



ADDIS ABABA UNIVERSITY  
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ANALYSIS OF THE DETERMINANTS OF ETHIOPIAN TRADE  
BALANCE:AN ARDL APPROACH

BY

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ANALYSIS OF THE DETERMINANTS OF ETHIOPIAN  
TRADE BALANCE: AN ARDL APPROACH

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## ***Abstract***

*Variables that determine the situation of a given economy could have short or long-run relationships. This study investigates the short and long-run relationships between the trade balance, real gross domestic product, real effective exchange rate, and inflation rate in the case of Ethiopian economy. The bounds testing approach to co-integration and error-correction models, developed within an autoregressive distributed lag(ARDL) framework is applied to quarterly data for the period 1993 to 2015 in order to investigate whether a long-run equilibrium relationship exists between the trade balance and the variables indicated above. The result indicates that in the long-run one per cent increase in real effective exchange rate increases trade balance by about 0.19 percent. Additionally, variance decompositions (VDCs) and impulse response functions (IRFs) are used to draw further inferences. Under Johansen co-integration approach the error correction model (ECM) shows both the short-run and long-run relationship among the indicated macroeconomic variables (real effective exchange rate, real gross domestic product and inflation). The coefficient of the error correction term indicates that 75.7% of shock (short-run disequilibria) will be adjusted within the same year, but under bound test of co-integration nearly 80 % of the previous quarter's shock adjusts back to long-run equilibrium in the current quarter.*

***Keywords:*** Trade Balance, Error Correction Model, Bound Test, Co-Integration

## ***List of Acronyms***

<i>ADF-test</i>	<i>Augmented Dickey Fuller test</i>
<i>ARDL</i>	<i>Autoregressive Distributed lag</i>
<i>CE</i>	<i>Co-integration Equation</i>
<i>CSA</i>	<i>Central Statistical Agency</i>
<i>ECM</i>	<i>Error Correction Model</i>
<i>ECT</i>	<i>Error Correction Term</i>
<i>INF</i>	<i>Inflation Rate</i>
<i>IRFS</i>	<i>Impulse Response Function</i>
<i>LREER</i>	<i>Logarithm of Real Effective Exchange Rate</i>
<i>LRGDP</i>	<i>Logarithm of Real Gross Domestic Product</i>
<i>LM-test</i>	<i>Lagrange Multiplier Test</i>
<i>LTB</i>	<i>Logarithm of Trade Balance</i>
<i>NBE</i>	<i>National Bank of Ethiopia</i>
<i>NX</i>	<i>Net export</i>
<i>PP-test</i>	<i>Philips -Perron test</i>
<i>REER</i>	<i>Real Effective Exchange Rate</i>
<i>RGDP</i>	<i>Real Gross Domestic Product</i>
<i>TB</i>	<i>Trade Balance</i>
<i>VAR</i>	<i>Vector Autoregression</i>
<i>VDC</i>	<i>Variance Decomposition Factor</i>
<i>VECM</i>	<i>Vector Error Correction Model</i>

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# **1. INTRODUCTION**

## **1.1 Background of the Study**

Trade is sensitive to changes in macroeconomic policies of a country because it increases expenditures on imports, diverts resources and affects financial markets through capital flows. Trade, in general connotation, means the purchase and sales of commodities. In International trade, purchases and sales are replaced by imports and exports.

Similarly, balance of trade plays a vital role in national income accounting of a country. Balance of trade is simply the difference between the value of exports and value of imports. Thus, trade Balance denotes the differences of imports and exports of a merchandise of a country during the course of year. It indicates the value of exports and imports of the country in question. If the value of its exports over a period exceeds its value of imports, it is called favorable balance of trade and, conversely, if the value of total imports exceeds the total value of exports over a period, it is unfavorable balance of trade. Favorable balance of trade indicates good economic condition of the country.

The balance of trade is the difference between the monetary value of exports and imports in an economy over a certain period of time or simply the difference between what goods a country produces and how many goods it buys from abroad. The difference can take the form of a deficit if imports overweigh exports or trade surplus if exports are more than imports or equivalent when the values of exports and imports are equal. The concept of trade deficit and surplus is known since the sixteenth century, but economists have debated its significance without agreement. A trade deficit occurs when, during a certain period, a nation imports more goods and services than it exports. A trade surplus occurs when a nation exports more goods and services than it imports. A positive balance is known as a trade surplus if it consists of exporting more than is imported; a negative balance is referred to as a trade deficit or, informally, a trade gap. As a result they are divided between those who are for and against trade surplus and trade deficits. Those who believe that trade deficits are harmful, have often interpreted it as a sign of a country's economic weakness and a source of increased and excessive foreign dependence, which is at the expense of domestic production and jobs. It also represents a sacrifice of future growth because the country purchases more than it produces, and investment in future growth is being traded for consumption in the present. Large trade deficits also create an environment

conducive to hyper financial crises that could damage the economy. Deficits are only good for transitional economies, and they are a sign of strength if they are accompanied by rising domestic investment and/or rising government expenditures on infrastructure. Global trade trends and policies have great influence on international trade, economic activity and growth. The aim of trade policies is to stimulate domestic output, protection to domestic industries, consumer protection and promotion of export etc.

Trade deficits are linked to economic development due to imports of capital goods, raw materials, intermediate products among others. Therefore, trade deficits cannot be condemned wholly and even the economic theory dictates that a trade deficit is not purely bad as it will correct itself over time (Kennedy, 2013).

Ethiopia introduced various economic policies to enhance the balance of trade and boost the economic activity and development which included tariff structure, exchange rate policy, import control, export taxation, foreign exchange allocation system etc.

According to the National Bank of Ethiopia, the country recorded a trade deficit of 3413.10 USD million in the second quarter of 2015. Balance of trade in Ethiopia averaged 1922.54 USD million between 2006 and 2015. Assessing the relationship between balance of trade and other economic variables such as real gross domestic product, real effective exchange rate and inflation rate has attracted the attention of many scholars (Petrović and Mirjana Gligorić (2010), Tihomir Stučka (2004), Wilson (2001), Bahmani-Oskoose (2001)), elsewhere in the world.

## **1.2 Statement of the Problem**

Trade balance is one of the most important macroeconomic variables that are used to understand the progress of a given economy. Therefore, policy makers are usually interested in the direction of trade balance, that is, whether there is deficit or surplus. In addition, there is a need for identifying the relationship between the balance of trade and other macroeconomic variables such as real gross product, real effective exchange rate and inflation rate.

Despite the fact that, in theory, nominal depreciation or appreciation of exchange rate is assumed to change the real effective exchange rate and thus has a direct effect on trade balance (Himarios, 1989; Bahmani-Oskooee 2001), various studies have found weak statistical evidence connecting exchange rate change and trade balance (Greenwood, 1984; Mahdavi and Soharabia, 1993; Rahaman and Mustata, 1996; Rahman et.al,1997). Empirical evidence also shows that change in real effective exchange rate has affected trade balances in some economies which implies that the direction of the impact of real effective exchange rate changes on trade balance of a given economy is still unclear. In light of the above it is important to know the effect of macroeconomic variables on Ethiopian trade balance. However, there are very few research findings which deal with the issue of the effect of the above macro-economic variables on Ethiopian trade balance. There is also not enough evidence that supports whether real gross domestic product and inflation rate affects Ethiopian trade balance.

More specifically, there is not enough empirical evidence that have been made to incorporate the theoretical views of trade balance in relation to real effective exchange rate, inflation rate and real gross domestic product. This study focused on the effect of real effective exchange rate, real gross domestic product and inflation rate on the balance of trade of Ethiopia

## **1.3 Objective of the study**

### **1.3.1 General Objective**

The general objective of this study is to assess short and long run relationships between trade balance and real effective exchange rate, real gross domestic product, as well as inflation rate using Co- integration and Error Correction Model with in Autoregressive Distributive Lag approach.

### **1.3.2 Specific Objectives**

The specific objectives of the study are:

- To see the properties of Autoregressive Distributive Lag model approach to co-integrated and Error Correction Model.
- To determine the empirical relationship between trade balance and its selected macro-economic variables under long and short run relations.
- To identify the effect of real effective exchange rate, real gross domestic product and inflation rate on Ethiopian trade balance.
- To assess the direction, magnitude and persistence of the trade balance in relation to variation in policy variables such as real gross domestic product, real effective exchange rate and inflation rate.

## **1.4. Significance of the Study**

There are limited empirical evidences which have examined trade balance in relation to inflation rate, real gross domestic product (RGDP) and real effective exchange rate (REER) in the case of Ethiopia. Therefore, the importance of the study lies in exploring the understandings of trade balance with inflation rate, real gross domestic product (RGDP) and real effective exchange rate (REER) empirically. Specifically:-

- ✓ The empirical evidence helps to explore the effect of real effective exchange rate on trade balance in Ethiopia
- ✓ The result of the analysis of the relationship between trade balance and its determinants could be used for policy decisions.
- ✓ The study could be used by policy makers, researchers and other end users as a source of information for further investigation and understand the relationship between trade balance and its determinants.

## **2. Literature Review**

### **2.1. The Relationship between Trade Balance and its Determinants**

Numerous studies have been conducted on the issue of factors determining trade balance, both taking itself as a subject of study or by breaking down to its components, namely import and export. Alternative theories have different predictions about the factors underlying balance of trade dynamics and about the sign and magnitude of the relationship between trade balance fluctuations and the determinants. The study of the determinants of trade balance was conducted theoretically and empirically by many scholars. In this section few of them are comprehensively summarized.

#### **2.1.1 Theoretical Literature**

Theoretically, the conventional view of the balance of payment says that a nominal devaluation of currency improves trade balance. This view is rooted in a static and partial equilibrium approach to the balance of payments that is well known as elasticity approach (Bickerdike, 1920; Robinson, 1947 Metzler, 1948). The essence of this view is the substitution effects in consumption and production induced by the relative price (domestic versus foreign) changes caused by a devaluation. The model, which is commonly known as BRM model, has been recognized in literature as providing a sufficient condition. In particular, the Marshall-Lerner condition states that for a positive effect of devaluation on the trade balance, and implicitly for a stable exchange market, the absolute values of the sum of the demand elasticities for exports and imports must exceed unity. Holding the Marshall-Lerner condition, when the exchange rate is above the equilibrium there is excess supply for foreign exchange and when the exchange rate is below the equilibrium there is excess demand of foreign exchange. The BRM and Marshall-Lerner conditions have become the underlying assumptions for those who support devaluation as a means to stabilize the foreign exchange market and to improve the trade balance.

#### **2.1.2. Empirical Literatures**

There are many studies on the impact of exchange rate on trade balance for developing countries which come to various conclusions.

Rose (1991) paper examined the empirical relation between real effective exchange rate and trade balance of major five OECD countries in the post-Bretton Woods era. Rose's study depicts

the exchange rate as insignificant determinant of balance of trade. Rose and Yellen (1989) could not reject the hypothesis that the real exchange rate was statistically insignificant determinant of trade flows. They examined the bilateral trade flows between the United States and other OECD countries using quarterly data.

