Energy Conservation Policies, Growth and Trade Performance: Evidence of Feedback Hypothesis in Pakistan

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Abstract
This study investigates the relationship between energy consumption and trade openness in Pakistan by using the annual time series data for the period of 1973-2011. Our main results show: i) the presence of long-run link between energy consumption and trade performance; *ii*) positive impact of gross domestic product, exports, and imports on energy consumption; *iii*) bidirectional causal relationship between exports and energy consumption, and also between imports and energy demand; and *iv*) bidirectional causality between gross domestic product and energy consumption points to the presence of feedback hypothesis in Pakistan. We therefore note that energy conservation policies will reduce the trade performance which in turn leads to the decline in economic growth in Pakistan. The present study may guide policymakers 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. To the extent that energy is a critical input for industrial production and economic activity, many studies have, since the oil shocks of the 1970s, investigated the relationship between energy consumption and economic growth (e.g., Yu and Choi, 1985; Ramcharran, 1990; Ebohon, 1996; Yang, 2000; Wolde-Rufael, 2004; Lee and Chang, 2005; Altinay and Karagol, 2005; Lee, 2006; Chen et al., 2007; Apergis and Payne, 2009; Wolde-Rufael, 2009; Ozturk, 2010; Shahbaz and Lean, 2012). There is also a separate and comparative literature available on the relationship between trade and economic growth (e.g., Culem, 1988; Black and Pain, 1994; Pain and Wakelin, 1998; Wong, 2010). However, very few studies have addressed the interactive relationship between energy consumption and trade openness.

The energy consumption-trade nexus is an important issue in an open economy for several reasons. If the causal relationship runs from energy consumption to trade or there is feedback relationship exists between them, then energy conservation policies will reduce the trade performance which would lower economic growth. Differently, if the causality goes from trade to energy or does not exist at all in either direction, energy conservation policies can be implemented without harmful effects on trade. Some studies have recently tackled this issue by using cross-country data (e.g., Narayan and Smyth, 2009; Sadorsky, 2011; Dedeoglu and Kaya, 2013). While the use of panel data may be suitable for providing insights about the energy-trade nexus across the whole sample countries, it fails to explain the causal effect at individual country level, which thus limits the policy implication for a specific country in terms of domestic economic, trade, and energy policies. Our paper makes 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 1973 to 2011 and by applying more rigorous econometric techniques.

The main contribution of our study is thus the fact that we do not restrict it to any particular econometric technique at any stage to estimate the relationship between energy consumption and trade openness, which is the case in most past studies. Instead, different sensitivity analyses (estimations techniques) are used to check the robustness of initial estimated relationships between energy consumption and trade openness in Pakistan. They specifically involve the application of three different econometric techniques in each step of estimations of unit root tests, long-run cointegration and long-run elasticities. Pakistan is the second-largest country in South Asia in terms of population and gross domestic product and thus serves as an elaborated case study as this country experienced a sharp decline in economic growth, exports, and energy consumption in 2000s, as compared with the 1980s and 1990s (Table 1).

[Please insert Table 1 here]

The rest of the paper is organized as follows. Section 2 reviews some selected theoretical and empirical literature on the relationship of energy consumption, economic growth and trade openness. Section 3 discusses the empirical strategy. Section 4 reports the estimation results. Section 5 provides some policy implications and concludes the paper.

2. Literature Review

2.1 Energy consumption and economic growth

Following the oil shocks of the 1970s, a number of studies have extensively analyzed the causal relationship between energy consumption and economic growth. For instance, studies such as Yu and Choi (1985), Ramcharran (1990), Masih and Masih (1996), Morimoto and Hope (2004), Wolde-Rufael (2004), Lee and Chang (2005), Altinay and Karagol (2005), Lee (2006), and Apergis and Payne (2009) document the unidirectional causality running from energy consumption to economic growth. On the other hand, studies such as Cheng and Lai (1997), Ghosh (2002), Soytas and Sari (2003), Yoo (2006), Halicioglu (2007) and Hu and Lin (2008) find evidence of the unidirectional causality running from economic growth to energy consumption. Finally, the evidence of bidirectional causality between energy consumption and economic growth has been found in, among others, Ebohon (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), Wolde-Rufael (2009), and Shahbaz et al. (2012).

Fewer studies have found the long-run relationship between energy consumption and economic growth. Squalli and Wilson (2006) investigate the electricity consumption-income growth nexus by using time series data from 1980 to 2003 for six member countries of the Gulf Council Countries. Their results from the ARDL bounds testing approach and Toda-Yamamoto causality test show evidence of a positive long-run relationship as well as the bidirectional causality between these two variables for Bahrain, Qatar and Saudi Arabia. In addition, there is unidirectional causality from economic growth to electricity consumption in Kuwait and no causal relationship in the United Arab Emirates. Ho and Sui (2006) find a long-run relationship between energy consumption and economic growth for Hong Kong. Ozturk and Acaravci (2010) investigate the association between energy consumption and economic growth for European emerging economies (Albania, Bulgaria, Hungary and Romania) and only find a long-run relationship in Hungary. Shahbaz et al. (2012) analyze the energy-growth nexus in Pakistan over the period

1972-2011 and find a long-run and positive relationship as well as the bidirectional causality between energy consumption and economic growth. Similar long-run relationship is found for China (Shahbaz et al., 2013).

Similarly, the long-run link has been found between electricity consumption and economic growth for Malaysia (Chandran et al., 2009), for the OPEC countries (Squalli, 2007), for Taiwan over the period 1980-2007 (Pao, 2009), for Nigeria (Akinlo, 2009), for Portugal (Shahbaz et al., 2011). In particular, Shahbaz and Lean (2012) prove the relationship between electricity consumption and economic growth by labor and capital in production function. They find that electricity consumption has positive impact on economic growth. Capital and labor also add in domestic production and hence in economic growth. Furthermore, there exists the bidirectional causal relationship between electricity consumption and economic growth.

