86	-2.04	-0.72	-3.91	-3.88
EXP	-1.46	1.88	-3.75	-3.57	-1.62	-2.49	-4.09	-3.99
IMP	1.33	-0.38	-5.67	-6.15	1.47	-0.34	-5.76	-6.16

Note: The critical values for ADF and PP tests with constant (c) and with constant & trend (C&T) 1%, 5% and 10% level of significance are -3.711, -2.981, -2.629 and -4.394, -3.612, -3.243 respectively.
Source: Authors' estimation.

Table 4.2: Zivot-Andrews Structural Break Trended Unit Root Test

Variable	At Level		At 1st Difference	
	T- Statistics	Time Break	T- Statistics	Time Break
ENC	-2.402 (1)	1992	-6.245 (1)*	2004
GDP	-3.188 (1)	1987	-5.862 (1)*	2004
EXP	-2.897 (1)	1997	-5.809 (2)**	1982
IMP	-3.001 (1)	1998	-6.432 (1)**	2003

Note: Lag order shown in parenthesis.
* Represents significance at 1% level.
** Represents significance at 5% level.
Source: Authors' estimation.

Table 4.3: Lag Length Selection & Bound Testing for Cointegration

Lags Order	AIC	HQ	SBC	F-test Statistics
0	-5.117	-5.056	-4.943	49.215*
1	-13.755	-13.448*	-12.194	
2	-13.761*	-13.209	-12.884*	

* 1% level of significant.
Source: Authors' estimation.

Table 4.4: J. J. Cointegration Test

Null Hypothesis No. of CS(s)	Trace Statistics	5% critical values	Max. Eigen Value Statistics	5% critical values
None *	45.093	40.175	24.327	24.159
At most 1	20.766	24.276	12.377	17.797
At most 2	8.389	12.321	8.147	11.225

Source: Authors' estimation.

Table 4.5: Gregory-Hansen Structural Break Cointegration Test

ADF Procedure	
Structural Break	1993
T-Statistics	-4.869
P-value	0.000
Phillips Procedure	
Structural Break	1993
T-Statistics	-4.954
P-value	0.000

Source: Authors' estimation.

Table 4.6: Lags Defined through VAR of Variables

Lag	0	1	2	Selected Lags
	SBC	SBC	SBC	SBC
ENC	1.492	-5.005*	-4.637	1
GDP	1.763	-4.772*	-4.487	1
EXP	2.803	-1.465*	-1.193	1
IMP	2.546	-0.769	-0.937*	2

* indicate minimum SBC values.
Source: Authors' estimation.

Table 4.7: Long Run Results using ARDL Approach

Variables	Coeff.	t-stats	Prob.
C	-0.097	-0.752	0.460
ENC (-1)	0.569	5.355	0.000
GDP	0.584	4.073	0.000
GDP (-1)	-0.223	-1.430	0.163
EXP	0.283	2.783	0.009
EXP (-1)	-0.222	-0.759	0.454
IMP	0.237	3.060	0.005
IMP (-1)	-0.131	-1.615	0.117
IMP (-2)	0.001	0.170	0.867
Adj. R^2	0.971		
D.W stats	2.161		
F-stats (Prob.)	6347.086 (0.000)		

Source: Authors' estimation.

Table 4.8: Short Run Results using ARDL Approach

Variables	Coeff.	t-stats	Prob.
C	-0.011	-0.309	0.760
ΔENC (-1)	0.248	4.576	0.000
ΔGDP	0.316	4.032	0.000
ΔGDP (-1)	-0.233	-1.592	0.123
ΔEXP	0.080	2.571	0.016
ΔEXP (-1)	-0.021	-0.681	0.501
ΔIMP	0.067	2.233	0.034
ΔIMP (-1)	-0.029	-1.422	0.166
ΔIMP (-2)	-0.030	-1.325	0.196
ECM(-1)	-0.122	-3.633	0.001
Adj. R^2	0.912		
D.W stats	1.971		
F-stats (Prob.)	4891.457 (0.000)		

Source: Authors' estimation.