Upadhyaya and Dhakal (1997), applying the methodology proposed by Wickens and Breusch (1988), test the effectiveness of devaluation on the trade balance for eight developing countries. The researchers find that devaluation improves the trade balance in the long-run only in Mexican economy.

Bahmani-Oskosee (2001) investigate the long-run response of Middle Eastern countries' trade balance to devaluation by applying the Engle-Ganger and Johansen-Juselius co-integration methodology and find a favorable long-run effect of real depreciation on the trade balance for seven countries.

Bahmani-Oskosee and Kanitpong (2001), when testing on disaggregated quarterly data by ARDL co-integration between Thailand and her main five trading partners for period 1973-1990, find evidence of the J-curve in bilateral trade with US and Japan only. Pavle Petrović and Mirjana Gligorić (2010) by using Johansen's procedure, ARDL and corresponding ECM show that exchange rate depreciation in Serbia improves trade balance in the long-run while deteriorate trade balance in the short-run. There are few quantitative studies on this relation in Vietnam. Lord (2002) uses co-integration equation and ECM model to explore the impact of real exchange rate on trade balance of Vietnam from 1990 – 2001. Obtained results indicate that the effect of Vietnam's real effective exchange rate on its international competitiveness and export demand are statistically significant in the global market and a number of regional markets. The long-run real exchange rate elasticity of demand for exports in the global market is equal to  $-1.8$  in the short run and  $-2.0$  in the long run. In the short run, the competitive price elasticity ranges from  $-0.1$  in the ASEAN-5 market to  $-0.3$  in the US market, while in the long run it ranges from  $0.4$  in the US market to  $-1.9$  in the EU market.

Hao (2007), using co-integration theory for quarterly data from 1995(1) to 2005(4), find that real exchange rate has impact on trade balance in the long run. One percent depreciation of real exchange rate causes trade balance to increase by 0.7 percent.

Wilson (2001) examines the relationship between the real trade balance and the exchange rate for bilateral merchandise trade between Singapore, Korea and Malaysia with respect to US and Japan but finds no evidence of a J-curve effect except Korean trade with the United States.

Singh (2002) demonstrates that real exchange rate and domestic income show a significant influence while foreign income shows an insignificant impact on 'trade balance' in Indian economy.

Onafowora's (2003) paper examined the effects of real exchange rate changes on the real trade balance. The study investigated three ASEAN countries, Malaysia, Indonesia and Thailand in their bilateral trade to the US and Japan by employing a co-integrating vector error correction model (VECM). The result indicates a positive long-run relationship between the real exchange rate and the real trade balance in all cases, i.e., Indonesia-Japan (+0.351), Indonesia-US (+0.243), Malaysia-Japan (+1.252), Malaysia-US (+0.644), Thailand-Japan (+1.082), and Thailand-US (+1.665). The estimations for Malaysia-US, Indonesia-US, and Indonesia-Japan indicate that real trade balance has a negative relationship with real domestic income and a positive relationship with real foreign income in the long run. However, the real trade balances in the models for Malaysia-Japan, Thailand-US, and Thailand-Japan depict a different result—a positive relationship with real domestic income and a negative relationship with real foreign income.

Tihomir Stučka (2004), using ARDL co-integration approach for Croatia, finds long-run and short-run relationship between real exchange rate and trade balance and J-curve effect.

Duasa (2007) examined the short and long run relationships between trade balance, inflation rate, real income and exchange rate in the case of Malaysia. The inclusion of income and money variables in the study was purposely to examine the monetary and absorption approach to the balance of payment beside the conventional approach of elasticity, using exchange rate. For this analysis he used time series data from 1974 to 2003. The author has employed bound testing approach to co-integration and error correction model, developed within ARDL framework. The existence of long-run equilibrium relationship between trade balance and its determinants was investigated. The findings suggest that the Marshall-Lerner condition does not hold in long run for Malaysia and a policy direction of Malaysian trade balance should be viewed from absorption and monetary approach.

Mohammad (2010) explores the long run as well as short run determinant of trade deficit with reference to Pakistan by using Johansen co-integration approach and error correction model

(ECM). Time series data from 1975 to 2010 were used for the study. The finding of the study suggests that foreign income, FDI, domestic house hold consumption and real effective exchange rate significantly affect the trade deficit. To highlight the short run dynamics vector error correction model (VECM) was used. The result of VECM pointed out that there is disequilibrium in the short run.

Waliullah, et al. (2010) examine the determinants of trade balance in Pakistan by applying ARDL co- integration approach using annual data for the period 1979 to 2005. They investigate whether along run equilibrium relationship exists between trade balance and its determinants. Additionally, variance decompositions (VDCs) and impulse response functions (IRFs) were used to draw further inferences. The result of the bounds test indicates that there is a stable long-run relationship between the trade balance and income, money supply, and exchange rate variables. The estimated results show that exchange rate depreciation is positively related to the trade balance in the long and short run, consistent with the Marshall Lerner condition. The results provide strong evidence that money supply and income play a strong role in determining the behavior of trade balance.

Kennedy (2013) investigates the major determinants of trade balance using annual data for the period 1963-2012 in Kenya. The author explores the long run and short run determinants of trade deficit using Johansen co integration approach and Error correction modeling (ECM). The results of his investigation indicate that the coefficients of trade balance are positively correlated with budget deficits, foreign direct investment (FDI) and exchange rates. The results show that FDI has a positive effect on trade balance because the trade balance in Kenya is negative. The estimation results also show that the real exchange rate depreciations improve the trade balance in a strong and significant way. The author suggested that this can be attributed to a huge negative trade balance and/or a large positive net foreign direct investment position, which is an indication that the trade balance is much less sensitive to movements in the real effective exchange rate.

Moses (2013) focused on the analysis of the main determinants that have an impact on trade balance of Tanzania. Specifically the study focused on the main cause of trade deficit by analyzing the impact of Foreign Direct Investment (FDI), Human Capital Development (HCD), Household Consumption Expenditure (HCEXP), Government Expenditure (GEXP), Inflation (INF), Natural Resources Availability (NRA), Real Exchange Rate (REX) and Foreign Income

(WY) and Trade Liberalization (TLB). The study uses ordinary least squares method (OLS) using data for a period 1980-2012 and the results.

Yibeltal (2011) paper examined the statistical analysis and prediction of the balance of trade using annual data for the period 1974/75-2009/2010 in Ethiopia. The author explores the long run and short run dynamics of trade balance using Error Correction and ARIMA models. The results of his investigation indicate that there exists a long run relationship between balance of trade and the selected macroeconomic variables, that is, balance of trade has negative long run relationship with debt, real effective exchange rate index and real gross domestic product and positive long run relationship with foreign income. The results of his investigation also shows that RGDP has a negative short run impact on the change in balance of trade, but debt, foreign income and real effective exchange rate index do not have short run effect on balance of trade since the coefficients of their first order difference are statistically insignificant at 5 % level of significance.

Borena (2013) investigates the effect of exchange rate movement on trade balance using annual data for the period 1970/71-2010/2011 in Ethiopia. The author explores the long run and short run effects of trade balance using SVAR approaches. The results of his investigation indicate that the coefficients of trade balance are correlated with the dummy variable drought or lack of rainfall, real government expenditure, external terms of trade and real effective exchange rate index. The result shows that the coefficients of all variables are negative, although statistically insignificant; but for REERI, it is positive and statistically significant at a 5 percent level confirming the hypothesis that real depreciation succeeds in improving trade balance of Ethiopia in the long run. The elasticity of real effective exchange rate 0.83 indicates that depreciation of real effective exchange rate by 10 percent would result in about 8.3 percent increase in trade balance per year.

Chalachew (2014) investigates the monetary policy and exchange rate shock on Ethiopian trade balance using quarterly data for the period 1997/98Q1 to 2012/2013 Q4. The author explores the monetary policy and exchange rate effects of trade balance using SVAR approaches. The results of his investigation indicate that the exchange rate appreciation affects the trade balance of Ethiopia by improving it in the short run (up to quarter two) and deteriorates after quarter two. While the effect of expansionary monetary policy is cyclical, it deteriorates up to quarter two, improves from the third to fourth quarter and then deteriorates. The expansionary monetary

policy explains the Ethiopian trade balance fluctuation highly over long periods as compared to exchange rate shock effect.

Gebe (2015) investigates the impact of trade balance using annual data for the period 1979/80-2011/2012 in Ethiopia. The author explores the long run and short run determinants of trade balance using ARDL- co integration approach and Error correction modeling (ECM). The results of his investigation indicate that the coefficients of trade balance are correlated with money supply, income and real exchange rates. The results show that real exchange rate has a positive effect on trade balance in Ethiopia. The estimation results also show that the money supply and economic growth play a strong role in determining the long run behavior of the trade balance as compared to the real exchange rate. This indicates that growth in domestic economy and lowering the relative prices or inflation rates determines the improvement of trade balances as compared to depreciation of exchange rate. The author suggested that the difficulties in trade balance should be corrected through policies of income or economic growth through export oriented goods and services as well as money supply through the change in relative prices or inflation rates of goods and services.

## **2.2. Trade Balance in Ethiopia**

In recent years, it was noted that the value of Ethiopian exports has shown a consistent and a remarkable growth. It was also noted that the imports of the country have shown even more pronounced increase during the same period. Consequently, the trade balance of the country has been showing a growing deficit. The aforementioned deficit in Ethiopia's trade balance can be interpreted in two ways. On a negative note, it can be seen as cause for alarm since such a wide and growing gap between the value of exports and imports of a country means that the country continues to need other sources of financing for its import demand such as foreign aid and credit; and needs the resources at an increasing rate. On a positive note, the fact that the lion's share of the value of imports is taken up by capital goods plus intermediate inputs is in fact an indication of the domestic economy is growing and the productive capacity of the country is expanding at an increasing rate. In any case, the fact still remains that Ethiopia remains what is technically known as an "import compressed" economy - an economy whose growth potential could artificially be limited by its inability to import what it needs for growth due to the gap between the value of exports and the import demand.

The fact that most of the import products of the country are "necessities" such as capital goods and petroleum means that trying to limit imports may not be a viable option to solve the problem of the persistent and widening trade imbalance. Therefore, it is believed that the challenge facing the country is to increase the pace of the growth of exports even more. It is with this understanding that the Government of Ethiopia is very keen to boost exports.

### **3. Data and Methodology**

#### **3.1. Description of the Study Area**

Ethiopia is one of the developing countries located in Eastern Africa. It borders Sudan and South Sudan on the West, Eritrea on the North, Djibouti and Somalia on the East, and Kenya on the South. Its geographical location is  $3^{\circ}$  and  $18^{\circ}$  N latitude, and  $38^{\circ}$  and  $48^{\circ}$  longitude, just north of the equator with a total land-area of about 122.2 million hectares.