In a related study, Lean and Smyth (2010a) investigate the relationship among carbon dioxide emissions, electricity consumption and economic growth for five ASEAN countries by employing a vector error-correction model. Their results point to a positive long-run link between the variables of interest as well as the unidirectional causality running from CO_2 emissions and electricity consumption to economic growth. Shahbaz et al. (2014) also confirm the positive impact of natural gas consumption on economic growth in the long run as well as in short run for Pakistan.

2.2 Energy consumption and trade

Only few studies have analyzed the relationship between energy consumption and trade openness. Narayan and Smyth (2009) focus on the Middle Eastern countries and show no causal relationship between energy consumption and exports from multivariate Granger causality tests. Erkan et al. (2010) document, from cointegration and vector error-correction models, a long-run relationship between energy consumption and exports in Turkey. They also obtain a unidirectional causality running from energy consumption to exports. Considering the Malaysian case, Lean and Smyth (2010b) find the unidirectional causality running from energy consumption to exports, but the neutral effect between energy generation and exports in Malaysia. Sami (2011) validates the long-run relationship between energy consumption and exports in Japan, and also finds that exports Granger-cause energy consumption. The same result is found for Turkey (Halicioglu, 2011).

Sadorsky (2011) uses panel cointegration and Granger causality, and find a positive and significant impact of both exports and imports on energy consumption in long run for Middle Eastern countries. A unidirectional causality from exports to energy consumption and bidirectional causality between imports and energy consumption are also detected. Sadorsky (2012) analyzes the relationship between energy consumption and trade in South American countries and only documents a bidirectional causal relationship between energy consumption and exports.

Dedeoglu and Kaya (2013) investigate the interactions among gross domestic product, trade and energy consumption in OECD countries. Their findings show the bidirectional causal relationship between energy consumption and each of the other variables (exports, imports, and input). Shahbaz et al. (2013) provide evidence of a positive long-run relationship between energy consumption and trade in China during the 1971-2011 period as well as the feedback hypothesis. Farhani et al. (2014) find evidence of cointegration and unidirectional causality running from trade to natural gas consumption in Tunisia over the period 1980-2010. The study by Sbia et al., (2014) shows that trade openness declines energy demand in the United Arab Emirates. Shahbaz et al. (2014) find the feedback effect (bidirectional causality) between trade openness and energy consumption for a panel of 91 high, middle and low income countries over the period 1980-2010.

3. Empirical Framework

If energy consumption significantly causes changes in trade or there is the feedback relationship exists between them, energy conservation policies will lead to lower trade performance, which in turn leads to lower economic growth. Such energy policy will not affect trade if there is unidirectional causality from trade to energy or no causality in either direction. The level of energy consumption is expected to have impacts on exports as energy is used as input for the production of goods destined for exports (Sadorsky, 2011). Exporting manufactured goods and raw materials also requires energy to fuel transportation. A dramatic decrease in energy consumption, resulting from an energy conservation program, could affect the ability to produce and transport the goods for exports. Inversely, an increase in exports represents an increase in economic activity and this should increase the demand for energy. All in all, the exports-led energy hypothesis posits that changes in exports affect changes in energy consumption. By contrast, the energy-led export hypothesis entails that change in energy consumption influence changes in exports. The feedback relationship may also exist between energy consumption and exports whereby energy consumption is important for explaining movements in exports and exports which are important for explaining movements in energy demand and changes in economic growth. It is also possible for the relationship between energy consumption and exports to be neutral. In this case, the correlation between energy consumption and exports is so negligible and does not show up as a statistically significant relationship at conventional tests levels (Sadorsky, 2011).

In the same way, the hypothetical links between energy consumption and imports can be highlighted. If there is unidirectional causality from energy consumption to imports or there exists a feedback between them, then reducing energy consumption (e.g., through energy conservation policies) will reduce imports. This could have very undesirable impacts on economic growth economy if imports consist of machinery, equipment and new technology products necessary for the country's ability to boost productivity and create economic wealth. On the other hand, the causality from imports to energy consumption or the absence of causality in either direction implies that energy conservation policies are not harmful for imports (Sadorsky, 2012). Theoretically, changes in imports may affect energy consumption in two ways. First, the distribution of imported goods into a country requires a transportation network which is fueled by energy. Second, imported goods can affect energy consumption through the mix of imported goods. Durable imported goods such as automobiles, air conditioners, and refrigerators are heavy users of energy and an increase in these types of imported goods will increase the demand for energy. Inversely, since energy is an essential input for the transportation process that facilitates imports, changes in energy use can significantly affect imports because inadequate use (or regulation) of energy will make it difficult to distribute imported goods and also to reduce the quantity of imported durable energy-intensive goods. Again, a neutral hypothesis may exist between energy consumption and imports.

The above theoretical discussions lead us to specify the following empirical model to examine the relationship between energy consumption and trade:

$$E_t = \beta_0 + \beta_1 Y_t + \beta_2 EX_t + \beta_3 IM_t + \varepsilon_t \quad (1)$$

where, ε_t is the error term; *E* is the energy consumption which is expressed in kg of oil equivalent; *Y* is the real gross domestic product per capita which is a proxy of economic growth; *EX* is the real value of exports of goods and services per capita; and *IM* is the real value of imports of goods and services per capita. All variables are measured in the natural log form. The expected sign for *Y* is positive while the sign of *EX* and *IM* are to be determined. In our basic model, we also consider real GDP to control the effects of economic growth in the model. Annual long time series data are used over the period from 1973 to 2011. The data for all the variables are collected from economic surveys of Pakistan (various issues).