Table 4.9: Robustness of Long run Coefficients

Variables	FMOLS			DOLS		
	Coeff.	t-stats	Prob.	Coeff.	t-stats	Prob.
C	0.061	1.222	0.230	0.089	1.621	0.119
GDP	0.544	13.044	0.000	0.579	10.710	0.000
EXP	0.255	5.177	0.000	0.265	4.559	0.000
IMP	0.270	13.354	0.000	0.232	10.951	0.000
Adj. R^2	0.972			0.981		
D.W stats	1.774			1.773		

Source: Authors' estimation.

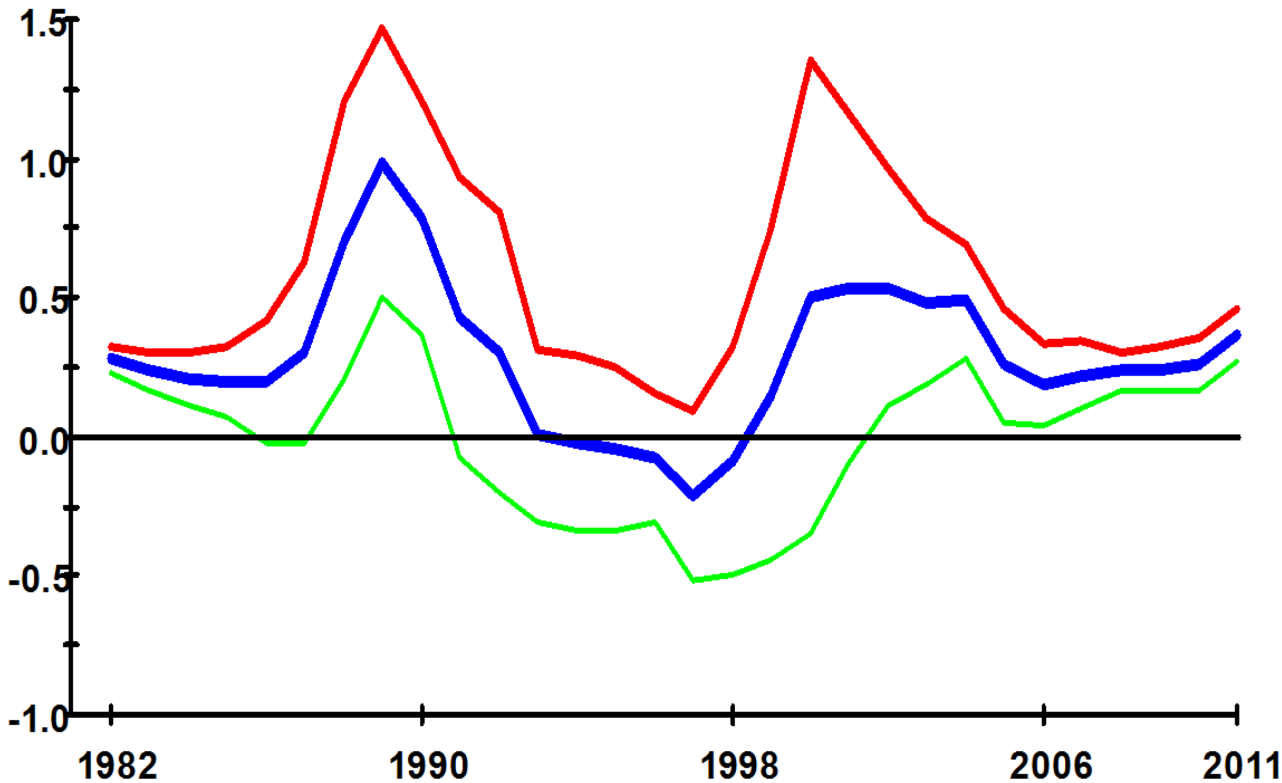

Figure 5.1 Coefficient of GDP and its two S.E. bands based on rolling OLS (Dependent Variable: ENC)