The country is divided into eleven administrative regions including two administrative cities. Addis Ababa and Dire-dawa. According to population and housing census conducted by Central Statistical Agency (CSA) (2007), the total population of Ethiopia was about 74 million. In 2015 the total population of Ethiopia is estimated to be 99 million. Ethiopia's economy is mainly based on agriculture, which accounts for 40 % of GDP and 85 % of total employment in 2012. The total trade export earning of Ethiopia was 3.163 billion US dollar and the total trade import was 10.6 billion US dollar. Being largely an agrarian economy, its trade exports are mainly composed of primary commodities and the trade import items are mainly industrial machinery and fuel.

#### **3.2. Data, variable selection and model specification**

The data used in this study are secondary data (quarterly data) obtained from National Bank of Ethiopia (NBE) and Central Statistical Agency (CSA). The variables of the study are trade balance (TB), real gross domestic product (RGDP), inflation rate (INF) and real effective exchange rate (REER). Usually, trade balance is measured by the difference of values of total export and values of total import. However, the ratio of export to import or its inverse has also been used in many empirical investigations of trade balance exchange rate relationship (Bahmain-Oskooee and Brooks (1999), Lol and lowinger (2001) and Onafowora (2003)). Scholars recommended this ratio, because it is not sensitive to the unit of measurement and can be interpreted as nominal or real trade balance (Bahmani-Oskooee, 1991). In this study, trade balance is measured as the ratio of values of total export to values of total import.

### 3.2.1 Description of Variables

**Table 3.1 Description of variables**

Type of Variables	Variable Designation	Variable
Dependent Variable	TB	Trade Balance
Independent Variables	RGDP	Real gross domestic product
	REER	Real effective exchange rate
	INFR	Inflation rate

### 3.2.2 Definition of Variables

**Trade Balance (TB):-**The ratio of total exports to imports over a specific period of time.

**Real gross domestic product (RGDP):-** It is gross domestic product at constant price. In other words, it is a nation's total output of goods and services, adjusted for price changes.

**Real effective exchange rate index (REER):-** It measures weighted average of nominal effective exchange rates against the currencies of principal trading partners, adjusted for relative movements in price or cost indicators against those selected trading partners.

**Inflation rate (INF):-** Is a measurement of the rise in price of a good or service over a period of time reflected as a percentage.

## 3.3 Methodology

### 3.3.1 VAR model

VAR models in economics were made popular by Sims (1980). The definitive technical reference for VAR models is Lutkepohl (1991), and updated surveys of VAR techniques are given in Watson (1994) and Lutkepohl (1999) and Waggoner and Zha (1999). Applications of VAR models to financial data are given in Hamilton (1994), Campbell, Lo and MacKinlay (1997), Cuthbertson (1996), Mills (1999) and Tsay (2001). The vector autoregression (VAR) model is one of the most successful, and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model has proven to be especially useful for

describing the dynamic behavior of economic and financial time series and for forecasting. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. Forecasts from VAR models are quite flexible because they can be made conditional on the potential future paths of specified variables in the model.

The general VAR (p) model has many parameters, and they may be difficult to interpret due to complex interactions and feedback between the variables in the model. As a result, the dynamic properties of a VAR (p) are often summarized using various types of structural analysis. The three main types of structural analysis summaries are 1) Granger causality tests; 2) impulse response functions; and 3) forecast error variance decompositions.

Co-integration in the multivariate analysis is an econometric concept which mimics the existence of a long-run equilibrium among economic time series. If two or more series are themselves nonstationary, but a linear combination of them is stationary, then they are said to be co-integrated (Wei, 2006). We should be concerned about co-integration because it is a possible solution to non-stationarity found in many economic time series, and if time series are non-stationary and co-integrated we use Vector Error Correction Model (VECM) an extension of VAR.

One of the main uses of VAR models is forecasting, structural inference and policy analysis. The structure of the VAR model provides information about variables or group of variables forecasting ability for other variables. The following intuitive notion of a variables forecasting ability is due to Granger (1969). If a variable, or group of variables,  $y_1$  is found to be helpful for predicting another variable, or group of variables,  $y_2$  then  $y_1$  is said to Granger-cause  $y_2$ ; otherwise it is said to fail to Granger-cause  $y_2$ . Formally,  $y_1$  fails to Granger-cause  $y_2$  if for all  $s > 0$  the MSE of a forecast of  $y_{2;t+s}$  based on  $(y_{2;t}, y_{2;t-1}, \dots)$  is the same as the MSE of a forecast of  $y_{2;t+s}$  based on  $(y_{2;t}, y_{2;t-1}, \dots)$  and  $(y_{1;t}, y_{1;t-1}, \dots)$ . Clearly, the notion of Granger causality does not imply true causality. It only implies forecasting ability. Given  $Y_t$  the vector of variables  $(Y_{1;t}, Y_{2;t})$ , the classical p-order bivariate VAR model can be represented as:-

$$Y_t = \beta_0 + \sum_{i=0}^p \Phi_i Y_{t-i} \dots \dots \dots 1$$

For further descriptions use the simple bivariate VAR(1) process in the form of two equations:-

$$Y_{1,t} = \beta_{0,1} + \phi_{1,1}Y_{1,t-1} + \phi_{1,2}Y_{2,t-1} + \varepsilon_{1,t} \dots \dots \dots 2$$

$$Y_{2,t} = \beta_{0,2} + \phi_{2,1}Y_{1,t-1} + \phi_{2,2}Y_{2,t-1} + \varepsilon_{2,t} \dots \dots \dots 3$$

There is one regression equation for each time series. Each regression equation has the same explanatory variables; a constant and a single lag of each of the two variables. It is sometimes convenient to write the model in vector notation.

$$Y_t = \beta_0 + \phi_1 Y_{t-1} + \varepsilon_t \dots \dots \dots 4$$

Where  $Y_t = \begin{pmatrix} Y_{1,t} \\ Y_{2,t} \end{pmatrix}$ ,  $\beta_0 = \begin{pmatrix} \beta_{0,1} \\ \beta_{0,2} \end{pmatrix}$ ,  $\phi_1 = \begin{pmatrix} \phi_{1,1} & \phi_{1,2} \\ \phi_{2,1} & \phi_{2,2} \end{pmatrix}$ ,  $\varepsilon_t = \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix}$

Let  $Y_t = (y_{1t}, y_{2t}, \dots, y_{nt})^T$  denotes an  $(n \times 1)$  vector of time series variables. The basic  $p$ -lag vector autoregressive VAR ( $p$ ) model has the form:

$$Y_t = \beta_0 + \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \dots + \pi_p Y_{t-p} + \varepsilon_t, t = 1, 2, \dots, T \dots \dots \dots 5$$

where  $\beta_0$  denotes an  $(n \times 1)$  vector of constants and  $\phi_j$  an  $(n \times n)$  matrix of auto-regressive Coefficients,  $j = 1, 2, \dots, p$  and  $\varepsilon_t$  is an  $(n \times 1)$  unobservable zero mean white noise vector Process (serially uncorrelated) with time invariant covariance matrix  $\Sigma$ :

$$E(\varepsilon_t) = 0 \text{ and } E(\varepsilon_t \varepsilon_s') = \begin{cases} \Sigma & t = s \\ 0 & t \neq s \end{cases} \dots \dots \dots 6$$

With  $\Sigma$  an  $(n \times n)$  symmetric positive definite matrix.

In lag operator notation the VAR ( $p$ ) is written as:

$$\phi(L)Y_t = \beta_0 + \varepsilon_t \dots \dots \dots 7$$

Where  $\phi(L) = I_n - \pi_1 L - \dots - \pi_p L^p$

The VAR ( $p$ ) is stable if the roots of:

$$\det(I_n - \pi_1 Z - \dots - \pi_p Z^p) = 0$$

lie outside the complex unit circle (has modulus greater than one). Assuming that the process has been initialized in the infinite past, a stable VAR ( $p$ ) process is stationary with time invariant means, variances and auto-covariances.

If  $Y_t$  in [5] is covariance stationary, then the unconditional mean is given by:

$$u = (I_n - \pi_1 - \dots - \pi_p)^{-1} \beta_0 \dots \dots \dots 8$$

The mean-adjusted form of the VAR ( $p$ ) is then:

$$Y_t - u = \pi_1(Y_{t-1} - u) + \pi_2(Y_{t-2} - u) + \dots + \pi_p(Y_{t-p} - u) + \varepsilon_t \dots \dots \dots 9$$

The basic VAR (p) model may be too restrictive to represent sufficiently the main characteristics of the data. In particular, other deterministic terms such as a linear time trend or seasonal dummy variables may be required to represent the data properly. Additionally, exogenous variables may be required as well. The general form of the VAR (p) model is given by:

$$Y_t = \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \dots + \pi_p Y_{t-p} + \varepsilon_t \dots \dots \dots 10$$

### 3.3.2 Error Correction Model (ECM)

Error Correction Models (ECMs) are a category of multiple time series models that directly estimate the speed at which a dependent variable returns to equilibrium after a change in an independent variable. ECMs are useful for estimating both short term and long term effects of one time series on another.

The co-integrating regression so far considers only the long-run property of the model, and does not deal with the short-run dynamics explicitly. Clearly a good time series modeling should describe both short-run dynamics and the long-run equilibrium simultaneously. For this purpose, the error correction model (ECM) is developed. Although ECM has been popularized after Engle and Granger (1987), it has a long tradition in time series econometrics dating back to Sargan (1964).

In order to examine the short-run dynamics of the model, error correction model (ECM) has to be employed. ECM is the one period lagged value i.e. ECT (-1) of error terms which guides variables in the system to restore back to the long-term equilibrium relationship which shows the eliminated rate of the short-run disequilibrium in the long-run. Precisely, ECM correct disequilibrium and its coefficient should be negative and significant statistically after estimation which subsequently validates there is long-run equilibrium relationship among the variables.

Given a VAR (p);  $Y_t = \pi_1 Y_{t-1} + \pi_2 Y_{t-2} + \dots + \pi_p Y_{t-p} + \varepsilon_t$ ,

there always exists an error correction representation of the form ( $Y_t = Y_{t-1} + \Delta Y_t$ ) . The Vector Error Correction model can be formulated as:-

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \dots \dots \dots 11$$

$$\Pi = \sum_{i=1}^{p-1} \Gamma_i - I_n, \Gamma_i = -\sum_{j=i+1}^p \pi_j$$

Interpretation of  $\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$

- If  $\Pi = 0$ , then there is no co-integration. Non-stationarity of I (1) type vanishes by taking differences.