3.1 Bounds testing cointegration approach

The Autoregressive Distributed Lag (ARDL) method of cointegration developed by Pesaran and Pesaran (1997), Pesaran and Shin (1999), and Pesaran et al., (2000, 2001) is used with the help of unrestricted vector error-correction model in order to investigate the long-run relationship between energy consumption and trade performance. The ARDL bounds testing approach has several advantages upon other cointegration methods. For example, this approach may be applicable irrespective of whether underlying variables are purely *I(0)*, *I(1)* or mutually co-integrated (Pesaran and Shin, 1999). The bounds testing approach also provides better estimates for small sample data (Haug, 2002). The model's estimation is even possible if the explanatory variables are endogenous (Pesaran and Shin, 1999; Pesaran et al., 2001). The empirical equation of the ARDL model is given by

$$\begin{aligned}\Delta E_t &= \psi_0 + \psi_1 \sum_{i=1}^{p} \Delta E_{t-1} + \psi_2 \sum_{i=1}^{p} \Delta Y_{t-1} + \psi_3 \sum_{i=1}^{p} \Delta EX_{t-1} + \psi_4 \sum_{i=1}^{p} \Delta IM_{t-1} \\ &\quad + \gamma_1 E_{t-1} + \gamma_2 Y_{t-1} + \gamma_3 EX_{t-1} + \gamma_4 IM_{t-1} + \mu_i \end{aligned} \tag{2}$$

where ψ_0 is constant. μ_i is a white noise error term. The error-correction dynamics is captured by the elements associated with the summation symbols. The second part of the equation corresponds to long-run relationships between system variables. The Schwarz Bayesian Criteria (*SBC*) is used to identify the optimal numbers of lags. In the ARDL framework, we first estimate the *F* statistic value by fitting the appropriate ARDL models to the data. Then, the Wald test is used to investigate the long-run relationship among the variables. The null hypothesis of no cointegration is rejected if the calculated *F*-test statistic exceeds the upper critical bound. The results are said to be inconclusive if the *F*-statistic falls between the upper and lower critical bound. Lastly, the null hypothesis of no cointegration cannot be rejected if the *F*-statistic is below the lower critical bound. If the long-run relationship between energy consumption and trade performance is found, then we estimate the long-run coefficients using the following model:

$$\Delta E_t = \alpha_0 + \alpha_1 E_{t-1} + \alpha_2 Y_{t-1} + \alpha_3 EX_{t-1} + \alpha_4 IM_{t-1} + \mu_i \quad (3)$$

An error-correction model can be then derived to allow the simultaneous estimation of both short and long run dynamic adjustment such as:

$$\Delta E_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta E_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta Y_{t-1} + \sum_{i=1}^{p} \beta_3 \Delta EX_{t-1} + \sum_{i=1}^{p} \beta_4 \Delta IM_{t-1} + \eta ECT_{t-1} + \mu_i \quad (4)$$

The error-correction model thus permits the convergence of energy consumption towards its long-run equilibrium with other variables in the system following a short-run shock. μ_i is the coefficient of error-correction term (ECT_{t-1}) which measures the speed of adjustment towards the long-run steady state.

The Johansen and Juselius (1990) cointegration technique (J-J) is also used to analyze the existence of the long-run relationship between energy consumption and trade performance in Pakistan. The J-J cointegration test is based on $\lambda_{\max}$ and λ_{trace} statistics. The first is the maximum eigen value test. It denotes the estimated eigen values as λ_i^*, i = 1, 2…., n, the maximum eigenvalue test is given by

$$\lambda_{\max} = -T \log(1 - \lambda_{r+1}^*) \quad (5)$$

where the appropriate null hypothesis is r = g cointegrating vectors against the alternative hypothesis that r ≤ g + 1.

The second is the trace statistics and is computed as following:

$$\lambda_{trace} = -\sum_{i=r+1}^{n} T \log(1-\lambda_i^*) \quad (6)$$

Where the null hypothesis is r = g against the alternative hypothesis r ≤ g. The null hypothesis of the Johansen and Juselius (1990) cointegration test states that there is no long-run cointegration among the variables.

It is however worth noting that in existing literature, some conflicting evidence has been observed between the J-J cointegration test and the ARDL cointegration approach. Researchers often argue that these cointegration approaches fail to provide any information about the structural breaks in the underlying dynamics of the variables under consideration, which may thus generate doubtful results about the long-run relationships. For this reason, to ascertain the results of long run relationship between energy consumption and trade performance, we also use the Gregory and Hansen (1996)'s cointegration approach to account for the potential of structural breaks.

Furthermore, we use four different estimation methods to estimate the long-run coefficients and to analyze the stability of model in order to check the robustness of long-run relationship between energy consumption and trade performance in Pakistan. Specifically, we rely our discussion on: *i*) the ARDL-based estimation method; *ii*) the fully modified ordinary least squares method *(FMOLS*) method; *iii*) the dynamic ordinary least squares (*DOLS*) method; and *iv*) the rolling window analysis procedure. To complement these estimation methods, we use the variance decomposition method which allows us to evaluate the magnitude of the predicted error variance for a given variable which is accounted for by innovations from each of the independent variables over different time horizons (Wong, 2010; Raza and Jawaid, 2013). This modeling ensures the accuracy and reliability of our conclusions regarding the causal relationship between energy consumption and trade. The variance decomposition method thus outperforms the commonly-used causality tests in the sense that the latter are unable to assess the strength of the causal relations.

4. Results and Discussions

4.1 Short-run and long-run interactions

As a preliminary analysis, we first examine the stationarity of the variables in our study by using the Augmented Dickey Fuller (*ADF*) and Phillip Perron (*PP*) unit root tests. Table 2 reports the results of these tests applied to the level of variables and their first differences. We see that the null hypothesis of no unit root cannot be rejected at conventional levels for energy consumption (E_t), GDP (Y_t), exports (EX_t), and imports (IM_t) when they are expresses in levels, regardless of the tests used. All the variables are found to be stationary in their first differences. The variables in level are thus suitable for the analysis of cointegration.

[Please insert Table 2 here]

Since the ADF and PP unit root tests neglect the possibility that time series may be exposed to structural change over time, we also perform the Zivot and Andrews (1992) test which accommodates for structural breaks. Table 3 shows the obtained results. As it can be seen, all the variables under consideration are $I(1)$ or nonstationary in level (with intercept and trend), but they are found to be stationary in their first differences. These findings from the Zivot-Andrews test thus confirm those we obtained from the ADF and PP unit root tests.