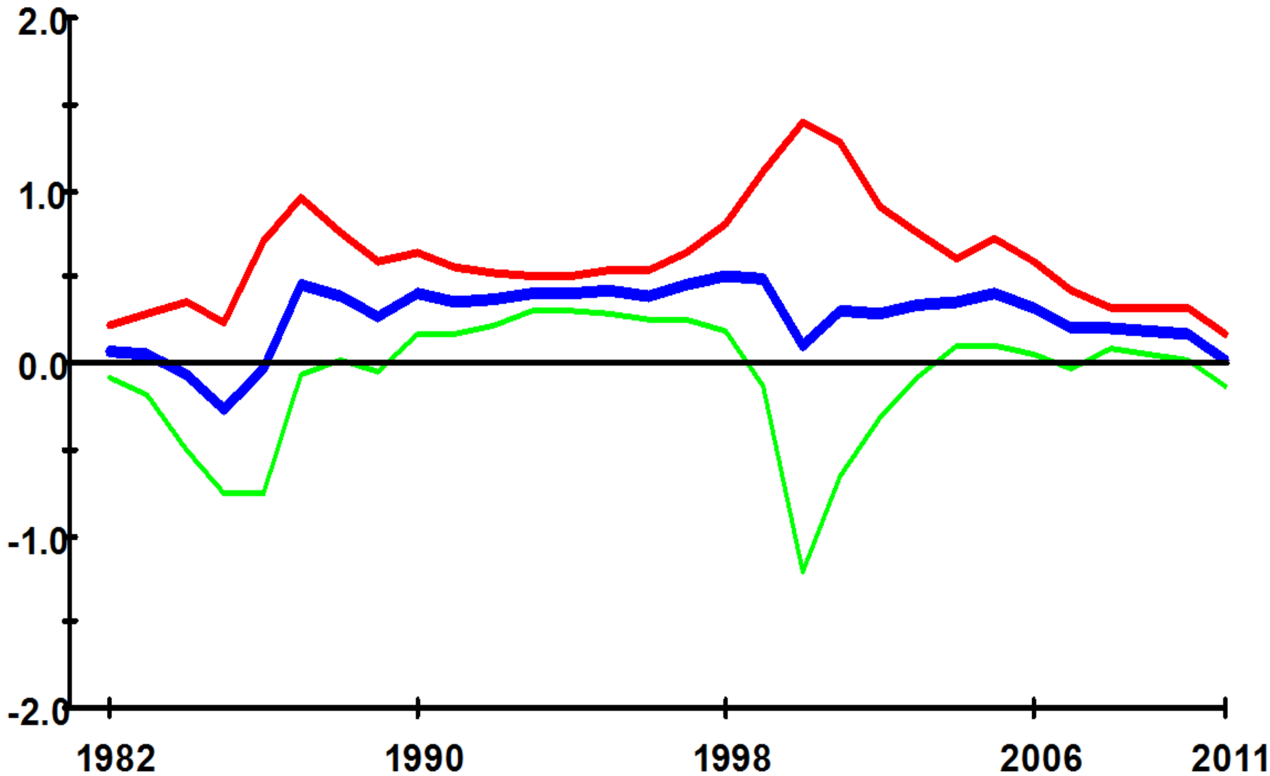

Figure 5.2 Coefficient of EXP and its two S.E. bands based on rolling OLS (Dependent Variable: ENC)