- If  $\Pi$  has full rank,  $k$ , then the  $Y$ 's cannot be I(1) but are stationary.

$$(\Pi^{-1}\Delta Y_t = Y_{t-1} + \dots + \Pi^{-1}\varepsilon_t).$$

- The interesting case is,  $\text{rank}(\Pi) = m$ ,  $0 < m < k$ , as this is the case of co-integration. We write  $\Pi = \alpha\beta'$

where the columns of  $\beta$  contain the  $m$  cointegrating vectors, and the columns of  $\alpha$  contain the  $m$  adjustment vectors.

$$\text{Rank}(\Pi) = \min [\text{Rank}(\alpha), \text{Rank}(\beta)].$$

Generally we can distinguish three cases for  $\text{rank}(\Pi) = m$ :-

- I.  $\text{Rank}(\Pi) = 0$ ,  $m = 0$ : In case of  $\text{Rank}(\Pi) = 0$ , i.e.  $m = 0$ , it follows  $\Pi = 0$ , the null matrix. There does not exist a linear combination of the I (1) variables, which is stationary. The  $Y$ 's are not co-integrated. The EC form reduces to a stationary VAR ( $p - 1$ ) in differences.

$$\Delta Y_t = \Pi + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t, \Pi \text{ has } m = 0 \text{ eigenvalues different from } 0.$$

- II.  $\text{Rank}(\Pi) = m$ ,  $0 < m < k$ : The rank of  $\Pi$  is  $m$ ,  $m < k$ . We factorize  $\Pi$  in two rank  $m$  matrices  $\alpha$  and  $\beta'$ .  $\text{Rank}(\alpha) = \text{Rank}(\beta) = m$ . Both  $\alpha$  and  $\beta$  are  $(k \times m)$ .  $\Pi = \alpha\beta' \neq 0$ . The VEC form is then  $\Delta Y_t = \gamma + \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$   
The  $Y$ 's are integrated, I (1). There are  $m$  eigenvalues  $\lambda(\Pi) \neq 0$ . The  $Y$ 's are co-integrated. There are  $m$  linear combinations, which are stationary.

- III.  $\text{Rank}(\Pi) = m$ ,  $m = k$ : Full rank of  $\Pi$  implies that  $|\Pi| = |-\Gamma_i(1)| \neq 0$ .  $Y_t$  has no unit root. That is  $Y_t$  is I (0). There are  $(k - m) = 0$  stochastic trends. As consequence we model the relationship of the  $Y$ 's in levels, not in differences. There is no need to refer to the error correction representation.

### 3.3.3 Modeling Techniques

Several studies have used the techniques of Engle and Granger (1987) and Johanson (1991) to identify the co-integration between macroeconomic variables. These technique requires that all variables (regressors) in the system be stationary and with an equal order of integration. Pesaran



$$\sum_{c=0}^{n_4} \alpha_c \Delta \ln REER_{3t-c} + \theta_0 \ln TB_{t-1} + \theta_1 \ln INF_{1t-1} + \theta_2 \ln RGDP_{2t-1} + \theta_3 \ln REER_{3t-1} + \varepsilon_t \dots \dots \dots 13$$

where  $\ln TB$ ,  $\ln INF$ ,  $\ln RGDP$  and  $\ln REER$  are the macro economic variables that have been defined in section 3.2;  $\Delta$  is the first difference operator;  $\beta_0$  is the constant term,  $\beta_i, \dots, \alpha_c$  are the short run coefficients,  $\theta_0, \dots, \theta_3$  represent the long-run coefficients,  $n_1 \dots n_4$  are the lag length, and  $\varepsilon_t$  is the error term. In order to test the existence of a short-term relationship among the identified variables (Eq.12), we can formulate the null and alternative hypotheses as follows:-

$H_0$ : there is no short-run relationship $\beta = \delta = \theta = \vartheta = 0$	$H_1$ : there is a short-run relationship $\beta \neq \delta \neq \theta \neq \vartheta \neq 0$ Where $\beta = (\beta_1, \dots, \beta_{n_1})$ $\delta = (\delta_0, \dots, \delta_{n_2})$ $\theta = (\theta_0, \dots, \theta_{n_3})$ $\vartheta = (\vartheta_0, \dots, \vartheta_{n_4})$
---	--

Moreover, to test the existence of the long-term relationship, the null and alternative hypotheses can be formulated as follows:-

$H_0$ : there is no long-run relationship $\theta_0 = \theta_1 = \theta_2 = \theta_3 = 0$	$H_1$ : there is a long-run relationship $\theta_0 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq 0$
--	---

The decision to reject or not reject  $H_0$  (no co-integration among the variables) is based on the following procedures (Pesaran et al. 2001), which is based on F statistics ( $F_S$ ):

If  $F_S >$  upper bound, then reject  $H_0$  and conclude that the variables are co-integrated. If  $F_S <$  lower bound, then do not reject  $H_0$  and conclude that the variables are not co-integrated. But if  $F_S$  is between the lower and upper bounds, then the decision is inconclusive. Here  $F_S$  is the F-statistic which is computed using Wald test of coefficient restriction.

The calculated F-statistics values are compared with upper and lower critical values which are given by Pesaran et al. (2001). If calculated F-values exceed the upper critical values, then the null hypothesis of no co-integration will be rejected irrespective of  $I(0)$  and  $I(1)$ . The next step

will then be to estimate long-run relationship using the selected ARDL model. The optimal lags will be chosen based on information criteria.

### 3.4 Unit-Root Test

A linear stochastic process is said to have a unit root if one is a root of the characteristic equation of the process. A test of stationarity (or non-stationarity) that has become widely popular over the past several years is the unit root test. For a number of reasons, it is important to know whether or not an economic time series has a unit root. Nelson and Plosser (1982) pointed out that stationarity often has important economic implications. It is therefore very important to be able to detect the presence of unit roots in time series, normally by the use of what are called unit root tests. If a variable is stationary in level, i.e. without running any differencing, then the variable is said to be integrated of order zero, denoted by I(0). Similarly, if it becomes stationary by differencing once, then the variable is said to be integrated of order 1, written as I(1). Unit-root test helps to detect whether a variable is stationary or not. For these tests, the null hypothesis is that the time series has a unit root and the alternative is that it is I(0). The widely used unit-root tests are Augmented Dickey Fuller test (ADF) and Phillips Perron (PP).

#### 3.4.1 The Augmented Dickey-Fuller (ADF) test

An augmented Dickey–Fuller test (ADF) is a test for a unit root in a time series. It is an augmented version of the Dickey–Fuller test. The augmented Dickey–Fuller (ADF) test statistic, used in the test, is a negative number. The more negative it is, the stronger the rejections of the hypothesis that there is a unit root at some level of confidence. The testing procedure for the ADF test is applied to the model:-

$$\Delta Y_t = b_0 + \beta Y_{t-1} + \mu_1 \Delta Y_{t-1} + \dots + \mu_p \Delta Y_{t-p} + \varepsilon_t \dots \dots \dots 14$$

where  $Y_t$  represents time series to be tested,  $b_0$  is the intercept term,  $\beta$  is the coefficient of interest in the unit root test,  $\mu_i$  is the parameter of the augmented lagged first difference of  $Y_t$  to represent the  $p^{\text{th}}$  order autoregressive process determined by minimizing Schwarz Bayesian Information Criterion and /or Akaike Information Criterion or lags are dropped until the last lag is statistically significant, and  $\varepsilon_t$  is the white noise error term. The suggested hypothesis is:-

$H_0: \beta = 0$  (the data is non stationary) versus the alternative.

$H_1: \beta < 0$  (the data is stationary).

### 3.4.2 The Phillips and Perron (PP) Test

The Phillips–Perron test is also a unit root test. That is, it is used in time series analysis to test the null hypothesis that a time series is integrated of order 1. It builds on the Dickey–Fuller test of the null hypothesis  $\rho = 0$  in  $\Delta y_t = \rho y_{t-1} + u_t$ , where  $\Delta$  is the first difference operator. Like the augmented Dickey–Fuller test, the Phillips–Perron test addresses the issue that the process generating data for  $y_t$  might have a higher order of autocorrelation than is admitted in the test equation—making  $y_t$  endogenous and thus invalidating the Dickey–Fuller t-test. Whilst the augmented Dickey–Fuller test addresses this issue by introducing lags of  $\Delta y_t$  as regressors in the test equation, the Phillips–Perron test makes a non-parametric correction to the t-test statistic. The test statistic for the PP tests is:-

$$\hat{t}_\alpha = t_\alpha \left( \gamma_0 / f_0 \right) 1/2 - T \frac{(f_0 - \gamma_0)}{2f_0^{1/2} s} (s_e(\hat{\alpha})) \dots \dots \dots 15$$

where  $\hat{\alpha}$  is the estimate,  $\hat{t}$  is the t-ratio of  $\alpha$ ,  $s_e(\hat{\alpha})$  is coefficient standard error and  $s$  is the standard error of the test-statistic. In addition,  $\gamma_0$  is a consistent estimate of the error variance and it is calculated as  $(T-k)s^2/T$ , where  $k$  is the number of regressors and  $f_0$  is an estimator of the residual spectrum at frequency zero.

Generally, in economic and financial analyses, stationarity tests are conducted to determine the stationarity of time series data. If the time series data are not stationary, the regression analysis would not be true or spurious regression (Gujarati and Porter, 2009). Before testing the bounds testing approach it needs to ensure that the variables are not I(2) stationary level to avoid spurious results (Pesaran et al. (2001)). Also if the variables are stationary at I(2), the computed F-statistics are not valid because a bounds testing is based on the assumption that the variables must be stationary at I(0), I(1) or both. Therefore, the implementation of the bounds test procedure might be still be necessary to ensure that none of the variables are stationary at I(2) level (Ahmed and Qayyum; 2008; Pesaran et al. 2001).

However, in an economic view, the variables will be co-integrated if they have long-run equilibrium relationship among each other (Bekhet and Mugableh, 2012). Also, the co-integration test was applied to determine which model would be suitable for the current study. In addition, Pesaran et al. (2001) developed a bounds testing approach and argued that the long-run equilibrium relationships could be estimated based on standard F-statistics test and short-run



$\theta = 1/2$  corresponds to a  $\pi$  frequency, a 2 period, and 2 cycles per year. Finally,  $\theta = 3/4$  corresponds to a  $3/2 \pi$  frequency, a  $4/3$  period and 3 cycles per year. In order to relate these cycles and roots in an intuitive way, let us consider the application of a particular factor (corresponding to the root of interest) of the difference operator to the series. For example, consider the deterministic process  $A(L)y_t = 0$ . If  $A(L) = (1+L)$  for root  $-1$ , then  $y_{t+1} = -y_t$  and,  $y_{t+2} = -(y_{t+1}) = y_t$ . Thus the process returns to its original value on a two-period cycle. If  $A(L) = (1-iL)$  for root  $i$ , then  $y_{t+1} = iy_t$ ;  $y_{t+2} = i(y_{t+1}) = y_t$ ;  $y_{t+3} = i(y_{t+2}) = iy_t$ ; and  $y_{t+4} = i(y_{t+3}) = y_t$ .

The process in this case returns to its original value on a cycle of four periods. Zero frequency is given, obviously, when  $A(L) = (1-L)$  in which case the unit root is positive ( $+1$ ) and  $y_{t+1} = y_t$ .