[Please insert Table 3 here]

Based on the results of the unit root tests, the Autoregressive Distributed Lag (ARDL) method for cointegration can be now used to estimate the long-run relationship between energy consumption and trade. In the first step, we use the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) to determine the optimal lag length of the variables in the system. In the second step, the F-test is employed to test for cointegration. Table 4 reports the results of the lag selection and the ARDL bounds testing approach to cointegration. We see that the null hypothesis of no cointegration is rejected because the estimated *F*-statistic is greater than the upper bound critical at the 1% level of significance. This result suggests the presence of a long-run relationship between energy consumption and trade performance in Pakistan.

[Please insert Table 4 here]

The Johansen and Juselius (1990) cointegration approach is also used to test for the long-run relationship. Table 5 shows the calculated as well as the critical values of Trace statistics and Maximum Eigen value statistics of Johansen-Juselius test. The results indicate the rejection of null hypothesis of no cointegration at the 5% level in favor of the alternative hypothesis that there is one cointegrating vector. This finding thus confirms the existence of a long-run relationship between energy consumption and trade performance in Pakistan, which was found by the ARDL bounds testing approach to cointegration.

[Please insert Table 5 here]

To the extent that the ARDL bounds testing approach and the Johansen and Juselius (1990) cointegration test may not be relevant in case where considered variables experience unexpected structural breaks, we finally test for cointegration by using the Gregory and Hansen (1996) cointegration approach which accounts for structural breaks. The results of the Gregory and Hansen (1996), shown in Table 6, are not different from those provided by the previous approaches.

[Please insert Table 6 here]

Overall, our results consistently point to the existence of a cointegration relationship between energy consumption and trade performance in Pakistan. The ARDL model can be straightforwardly estimated in order to evaluate the short-run and long-run dynamic adjustments of energy consumption to changes in trade performance. Table 7 shows the estimation results of the long-run dynamics from the ARDL model. They suggest that all the three independent variables (GDP, exports, and imports) drive up energy consumption in Pakistan as their associated coefficients are positive and highly significant at the 1% level. Specifically, economic growth is found to be the main determinant of energy consumption as energy consumption has to rise about 0.6% in order to support a 1% increase in GDP. As to trade activity, a 1% increase in exports causes energy consumption to increase by 0.283%. On the other side, a 1% increase in imports requires 0.237% increase in energy consumption. For instance, Shahbaz et al. (2013) and Shahbaz et al. (2014) find evidence of the neutral effect between exports and neural gas consumption and, trade-led energy hypothesis in case of Pakistan. We note that both studies present ambiguous findings. For example, Shahbaz et al., (2013) used natural gas consumption as proxy for energy consumption and exports as an indicator of trade. So, the use of natural gas consumption is unable to capture the effect of energy consumption and exports just represent the exports capacity rather than trade. Shahbaz et al. (2014) used bivariate model to examine the relationship between trade and energy consumption. Their findings suffer from misspecification problem. It is argued by Stern (2004) exclusion of relevant variables affect growth-energy nexus. This shows that our findings are more efficient and reliable covering issues of misspecification and exclusion of relevant variables impacting both economic growth and energy consumption.

[Please insert Table 7 here]

Table 8 shows the short-run relationship between energy consumption and trade performance. We see that the lagged error-correction term is negative and statistically significant, which typically indicates the stability of the model and gradual adjustment of energy consumption towards its equilibrium with GDP and trade variables. The error-correction term value is -0.122 shows that about 12 % of the disequilibrium is corrected each year. The empirical results also uncover the positive and significant impact of GDP, exports and imports on energy consumption in the short run.

[Please insert Table 8 here]

4.2 Sensitivity analysis of the long-run interactions

To check the robustness of initial results of the long-run relationships that we detect from using the ARDL model, we conduct two sensitivity analyses relying on the use of two other alternative estimation approaches: the Dynamic Ordinary Least Squares (*DOLS*) developed by Stock and Watson (1993) and the Fully Modified Ordinary Least Squares (*FMOLS*) developed by Philips and Hansen (1990). The *DOLS* estimation technique involves regressing the dependent variable on the levels, leads and lags of the explanatory variable. It particularly resolves the issues of small sample bias, endogeneity and serial correlation problems through the presence of the leads or lags of explanatory variable (Stock and Watson, 1993). On the other hand, the *FMOLS* provides the optimal estimates of the cointegration equation, while controlling for the problems of serial correlation and endogeneity in the regressors which may result from the existence of a cointegrating relationship (Philips and Hansen, 1990).

[Please insert Table 9 here]

Table 9 reports the obtained results. Regarding the *DOLS* estimation, we estimate our empirical model by taking a lead and a lag of 2. The corresponding results confirm that the coefficients associated with the explanatory variables (growth, import, and exports) remain globally the same as compared with those we obtained from the ARDL approach in terms of both sign and magnitude. Similar results are found when the *FMOLS* estimation method is used since the estimated coefficients are also positive and highly significant. These findings therefore suggest that our initial ARDL-based results are robust to potential statistical biases.

4.3 Stability of the short- and long-run interactions: rolling window analysis

Another question that can emerge is whether the estimated long-run relationship is stable over time. For this purpose, we check the stability of the coefficients governing the long-run relationship by using the rolling window estimation method with the window size of 10 years. Figures 1-2-3 (see appendices) and Table 10 report the evolution of the coefficients associated with GDP, exports and imports throughout the sample.

[Please insert Table 10 here]

Our rolling-window results indicate that the coefficient related to GDP is positive throughout the sample, except for the years from 1994 to 1998. This coefficient has some high values between 1998 and 1990, and is continuously increasing from 2006. The coefficient related to exports is also positive throughout the sample, except for the years from 1984 to 1986. Alternative positive and negative values are found for the coefficient related to imports, with however a dominant of positive values. We also evaluate the stability of short-run coefficients in the ARDL model by using the cumulative sum (CUSUM) and the CUSUM of squares tests on the recursive residuals. The CUSUM test detects systematic changes from the regression coefficients, while the CUSUM of squares test enables the detection of sudden changes that may affect the constancy of regression coefficients (Brown et al., 1975). Figures 4-5 in appendices show the results of the CUSUM and the CUSUM of squares tests, respectively. The fact that the statistics of both CUSUM and CUSUM of squares tests are bounded within the 95% confidence interval bands suggests no structural instability in the residuals of equation characterizing the dynamics of energy consumption with respect to GDP, exports, and imports.