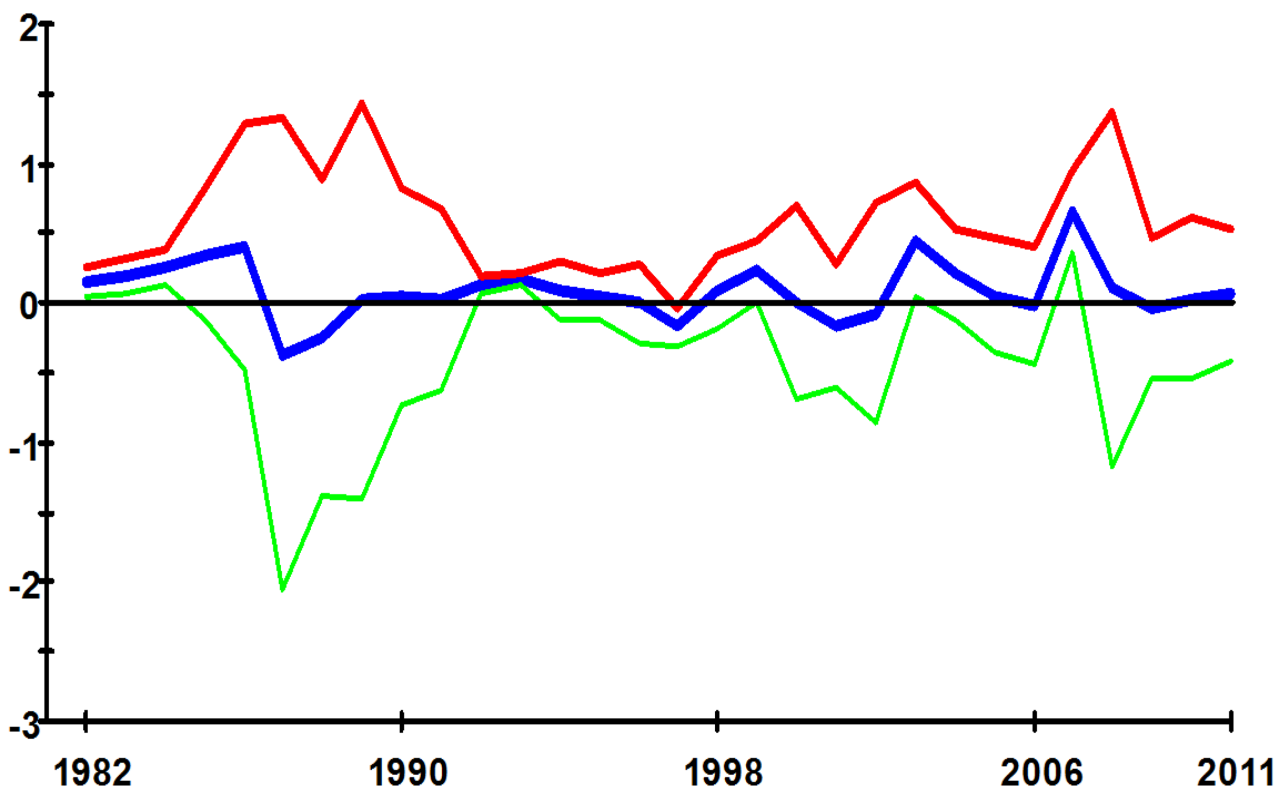

Figure 5.3 Coefficient of IMP and its two S.E. bands based on rolling OLS (Dependent Variable: ENC)

Table 5.1 Long run Coefficients

Year	GDP	EXP	IMP
1982	0.277	0.065	0.156
1983	0.239	0.046	0.187
1984	0.205	-0.074	0.253
1985	0.200	-0.261	0.348
1986	0.200	-0.028	0.408
1987	0.301	0.449	-0.365
1988	0.703	0.388	-0.250
1989	0.987	0.275	0.020
1990	0.781	0.399	0.045
1991	0.429	0.354	0.028
1992	0.303	0.367	0.127
1993	0.003	0.402	0.165
1994	-0.018	0.400	0.085
1995	-0.047	0.415	0.052
1996	-0.077	0.393	-0.003
1997	-0.210	0.447	-0.170
1998	-0.084	0.499	0.078
1999	0.147	0.492	0.229
2000	0.504	0.093	0.010
2001	0.536	0.309	-0.158
2002	0.538	0.293	-0.073
2003	0.485	0.341	0.450
2004	0.486	0.352	0.205
2005	0.257	0.409	0.052
2006	0.189	0.320	-0.023
2007	0.220	0.194	0.656
2008	0.236	0.203	0.100
2009	0.244	0.184	-0.038
2010	0.258	0.164	0.030
2011	0.361	0.015	0.060

Source: Authors' estimation.