Testing for a unit root at a seasonal frequency has much in common with testing for unit roots at zero frequency (Banerjee et al. 1993). In order to test the null hypothesis that the roots of  $A(L)$  lie on the unit circle against the hypothesis that they lie outside, Hylleberg et al. (1990) define three positive parameters  $\delta_1, \delta_2$ , and  $\delta_3$  so that,

$$A(L) = (1 - \delta_1 L)(1 + \delta_2 L)(1 + \delta_3 L^2) \dots \dots \dots 17$$

For  $\delta_j$  close to unity, the expansion of the series can be carried out by using a Taylor approximation around the four roots. This polynomial yields terms that correspond to each of the roots plus a remainder ( $R$ ) as,

$$A(L) = -\pi_1(1 + L + L^2 + L^3)(L) - \pi_2(1 - L + L^2 - L^3)(-L) - (\pi_4 + \pi_3 L)(-L)(1 - L^2) + R \dots \dots \dots 18$$

The polynomial  $A(L)$  will have a root at  $1, -1, i$ , and  $-i$  if the corresponding terms in  $\pi_i$  are zero.

The factorization of (17) yields,

$$(1 - L^4)y_t = \pi_1 y_{1t-1} + \pi_2 y_{2t-1} + \pi_3 y_{3t-2} + \pi_4 y_{3t-1} - \varepsilon_t \dots \dots \dots 19$$

where the polynomials in the lag operator,

$$\begin{aligned} y_{1t} &= (1 + L + L^2 + L^3)y_t \\ y_{2t} &= -(1 - L + L^2 - L^3)y_t \\ y_{3t} &= -(1 - L^2)y_t \end{aligned}$$

represent different filters. Thus, filter  $y_{1t}$  will adjust any series for all roots except for that corresponding to the factor  $1-L$ ; filter  $y_{2t}$  will adjust any series for all roots except for that

corresponding to the factor  $1+L$ ; and filter  $y_{3t}$  will adjust any series for all roots except for those corresponding to the two complex roots in the factor  $1 + L^2$ .

Equation (18) is amenable to a test where the maintained model includes an intercept, a time trend, and some seasonal dummies. According to Perron (1988), the inclusion of seasonal dummies is due to the fact that the critical values might be influenced by starting values of the dependent variable in their simulations. Equation (18) can be estimated by OLS, with additional lags of the dependent variable  $\Delta_4 y_t = (1 - L^4)y_t$  to avoid serial correlation in the errors. In order to test the null hypothesis that there is a unit root at zero frequency one tests  $\pi_1 = 0$ . To test the null for a unit root of  $-1$  (half-yearly frequency) one tests  $\pi_2 = 0$ . For the complex roots of  $\pm i$  (annual frequency) one applies a joint test of  $\pi_3 = 0$  and  $\pi_4 = 0$ . The alternative hypotheses are that there will be no seasonal unit roots if  $\pi_2$  and either  $\pi_3$  or  $\pi_4$  are different from zero and no long run unit root if  $\pi_1$  is also different from zero. Rejection of all the aforementioned null hypotheses indicates stationarity of the process.

### 3.4.3.2 DHF Tests

Let  $x_t$  be a univariate stochastic process:

$$x_t = \alpha x_{t-4} + u_t, \quad t = 1, 2, \dots, T \tag{20}$$

where  $u_t$  is either a stationary process with zero mean and constant variance or, alternatively, depending on the context and test,  $u_t$  is a martingale difference sequence following the regularity conditions appearing in Phillips (1987) and Chan and Wei (1988). The process  $x_t$  has four roots on the unit circle when  $\alpha = 1$ ; one at frequency  $\theta = 0$ , one at frequency  $\theta = \pi$ , and a pair of complex roots at frequencies  $\theta = \pi/2, 3\pi/2$ .

DHF (1984) examined several regression-based tests for the hypothesis that  $\alpha = 1$  in model (19) where  $u_t$  is i.i.d.  $N(0, 1)$  and computed percentiles of their distributions. They suggested two types of test statistics derived from the least squares estimator in regression models with and without constant and/or seasonal dummies. The DHF tests are based on the following regression:

$$x_t = \alpha x_{t-4} + \sum_{j=1}^l \Delta_4 x_{t-j} + [\text{set of fixed regressors}] + \varepsilon_t \tag{21}$$

where the set of fixed regressors may include a constant, seasonal dummies, and a linear trend. Regression (20) is estimated with OLS. DHF proposed two types of statistics for  $H_0: \alpha = 1$ , based on  $\hat{\alpha}$  in (20) - namely, a normalized statistic  $T(\hat{\alpha} - 1)$  and a t-statistic.

### 3.4.3.3 Joint Tests for Seasonal Unit Roots

To compare the DHF and HEGY tests directly, a joint HEGY-type test is introduced which tests for the presence of unit roots at the zero as well as all seasonal frequencies. Ghysels, Lee and Noh (1994) claim that the HEGY-type tests are somewhat superior to the DHF test; however, its size deteriorates for data generating processes with a parameter close to a unit circle.

In this section, the Dickey and Fuller (1981) F-type statistics are extended to deal with deterministic components of seasonal time series processes. Using these F-tests, it is possible to formulate a general approach to test for seasonal unit roots. The generalized procedure enables us to distinguish among integrated seasonal processes with a set of fixed regressors which may include constant, seasonal dummies, the time trend and the seasonal linear trend.

Of interest is a time-series process  $x_t$  of the type

$$\phi(B)x_t = \varepsilon_t \dots \dots \dots 22$$

where  $\phi(B)$  is in general an  $n^{\text{th}}$  order polynomial with  $n$  distinct roots and  $\varepsilon_t$  is an i.i.d. stochastic process with a zero mean and a constant variance. The focus of the paper is on quarterly data frequency - consequently, the special case of (21) is the fourth-order polynomial.

$$\phi(B) = (1 - B^4) = (1 - B)(1 + B)(1 - iB)(1 + iB) \dots \dots \dots 23$$

with respective unit roots  $e^{i\theta}$  where  $\theta = 0, \pi/2, \pi, 3\pi/2$ , i.e. 1, -1,  $i$  and  $-i$ . 1 is the non-seasonal, zero-frequency root (zero cycles per year) while -1,  $i$  and  $-i$  are the seasonal unit roots. -1 corresponds to 2 cycles per year and  $i$  or  $-i$  correspond to one cycle per year.

The first approach is the DHF test which is based on the auxiliary regression:

$$x_t = \mu_t + \rho x_{t-4} + \varepsilon_t \dots \dots \dots 24$$

where  $\mu_t$  may contain deterministic components such as the intercept, seasonal dummies, the regular trend and the seasonal trend. DHF use the z-type and t-type test statistics for  $\rho = 1$ . The DHF procedure assumes that there are unit roots at some or all of the other frequencies in (23).

The second approach is that of HEGY test, which uses the model:

$$\phi^*(B)y_{4t} = \mu_t + \pi_1 y_{1t-1} + \pi_2 y_{2t-1} + \pi_3 y_{3t-2} + \pi_4 y_{3t-1} + \varepsilon_t \dots \dots \dots 25$$

where

$$\begin{aligned}
 y_{1t} &= (1 + B + B^2 + B^3)x_t \\
 y_{2t} &= -(1 - B + B^2 - B^3)x_t \\
 y_{3t} &= -(1 - B^2)x_t \\
 y_{4t} &= (1 - B^4)x_t
 \end{aligned}$$

with  $\phi^*(B)$  being an AR polynomial whose order is determined using diagnostic checks ensuring that  $\varepsilon_t$  is roughly white noise. If  $\pi_1 = 0$ , one cannot reject the non-seasonal unit root 1. If  $\pi_2 = 0$ , the presence of the seasonal unit root -1 cannot be rejected. Similarly, if  $\pi_3 = \pi_4 = 0$ , the seasonal unit roots  $i, -i$  cannot be rejected. HEGY propose t-tests for each  $\pi_i$  ( $t(\pi_i)$ ,  $i = 1, \dots, 4$ ) and joint F-type statistic for  $\pi_3$  and  $\pi_4$  (denoted F34), which are further extended by GLN F-type statistics for the joint significance of  $\{\pi_1; \pi_2; \pi_3; \pi_4\}$  and  $\{\pi_2; \pi_3; \pi_4\}$  (denoted respectively as F1234 and F234). Smith and Taylor (1998) are the first ones to include seasonal time trend in  $\mu_t$ . The F-type statistics for the joint significance of  $\{\pi_1; \pi_2; \pi_3; \pi_4\}$  tests the same hypothesis as the DHF statistics but, according to GLN, has better power properties against common alternatives. Also, the HEGY test statistics enable one to test for a particular unit root and simulated critical values are available for all combinations of deterministic elements in  $\mu_t$ . Consequently, we use HEGY tests in combination with the proposed F-type statistics.

The shortcoming of both the DHF and HEGY type tests is the implicit assumption of knowing the exact composition of the deterministic component of  $x_t$ . However, the distribution of these components is affected by the potential presence of unit roots. In a non-seasonal context, Dickey and Fuller (1981) tabulate critical values for statistics testing various hypotheses regarding the intercept, the time trend and the autoregressive coefficient in the regression (24). Smith and Taylor (1999) extend this line of research in these seasonal context. Perron (1988) and Ayat and Burrige (2000) suggest strategies of systemic approach to uncertainty about the non-stochastic trend. We can construct tests similar to ones in Dickey and Fuller (1981), which are suitable for our general auxiliary regression and provide a simple alternative to tests in Smith and Taylor (1999) and then use them in a sequential procedure. Consider the auxiliary regression:

$$x_t = \sum_{i=1}^4 \alpha_i D_{it} + \sum_{i=1}^4 \beta_i D_{it}t + \rho x_{t-4} + \varepsilon_t \dots \dots \dots 26$$

where  $x_t$  is the time series of interest,  $D_{it}$ 's are the seasonal dummies,  $t$  the time trend, and  $\alpha$ 's,  $\beta$ 's, and  $\rho$  are the corresponding coefficients. This formulation encompasses all the possible combinations of deterministic elements in  $\mu_t$ . We now formulate the null hypotheses, which aim at deciding on the deterministic part of the seasonal stochastic processes:

$$\begin{aligned}
 H_{01}: (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, \rho) &= (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, 1) \\
 H_{02}: (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, \rho) &= (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta, \beta, \beta, \beta, 1) \\
 H_{03}: (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, \rho) &= (\alpha_1, \alpha_2, \alpha_3, \alpha_4, 0, 0, 0, 0, 1) \\
 H_{04}: (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, \rho) &= (\alpha, \alpha, \alpha, \alpha, \beta, \beta, \beta, \beta, 1) \\
 H_{05}: (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, \rho) &= (\alpha, \alpha, \alpha, \alpha, 0, 0, 0, 0, 1) \\
 H_{06}: (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_1, \beta_2, \beta_3, \beta_4, \rho) &= (0, 0, 0, 0, 0, 0, 0, 0, 1)
 \end{aligned}$$

The above listed null hypotheses do not include all the possible combinations of fixed regressors. Their choice is driven by availability of critical values of the HEGY type tests. However, the missing hypotheses are not very useful anyway. For instance, it is unlikely for a time series to have zero intercepts and four different seasonal time trends. Also, note that

$H_{0i}$ 's are ordered according to increasing number of restrictions on the parameters.