4.4 Strength of the causal relationships

Generalized forecast error variance decomposition under the Vector Autoregressive (VAR) framework is finally used to analyze the strength of the causal relationship between energy consumption and trade. This method provides the size of the predicted error variance of a time series (dependent variable) which is attributed to innovations from each of the independent variable in the VAR model over different time horizons. Wong (2010), and Raza and Jawaid (2013) have used this approach to examine the causal relationship among considered variables. Table 11 reports the results of the variance decomposition for 10 periods ahead. The results show that at period 1 the change in energy consumption is explained fully by its own innovations. The proportion of forecast error variance for energy consumption which is explained by the other variables increases from period 2 to period 10. For example, at period 2, 82.88% of the predicted error variance for energy consumption is explained by its own innovation, 11.83% by the innovation of GDP, 2.77% by the innovation of exports and 2.53% by the innovation of imports. At period 10, these decompositions are respectively 22.76%, 31.46%, 23.46%, and 22.33%.

[Please insert Table 11 here]

On the other hand, the forecast error variance of GDP, exports, and imports is also increasingly explained by the shocks affecting energy consumption, since the period 1. We also note the determinant role of changes in energy consumption in explaining the variations in GDP. For instance, at periods 1, 5 and 5, shocks to energy consumption account for 29.88%, 37.40%, and 36.31% of the forecast error variance of GDP. These proportions are respectively 0.19%, 10.66%, and 18.15% for exports, while they are respectively 9.56%, 15.58% and 23.56% for imports. Taken together, these findings confirm our previous results in that there exists the bidirectional causal relationship between energy consumption, on the one hand, and economic growth, exports and imports, on the other hand in Pakistan. They thus support the presence of the feedback hypothesis, which implies that energy conservation policies will reduce trade performance which then leads to lower economic growth.

5. Concluding Remarks

We investigated the relationship between energy consumption and trade performance in Pakistan by using the annual data over the period 1973-2011, while controlling for the effect of economic growth. The ARDL bounds testing approach to cointegration, Johansen and Juselius (1990) cointegration test, and the Gregory and Hansen (1996) cointegration approach which is robust to the presence of structural breaks show evidence of a positive and significant long-run relation between energy consumption and trade. This relationship remains intact in terms of both sign and magnitude when other commonly-used estimation methods are used, but seems to change over time in views of our rolling window analysis. Note also that the same positive and significant relationship between the variables of interest is found in the short-run and that there is no structural instability in the residuals of the equation governing the dynamics of energy consumption. Finally, the results from the VAR-based generalized forecast error variance decomposition point to the existence of the bidirectional causal relationship between energy consumption and economic growth, exports and imports in Pakistan.

Given the context of the post-global financial crisis and the economic problems facing Pakistan (high public debt, unemployment, high inflation, low savings, low investments and income inequality), this country has to stimulate economic growth and to increase international trade. In favor of this argument, the evidence of bidirectional causal relationship between energy consumption and economic growth, exports and imports can have important policy implications. The verification of the feedback hypothesis specifically implies that energy conservation policies will lead to decrease in trade performance and subsequently economic growth in Pakistan. Thus, any energy or environment policy aiming at reducing energy consumption should be designed to do this through energy-intensity reduction to avoid output and trade declines. Policymakers should have interest to make export promotion and economic growth related policies, given their bidirectional positive causal relationship with energy consumption. It means that policies for economic growth and trade expansion may not be successful if energy consumption considerations are ignored because energy shortages and supply interruptions can reduce the expected results.

On the other hand, in order to avoid the worldwide pressure about reducing CO_2 emissions, which constitute the main source of global warming, Pakistan should rapidly invest in energy infrastructure and particularly energy produced from renewable sources such as hydroelectricity, wind power, hydropower, solar, and bio-fuel. A dual strategy of investment by investing in electricity infrastructure and by stepping up electricity conservation policies could be implemented since it prevents the adverse effects on economic growth if electricity consumption is reduced.

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Table 1: Trend of gross domestic product (GDP), exports, imports and energy consumption in Pakistan

Time Period	GDP		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 2: Results of unit root tests

Variables	ADF Test				P-P Test			
	Level		First differences		Level		First differences	
	C	C&T	C	C&T	C	C&T	C	C&T
E_t	1.21	-2.72	-5.25*	-5.41*	1.06	-2.72	-5.32*	-5.42*
Y_t	1.95	-0.95	-3.99*	-3.86**	-2.04	-0.72	-3.91*	-3.88**
EX_t	-1.46	1.88	-3.75*	-3.57***	-1.62	-2.49	-4.09*	-3.99**
IM_t	1.33	-0.38	-5.67*	-6.15*	1.47	-0.34	-5.76*	-6.16*

Notes: The critical values for ADF and PP tests with constant (c) and with constant & trend (C&T) at the 1%, 5% and 10% levels of significance are -3.711, -2.981, -2.629 and -4.394, -3.612, -3.243 respectively. *, **, and *** indicate rejection of the null hypothesis of the presence of unit root at the 1%, 5%, and 10%, respectively.

Table 3: Zivot-Andrews trended unit root test in the presence of structural break

Variable	Level		First differences	
	T-statistics	Time break	T-statistics	Time break
E_t	-2.402 (1)	1992	-6.245 (1)*	2004
Y_t	-3.188 (1)	1987	-5.862 (1)*	2004
EX_t	-2.897 (1)	1997	-5.809 (2)**	1982
IM_t	-3.001 (1)	1998	-6.432 (1)**	2003

Notes: The optimal lag order is shown in parenthesis. * and ** represents the significance at the 1% and 5% levels.

Table 4: Lag Length Selection & Bound Testing for Cointegration

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

Note: * indicates significance at the 1% level.

Table 5: Johansen and Juselius (1990) cointegration test

Null hypothesis No. of CS(s)	Trace statistics	5% critical values	Max. Eigenvalue 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

Note: * indicates significance at 1% level.