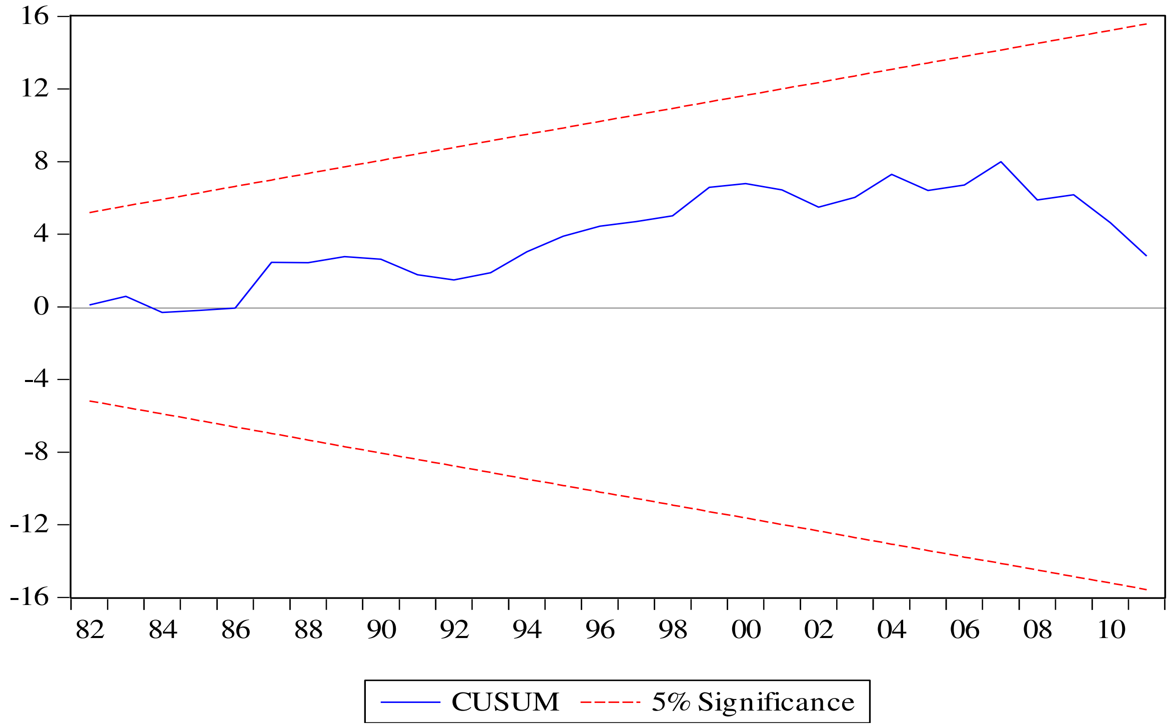

Figure 6.1. Plot of cumulative sum of recursive residuals. The straight lines represent critical bounds at 5% significance level