The F-statistics are calculated as:

$$F_i = \frac{(RSS_0^i - RSS_1) / V_0^i}{RSS_1 / V_1}, i = 1, \dots, 6 \dots \dots \dots 27$$

where  $SSE_0^i$  and  $SSE_1$  denote respectively the residual sum of squares in the restricted model (under the null hypothesis  $i$ ) and in the unrestricted regression (26). Similarly,  $V_0^i$  and  $V_1$  denote degrees of freedom.  $V_0^i = 9 - k$  with  $k$  being the number of regressors in the restricted models and  $V_1 = T - 13$  with  $T$  the number of observations.

To conduct the F-tests to identify the joint hypothesis of a unit root and a certain combination of deterministic components, which cannot be rejected,  $H_{01}$  is tested first using  $F_1$  defined in (26). If the null hypothesis is rejected, there are no unit roots and one can use standard F tests to find the right combination of deterministic variables. If the null cannot be rejected, we continue by testing  $H_{02}$  and soon, until we reject  $H_{0i}$  for some  $i$ . Then the specification defined by  $H_{0,(i-1)}$  is tested for theseasonal (and non-seasonal) unit roots using the HEGY type test with critical values

from HEGY, GLN, and Smith and Taylor (1998). When  $H_{04}$  is the first rejected hypothesis, the adopted specification is defined by  $H_{02}$  since  $H_{03}$  does not encompass  $H_{04}$ .

### **3.5 Co-integration tests**

On the basis of the theory that integrated variables of order one,  $I(1)$ , may have a co-integration relationship, it is crucial to test for the existence of such a relationship. If a group of variables are individually integrated of the same order and there is at least one linear combination of these variables that is stationary, then the variables are said to be co-integrated. The co-integrated variables will never move far apart, and will be attracted to their long-run relationship. Testing for co-integration implies testing for the existence of such a long-run relationship between economic variables. This study considers a number of co-integration tests, namely the Engle-Granger method (commonly known as the two-step estimation procedure) and the Johansen's procedure.

#### **3.5.1 Engle-Granger method**

As stated earlier, the regression of non-stationary series on other series may produce spurious regression. If each variable of the time series data is subjected to unit root analysis and it is found that all the variables are integrated of order one,  $I(1)$ , then they contain a unit root. There is a possibility that the regression can still be meaningful (i.e. not spurious) provided that the variables co-integrate. In order to find out whether the variables co-integrate, the least squares regression equation is estimated and the residuals (the error term) of the regression equation are subjected to unit root analysis. If the residuals are stationary, that is  $I(0)$ , it means that the variables under study co-integrate and have a long-term or equilibrium relationship.

In the two-step estimation procedure, Engle-Granger considered the problem of testing the null hypothesis of no co-integration between a set of variables by estimating the coefficient of a relationship between economic variables using OLS and applying well-known unit root tests to the residuals to test for stationarity. Rejecting the null hypothesis of a unit root is evidence in favor of co-integration.

#### **3.5.2 Johansen's procedure**

Johansen's procedure builds co-integrated variables directly on maximum likelihood estimation instead of relying on OLS estimation. This procedure relies heavily on the relationship between

the rank of a matrix and its characteristic roots. Johansen derived the maximum likelihood estimation using sequential tests for determining the number of co-integrating vectors. This procedure is a vector co-integration test method. It has the advantage over the Engle-Granger method in that it can estimate more than one co-integration relationship if the data set contains two or more time series. There are two types of tests for Johansen co-integration approach called trace test and the maximum Eigen-value test.

The test statistics for the trace test and maximum Eigen-value test are shown in the following equations [28] and [29] respectively.

$$J_{\text{trace}} = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \dots\dots\dots 28$$

$$J_{\text{max}} = -T \ln(1 - \hat{\lambda}_{r+1}) \dots\dots\dots 29$$

where  $T$  is the sample size,  $n$  is number of endogenous variables and  $\hat{\lambda}_1$  is the largest eigenvalue of  $(\pi)$ . The trace test tests the null hypothesis of  $r$  co-integrating vectors against the alternative hypothesis of  $n$  co-integrating vectors. The maximum eigen-value test, on the other hand, tests the null hypothesis of  $r$  co-integrating vectors against the alternative hypothesis of  $r + 1$  co-integrating vectors where  $r = 1, 2, \dots, n$ . Neither of these test statistics follows a chi-squared distribution in general; asymptotic critical values can be found in Johansen and Juselius (1990). Since the critical values used for the maximum eigen-value and trace tests are based on a pure unit-root assumption, they will no longer be correct when the variables in the system are near-unit-root processes. Thus, the real question is how sensitive Johansen's procedures are to deviations from the pure-unit root assumption. Although Johansen's methodology is typically used in a setting where all variables in the system are  $I(1)$ , having stationary variables in the system is theoretically not an issue and Johansen (1995) states that there is little need to pre-test the variables in the system to establish their order of integration. If a single variable is  $I(0)$  instead of  $I(1)$ , this will reveal itself through a co-integrating vector whose space is spanned by the only stationary variable in the model.

### 3.6 Bounds Testing

When time series data are not in the same order of integration, i.e. some variables are  $I(0)$  and the others  $I(1)$ , conventional co-integration tests cannot be used. Therefore, we use the bounds testing approach to investigate the co-integration relationship of the variables. Bounds testing is

employed through the ordinary least squares (OLS) method and the computed F-statistics for the joint significance of the lagged levels of variables are compared with the critical values provided by Pesaran et al (2001). Bounds testing approach has some advantages over the conventional approach of co-integration models. First, the bounds testing approach can be employed irrespective of whether the regressors are purely  $I(0)$  or  $I(1)$  or fractionally integrated. Second, the bounds testing co-integration approach has superior properties in small sample sizes than other multivariate co-integration approaches. Third, the error correction model can be obtained from the ARDL through a simple linear combination that amalgamates both short-run adjustments with long-run information without losing previous information.

In an economic view, the variables will be co-integrated if they have the long-run equilibrium relationship among each other (Bekhet and Mugableh, 2012). Also, the co-integration test would be applied to determine which model would be suitable for the current study. In addition, Pesaran et al. (2001) developed an alternative bounds testing approach and argued that the long-run equilibrium relationships could be estimated based on standard F-statistics test and short-run relationship could be directly estimated. The bound test approach was chosen as it can be used in small sample sizes, estimates long-run and short-run relationships simultaneously and allows the test on existence of relationships among variables at various levels,  $I(0)$ ,  $I(1)$  or both. In other words if all variables are stationary at  $I(0)$  or  $I(1)$  or both and co-integrated, then the bounds testing approach can be used (Pesaran and Pesaran, 1997).

### **3.7 Lag Length Selection Criteria**

Information criteria are often used as a guide in model selection. The notion of an information criterion is to provide a measure of information that strikes a balance between this measure of goodness of fit and parsimonious specification of the model. When using information criteria for model selection, it should be noted that the model with the smallest value is considered most desirable. The various information criteria differ in how to strike this balance. The following are five basic lag length selection criteria:-

1. The LR describes a series of joint hypothesis test (they are Likelihood Ratio tests, hence the LR notation). The significance of all of the coefficients of the longest lag are tested first. If they are jointly insignificant, the lag is dropped and the VAR is re-estimated. The new longest lag is now tested for significance. The process is repeated until a significant lag is found.

2. The FPE (final prediction error) has the formula

$$FPE(p) = \frac{(T+mp+1)^m}{T-mp-1} |\hat{\Sigma}_p|$$

where  $\hat{\Sigma}_p$  is the estimated residual variance matrix from a VAR (p) model. The laglength is chosen to minimize this criterion. This criterion is similar to the well known AIC and SC, which attempt to provide a balance between goodness of fit (minimizing  $\hat{\Sigma}_p$ ) and model simplicity (minimizing p). The FPE is most closely related to the AIC.

3. The AIC (Akaike information criterion) chooses p to minimize

$$AIC(p) = \log |\hat{\Sigma}| + 2 \frac{m(p^2+1)}{T}$$

Note that  $m(p^2+1)$  is the number of parameters in all of the equations in the VAR model.

4. The SC (Schwartz criterion) chooses p to minimize

$$SC(p) = \log |\hat{\Sigma}| + (\log T) \frac{m(p^2+1)}{T}$$

5. The HQ (Hannan-Quinn) criterion chooses p to minimize

$$HQ(p) = \log |\hat{\Sigma}| + (2 \log \log T) \frac{m(p^2+1)}{T}$$

In fact, all these five criteria are just different ways of trading off the minimization of  $\hat{\Sigma}_p$  against the minimization of p. In cases such as this, where there is uncertainty about the lag length, it is a good idea to look at the residual correlograms. After selecting the optimal lag length using the above criteria, the next step is estimating the parameters of the VAR(p) model using multivariate least squares (MLS). As the explanatory variables are the same in each equation, MLS is equivalent to the ordinary least squares estimator applied to each equation separately.

### 3.8 Diagnostic tests

Several diagnostic tests are conducted to ensure the goodness of fit of the model. These tests examine the serial correlation, functional form, normality and heteroscedasticity associated with the selected model. Furthermore, Pesaran (1997) suggests using Brown et al.'s (1975) stability test to check the stability of the coefficients of the regression. This technique is also known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ). The CUSUM and CUSUMQ statistics are updated recursively and plotted against the break points. If the plots of CUSUM and CUSUMQ statistics stay within the critical bounds of 5% level of significance, the

null hypothesis of all coefficients in the given regression are stable cannot be rejected. Furthermore, variance decomposition (VDCs) and impulse response function (IRFs) can be simulated for further inferences. VDCs and IRFs serve as tools for evaluating the dynamic interactions and strength of causal relations among variables in the system. The VDC indicates the percentages of a variable's forecast error variance attributable to its own innovations and innovations in other variables. Thus, from the VDC, we can measure the relative importance of the real effective exchange rate (REER), real gross domestic product (RGDP), and inflation rate (INF) fluctuations in accounting for fluctuations in the trade balance (TB). Moreover, the IRF traces the directional responses of a variable to a one-standard deviation shock to another variable. This means that we can observe the direction, magnitude, and persistence of trade balance to variations in the REER, RGDP, and inflation rate.