Table 6: Gregory-Hansen cointegration test

ADF test	
Structural break	1993
T-statistics	-4.869
P-value	0.000
Phillips-Perron test	
Structural break	1993
T-statistics	-4.954
P-value	0.000

Table 7: Long-run dynamics using the ARDL approach

Variables	Coefficients	T-stats	Prob.
Constant	-0.097	-0.752	0.460
E_{t-1}	0.569*	5.355	0.000
Y_t	0.584*	4.073	0.000
Y_{t-1}	-0.223	-1.430	0.163
EX_t	0.283*	2.783	0.009
EX_{t-1}	-0.222	-0.759	0.454
IM_t	0.237*	3.060	0.005
IM_{t-1}	-0.131	-1.615	0.117
Adj. R^2	0.971		
D.W stats	2.161		
F-stats (Prob.)	6347.086 (0.000)		

Notes: * indicates that the coefficient is significant at the 1% level.

Table 8: Short-run dynamics using the ARDL approach

Variables	Coefficients	T-stats	Prob.
Constant	-0.011	-0.309	0.760
ΔE_{t-1}	0.248*	4.576	0.000
ΔY_t	0.316*	4.032	0.000
ΔY_{t-1}	-0.233	-1.592	0.123
ΔEX_t	0.080**	2.571	0.016
ΔEX_{t-1}	-0.021	-0.681	0.501
ΔIM_t	0.067**	2.233	0.034
ΔIM_{t-1}	-0.029	-1.422	0.166
ΔIM_{t-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)		

Notes: * and ** indicate that the coefficient is significant at the 1% and 5% levels.

Table 9: Robustness check for the stability of long-run interactions

Variables	*FMOLS*			*DOLS*		
	Coefficients	T-stats	Prob.	Coefficients	T-stats	Prob.
Constant	0.061	1.222	0.230	0.089	1.621	0.119
Y_t	0.544*	13.044	0.000	0.579*	10.710	0.000
EX_t	0.255*	5.177	0.000	0.265*	4.559	0.000
IM_t	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		

Table 10: Stability of the long-run coefficients

Year	Y_t	EX_t	IM_t
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

Table 11: Results of the variance decomposition approach

Period	E_t	Y_t	EX_t	IM_t
Variance Decomposition of E_t				
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 Y_t				
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 EX_t				
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 IM_t				
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

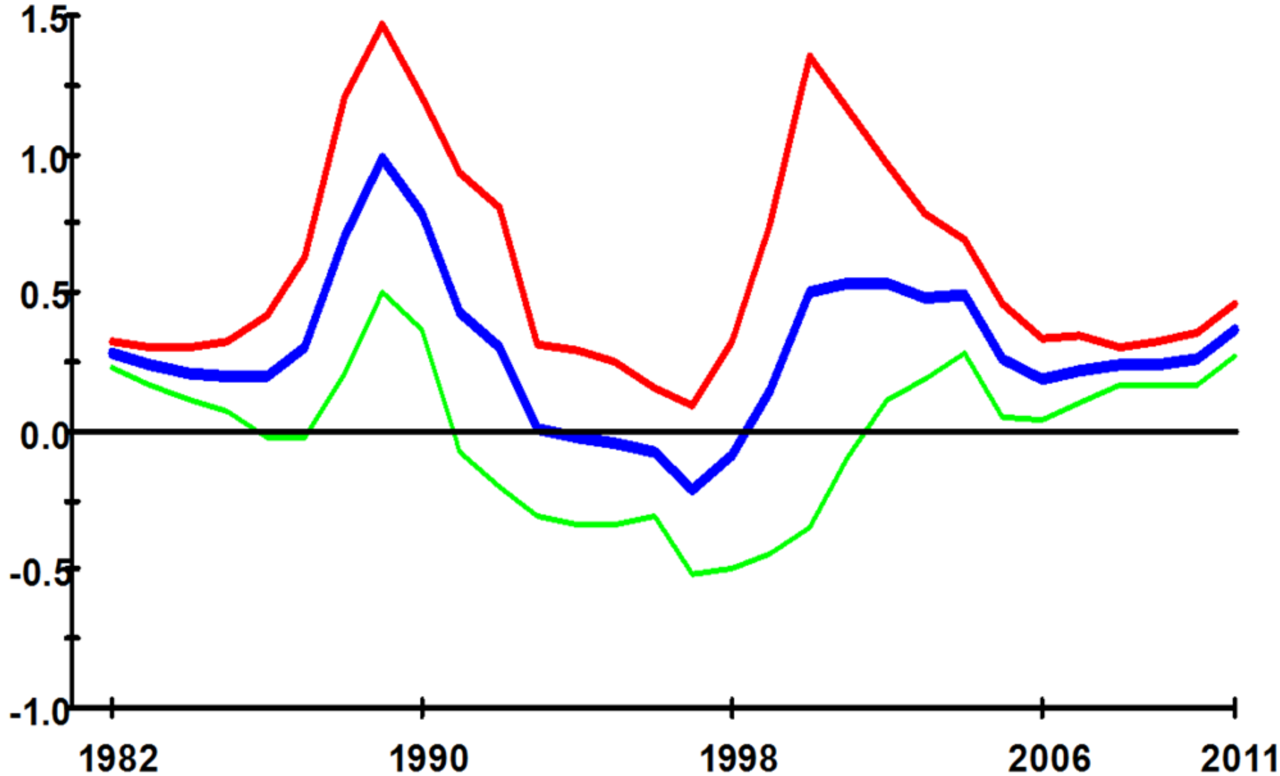

Figure 1. Coefficient of GDP and its two S.E. bands based on rolling OLS (Dependent Variable: ENC)