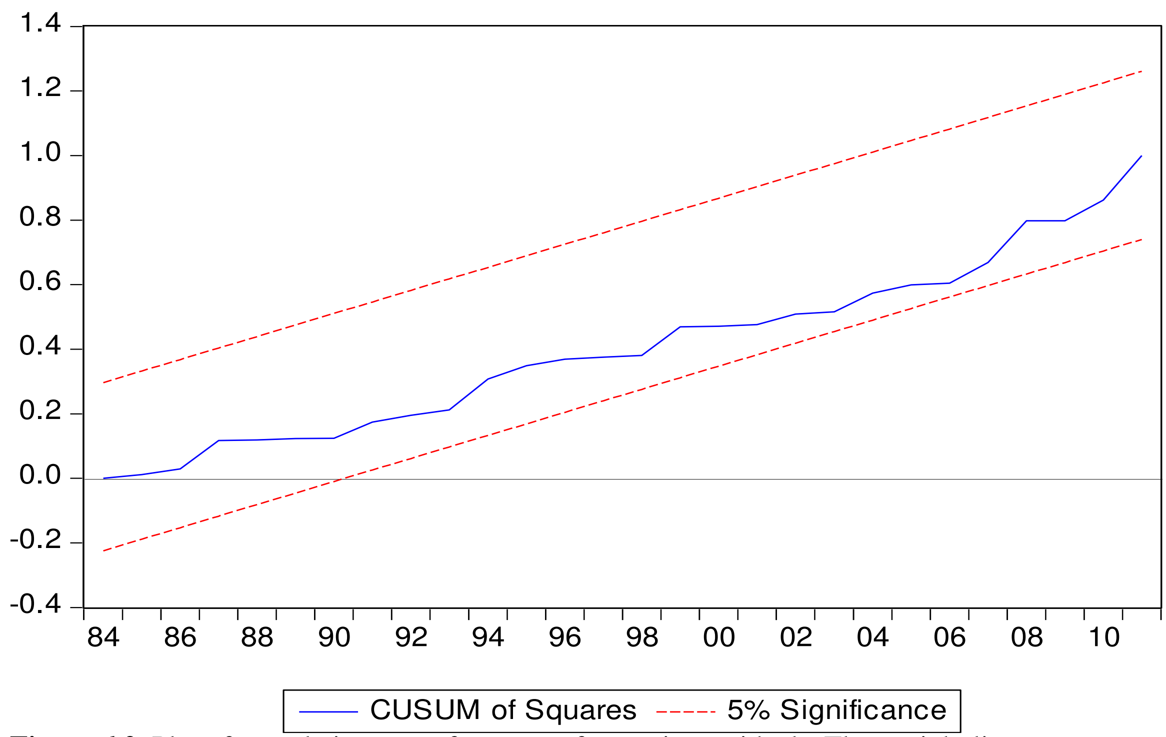

Figure 6.2. Plot of cumulative sum of squares of recursive residuals. The straight lines represent critical bounds at 5% significance level

Table 7.1: Results of Variance Decomposition Approach

Period	ENC	GDP	EXP	IMP
Variance Decomposition of ENC				
1	100.000	0.000	0.000	0.000
2	82.877	11.828	2.766	2.529
3	73.017	18.315	2.711	5.957
4	67.339	21.238	3.365	8.059
5	61.747	22.724	4.756	10.772
6	54.827	23.770	6.944	14.460
7	47.086	24.535	9.759	18.620
8	40.444	26.934	12.950	19.673
9	32.973	29.895	16.255	20.877
10	22.755	31.457	23.458	22.330
Variance Decomposition of GDP				
1	29.880	70.120	0.000	0.000
2	37.764	60.052	2.145	0.038
3	37.606	57.357	2.873	2.164
4	37.638	52.269	5.678	4.415
5	37.397	48.556	6.239	7.808
6	37.110	41.768	9.842	11.279
7	36.836	37.864	11.535	13.765
8	36.609	34.863	14.306	14.222
9	36.436	30.797	17.135	15.632
10	36.310	24.695	21.006	17.989
Variance Decomposition of EXP				
1	0.192	20.994	78.814	0.000
2	3.806	23.895	72.299	0.000
3	6.298	28.497	64.850	0.355
4	8.560	32.716	57.361	1.364
5	10.658	35.867	50.859	2.615
6	12.593	38.137	45.587	3.684
7	14.323	39.788	41.439	4.450
8	15.817	41.017	38.205	4.961
9	17.084	41.961	35.663	5.292
10	18.154	42.715	33.628	5.503
Variance Decomposition of IMP				
1	9.563	15.306	4.446	70.685
2	6.513	37.224	7.170	49.093
3	10.925	40.985	6.262	41.828
4	13.695	42.340	11.909	32.056
5	15.578	42.377	12.583	29.462
6	16.844	42.081	14.821	26.254
7	17.792	41.829	15.105	25.274
8	18.531	41.702	17.277	22.489
9	21.110	41.675	21.348	15.866
10	23.562	41.709	22.358	12.372

Source: Authors' estimation.