## 4. Results and Discussion

### 4.1 Descriptive Statistics

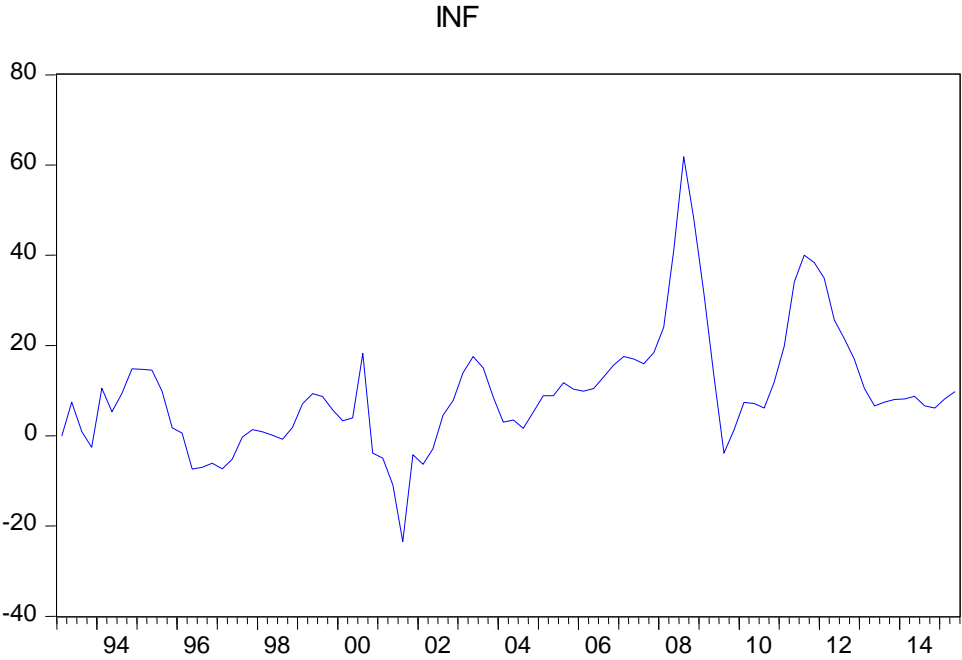
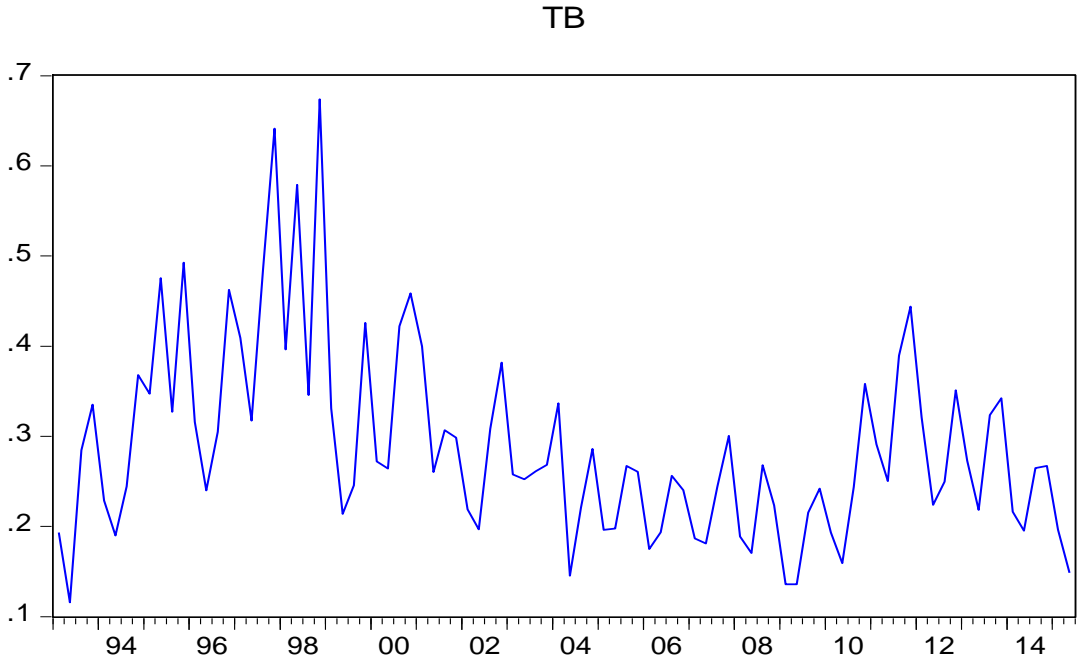
Some descriptive statistics including the mean, the median, the standard deviation, the minimum and maximum values of the series under study are presented in table 4.1. From the result for instance, the quarterly mean value of trade balance (export/import), real gross domestic product, inflation rate and real effective exchange rate over the study period are 0.29, 321296.3, 9.52 and 134.08, respectively. And the maximum and minimum value of trade balance is 0.67 and 0.12, respectively.

**Table 4.1** Descriptive statistics for Trade balance and its determinants

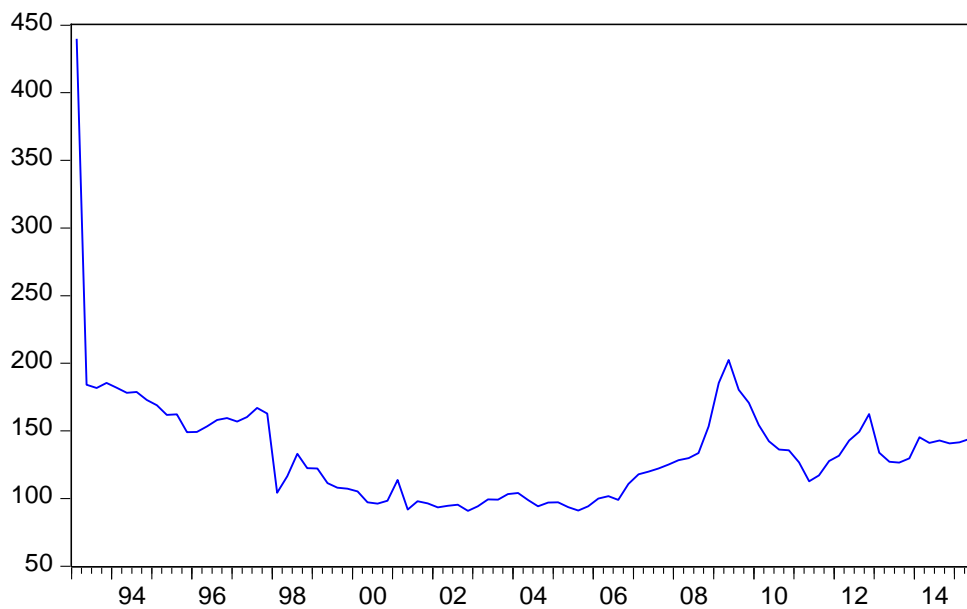
<b>Statistics</b>	<b>Trade Balance</b>	<b>Inflation Rate</b>	<b>Real Effective Exchange Rate</b>	<b>Real Gross Domestic Product (in millions of Birr)</b>
Mean	0.29	9.52	134.08	321296.3
Median	0.26	8.09	128.03	239600.1
Maximum	0.67	61.82	439.89	748021.1
Minimum	0.12	-23.45	90.80	141893.2
Standard Deviation	0.12	13.17	43.93	173784.9

The plots of the time series are shown in Figure 1. Trade balance has highly fluctuated from 1993 to 2014. Inflation has small fluctuations from 1993 to 2007, but strictly rises and drops from 2008 to 2015. Real effective exchange rate was steadily dropping with very little fluctuation, from 1993 to 2006 and rise in fluctuation from 2006 to 2009. From the time plot we can observe that real gross domestic product shows an increasing trend over the study period.

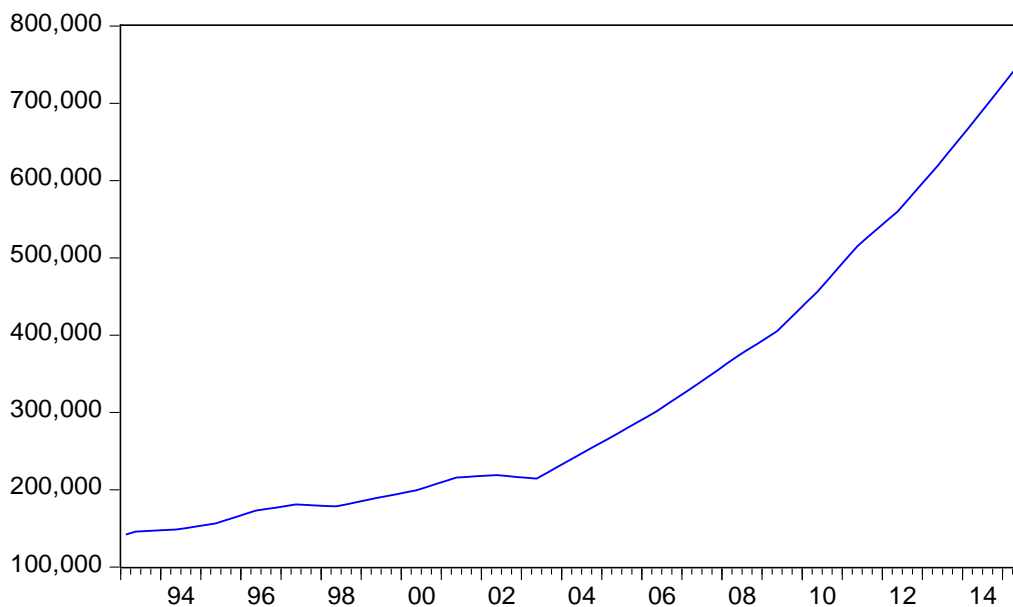
Figure 1 Data trend of the study variables from 1993Q1 to 2015Q2



REER



RGDP



## 4.2 EMPIRICAL RESULTS

Our sample period is from 1993Q1 to 2015Q2. Unit root testing of the variables is the first task to be conducted before other tests to be followed.

### 4.2.1 Unit root Test

If the time series data is not stationary and have a trend data transformation like logarithmic and differencing of various order is applied until the data become stationary. To see whether the time series is stationary or not, we used statistical test known as unit root test. There are two conventional ways of testing for unit roots-Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). In this study we employed both the ADF and PP methods in testing for unit roots. In ADF and PP methods, the null hypothesis is that the time series have unit root, that is, they are non-stationary. If the calculated test-statistics for our variables in their level forms are more negative than the critical values, the null hypothesis is rejected, suggesting that variables are stationary in their level forms, i.e. they are  $I(0)$ . In case the variable is not stationary in levels, we should investigate the stationarity in first differences. If the calculated test-statistics for our variables in their first differenced forms are more negative than the critical values, the null hypothesis can be rejected, suggesting that our variables are stationary after differencing, which is denoted as  $I(1)$ .