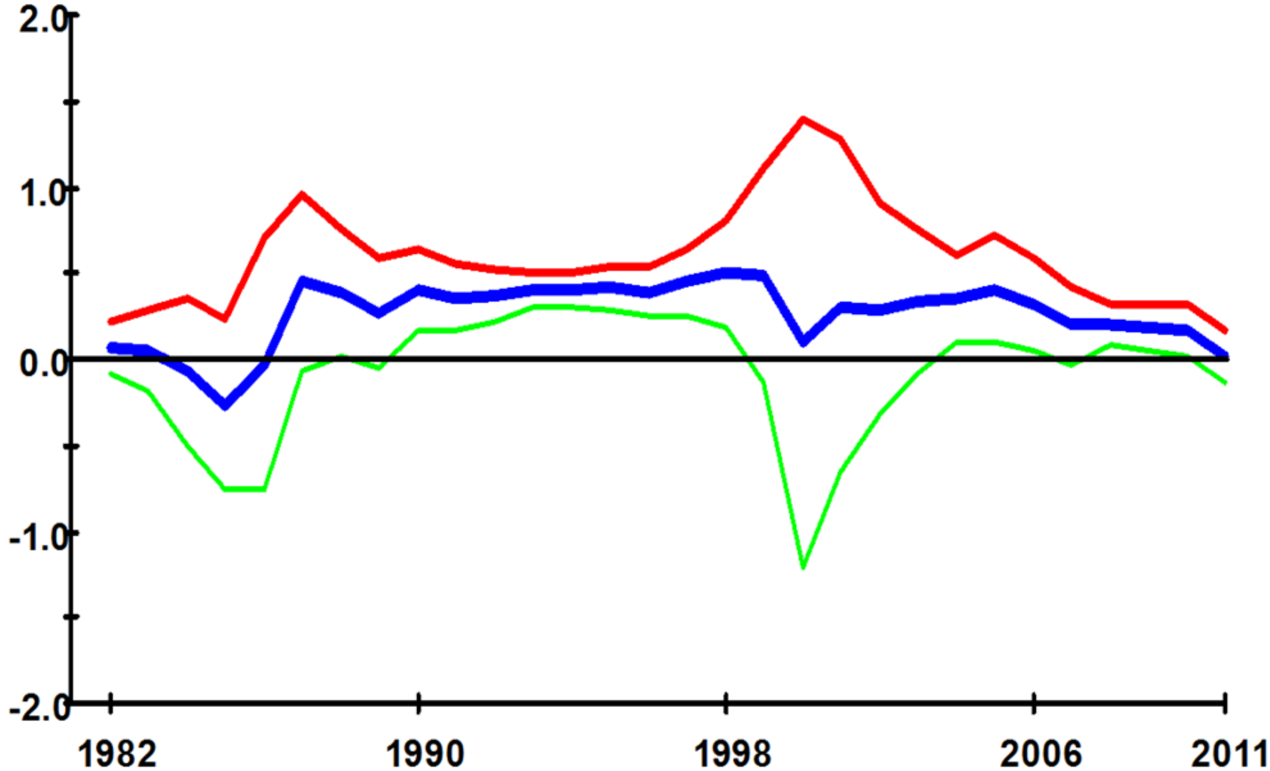

Figure 2. Coefficient of EXP and its two S.E. bands based on rolling OLS (Dependent Variable: ENC)

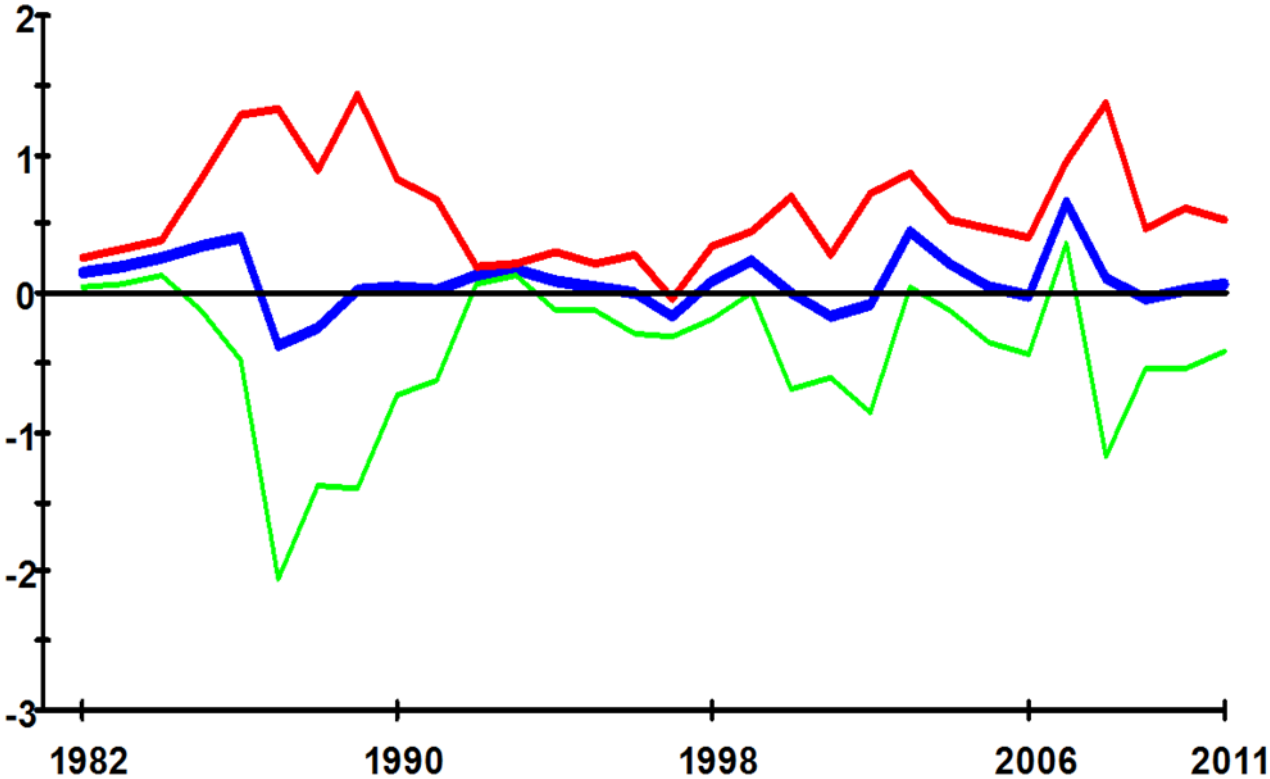

Figure 3. Coefficient of IMP and its two S.E. bands based on rolling OLS (Dependent Variable: ENC)

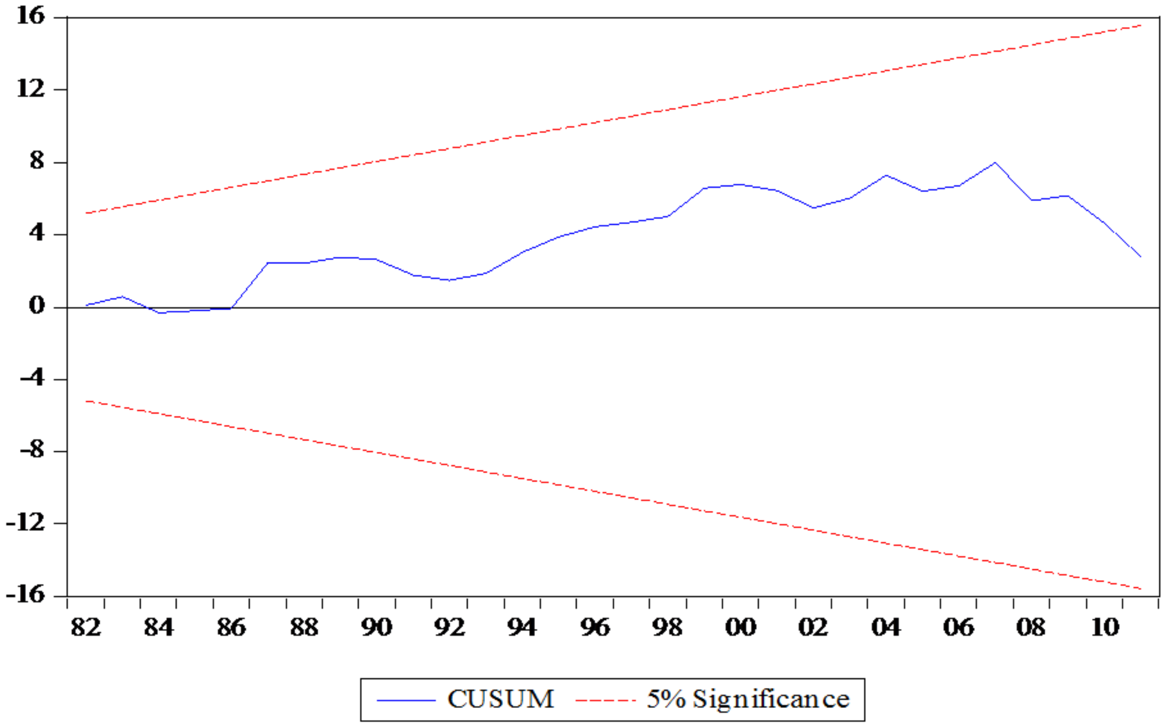

Figure 4. Plot of cumulative sum of recursive residuals. The straight lines represent critical bounds at 5% significance level

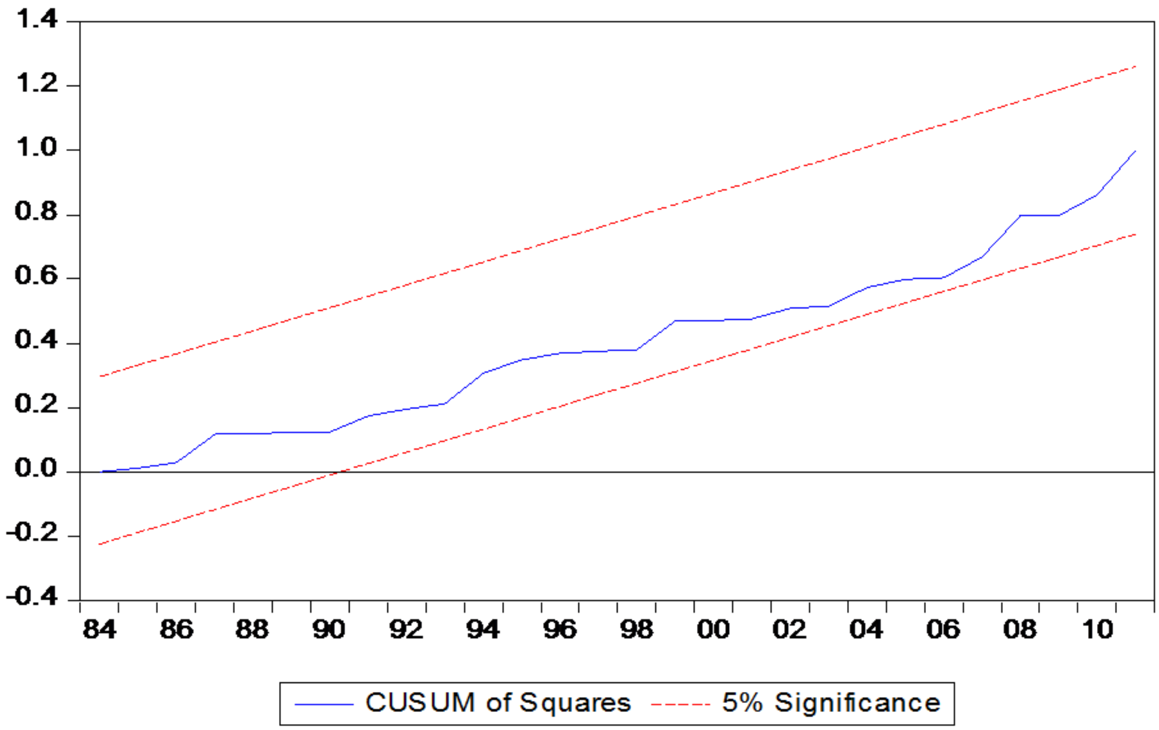

Figure 5. Plot of cumulative sum of squares of recursive residuals. The straight lines represent critical bounds at 5% significance level