**Table 4.2 ADF and PP tests for TB and its determinant at level with trend and intercept**

Variables	Test Statistics		P-value		Remark
	ADF	PP	ADF	PP	
TB	-0.103114	-0.614343	0.6452	0.4486	Non stationary
REER	-1.219085	-1.210588	0.2029	0.2057	Non stationary
RGDP	2.693120	8.420275	0.9982	1.0000	Non stationary
INF	-1.026049	2.419182	0.2721	0.2044	Non stationary

As we see clearly from Table 4.2, the test failed to reject the null hypothesis of a unit root for each variable. That is, the respective ADF and PP statistics are less than the critical value at both 5 % and 10 % significance levels. But after differencing the series once, the series under question become stationary. Table 4.3 shows the result of the ADF and PP test after differencing these series.

**Table 4.3 ADF and PP tests for TB and its determinant at first difference with trend and intercept**

Variables	Test Statistics		P-value		Remark
	ADF	PP	ADF	PP	
D(LTB)	-5.258529	-15.40043	0.0000	0.0000	Stationary
D(LREER)	-13.92763	-14.42559	0.0000	0.0000	Stationary
D(LRGDP)	-1.517034	-3.243141	0.0205	0.0208	Stationary
D(INF)	-7.610794	-6.548370	0.0000	0.0158	Stationary

Thus, the results of both ADF and PP tests show that all the given variables become stationary at first differences, i.e. all variables are I (1).

#### **4.2.1.1. Seasonal Unit Root Tests**

Table 4.4 reports the results of seasonal unit root test for quarterly data. The first column indicates the roots (the corresponding frequencies are shown below the table). The quarterly time series data under consideration are: trade balance, real effective exchange rate, real gross domestic product and inflation. The numbers in the cells express the *ADF* statistics on the coefficients.

**Table 4.4. Tests for seasonal unit roots (HEGY), quarterly data**

	TB	REER	RGDP	INF
	Lag 1	Lag 1	Lag 1	Lag 1
$\pi_1$	1.76*	0.006*	0.17*	0.60*
$\pi_2$	-3.76	-5.35	-2.98*	-4.32
$\pi_3$	-6.76	-6.12	-8.07	-3.68
$\pi_4$	-4.43	-4.73	-4.02	-4.88

Critical values  $\pi_1 \pi_2 \pi_3 \pi_4$

**5% (Intercept, Seasonal Dummies, No trend) -3.59 -3.27 -2.55 -1.44**

**1% -4.33 -3.49 -3.38 -2.95**

**Note:**  $\pi$  denotes the root at each frequency. Thus,  $\pi_1$  corresponds to frequency 0 (long run trend and no cycles);  $\pi_2$  to frequency  $\pi/2$  (annual cycle);  $\pi_3$  to frequency  $\pi$  (two cycles per year);  $\pi_4$  to frequency  $3/2\pi$  (three cycles per year).

In the first place, it is worth noting that the null hypothesis for every series at zero frequency (root  $\pi_1$ ) cannot be rejected. This indicates that there exists a unit root in the long run for every variable. However, for seasonal unit roots it seems that there is little evidence. Only seasonal unit roots at frequency  $\pi/2$  for RGDP cannot be rejected. The most striking aspect in quarterly data, then, is the fact that practically in all cases no seasonal pattern emerges at any frequency at 5 percent significance level. For all variables trade balance, real effective exchange rate, and RGDP, unit roots at all seasonal frequencies are not rejected at the 5 percent level.

**Table 4.5: Joint Tests of Seasonal Unit Roots**

Series	T	F <sub>1</sub>	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>	F <sub>5</sub>	F <sub>6</sub>
ETB	90	5.57	1.44	1.15	0.84	0.73	98.90***
EREER	90	5.69	1.49	1.54	0.91	1.01	169.33***
ERGDP	90	24.85	6.26	6.43*	3.60	4.03	10.44***
EINF	89	26.25 *	6.61	5.74	3.80	3.61	3.97

**Table 4.6: Seasonal HEGY type t-tests and F-tests**

Series	T	t( $\pi_1$ )	t( $\pi_2$ )	t( $\pi_3$ )	t( $\pi_4$ )	F <sub>34</sub>	F <sub>234</sub>	F <sub>1234</sub>
<b>TB</b>	<b>90</b>	0.03	-2.77	-5.33 **	-5.32 **	33.02 **	26.67 **	20.01 **
<b>REER</b>	<b>90</b>	1.22	-1.90	-4.27 **	-3.31 **	15.70 **	12.04 **	9.44 **
<b>RGDP</b>	<b>90</b>	-3.13 **	-3.13 **	-2.27	-1.80 *	4.33 **	6.58 **	8.43 **
<b>INF</b>	<b>89</b>	-2.89 **	-0.23	-0.30	-0.58	0.21	0.16	2.28

The t-statistics  $t(\pi_i)$ ;  $i=1,2,3$  are one sided while  $t(\pi_4)$  is two-sided. We only test for significance at 10% and 5% levels due to availability of critical values in GLN.

Table 4.5 and 4.6 presents the results for all time series together with the corresponding number of observations to determine the appropriate critical values in each case. The results reflect the tendencies already identified using the unrestricted OLS regression. The HEGY tests indicate that there are no seasonal unit roots in either case. While the zero-frequency unit roots are not rejected, the t-statistics are negative and not far from their critical values.

Therefore, there is a possibility that presence of the non-seasonal unit root is not rejected due to the lack of power of the HEGY tests. To investigate this possibility, the standard DF t-statistics are used with a constant and a trend. The null hypothesis is rejected in both cases, thus confirming the outcome of the seasonal F-tests. If a researcher wants to use the two series in a regression, no differencing is necessary provided that the regression includes seasonal dummies and a seasonal trend, this implies that all the series contain the non-seasonal unit root.

## 4.2.2 Co-integration Tests

As we have seen from above all macro-economic variables are non-stationary at levels with trend and intercept. So to determine the long run relationship between trade balance and its selected macro-economic variables in this study, we can apply the Johansen co-integration test.

### 4.2.2.1 The Johansen Co-integration Approach

Because all of the variables appear to be integrated of order one (their first differences appear to be stationary), they all are candidates to be included in along-run relationship. The next procedure is to test for co-integration. The idea behind co-integration analysis is that, although macroeconomic variables may tend to trend up and down over time, groups of variables may drift together.

To determine the number of co-integrating relationships, the Johansen approach to co-integration is applied. The two tests for the number of tests for co-integration are the trace test and the maximum eigen-value statistics. Here, these two test statistics are computed to determine the number of co-integrating vectors in the model. The results of co-integration test are presented in the following table.

**Table 4.7 Johansen's trace co-integration test**

<b>Hypothesized No. of CE(s)</b>	<b>Eigenvalue</b>	<b>Trace Statistic</b>	<b>0.05 Critical Value</b>	<b>Prob.</b>
None	0.251057	50.81884	47.85613	0.0257
At most 1	0.173381	26.24597	29.79707	0.1215
At most 2	0.097147	10.06097	15.49471	0.2761
At most 3	0.016039	1.374330	3.841466	0.2411

From Table 4.7, we observe that the trace statistic (50.81884) exceeds the respective critical value (47.85613) with p-value (0.0257). That is, the trace test result indicates only one co-integrating equation at 5 % level of significance. This implies that the null of no-co-integration relations is rejected at the 5% significance level in favour of the alternative one co-integration relation.

**Table 4.8 Johansen maximum Eigen-value co-integration test**

<b>Hypothesized No. of CE(s)</b>	<b>Eigenvalue</b>	<b>Max-Eigen Statistic</b>	<b>0.05 Critical Value</b>	<b>Prob.</b>
None	0.251057	34.57287	27.58434	0.0159
At most 1	0.173381	16.18500	21.13162	0.2142
At most 2	0.097147	8.686638	14.26460	0.3132
At most 3	0.016039	1.374330	3.841466	0.2411

Similarly, as shown in Table 4.8, the max-eigenvalue statistic (34.57287) exceeds the critical value (27.58434) with p-value (0.0159). Thus, the max-eigenvalue test suggests only one co-integrating relationship since the null of no co-integrating equation is rejected at the 5 % significance level. Rejection of the null implies that variables do not drift apart and share at least a common stochastic trend in the long run. Both test results indicate that one co-integrating equation is sufficient. The next output in Table 4.9 gives the normalized co-integrating coefficients for one co-integrating equation. The numbers in the parenthesis under the estimated coefficient are the asymptotic standard errors. Some of the normalized coefficients will be shown without standard errors. That will be the case for coefficients that are normalized to 1.0 and for coefficients that are not identified.

**Table 4.9 Normalized Co-integration coefficient**

1 Cointegrating Equation(s):		Log likelihood	-195.2230
Normalized co-integrating coefficients (standard error in parentheses)			
LTB	LREER	LRGDP	INF
1.00000	0.364026	0.090168	0.027879
	(0.32657)	(0.17830)	(0.00890)

The main rationale of co-integration analysis is to get a stationary series from two or more non-stationary series. The resulting stationary series is written as a linear combination of the non-stationary series. In our case, we found that there is only one stationary co-integrated series from the non-stationary series. This stationary series, denoted by ECT, is simply a linear combination of the study variables. Then using the result in Table 4.9 we can write this ECT as follows:-

$$\text{ECT} = \text{LTB} - 0.364026 \text{LREER} + 0.090168 \text{LRGDP} + 0.027879 \text{INF} \dots \dots \dots 31$$

The result shows that, in the long run, ECT is stationary despite the fact that all the four series are non-stationary. One can infer from this result that there exists a long run relationship between balance of trade and its selected macro-economic variables, that is, balance of trade has positive long run relationship with real effective exchange rate and negative long run relationship with real gross domestic product and inflation rate. This negative long run relation proves that Ethiopia is an import compressed economy and the positive long run relationship shows that a 1% increase/appreciation in REER increases trade balance by 0.36. In other words, devaluation/depreciation of domestic currency will improve trade balance. This result is somehow consistent with a study Waliullah et al. (2010) which found that exchange rate has a significant impact on the change in trade balance in case of Pakistan. But the results are inconsistent with a study by Kim-senLiew et al. (2003) which found that the role of exchange rate is rather insignificant in initiating changes in the trade balance in the case of Malaysia, Singapore, Thailand and the Phillipines.

The previous ECT equation shows that the variables tend to move together in the long run. Short run deviations, however, could occur due to shocks to any of the variables. The Johansen representation showed that if co-integration exists between non-stationary variables, then an error correction representation exists for the variables. Therefore, to analyze the short run dynamics, the next step is to specify and estimate an appropriate Error Correction Model (ECM). Before the construction of an error correction model, we have to check the stationarity of the error correction term (ECT). This error correction term should be stationary at level or I(0). The following table shows the test of unit root for the error correction term. The result shows that we have to reject the null hypothesis, that is, there is no unit root problem at the 5% level of significance.

**Table 4.10 ADF test for ECT at level**

t-statistic	Prob.
Augmented Dickey-Fuller test statistic	-1.9527610.0491

\*MacKinnon (1996) one-sided p-values.

After we check the stationarity of the error correction term, we can construct an error correction model as follows:-

$$D(LTB)_t = C_1 + C_2 D(LRGDP)_t + C_3 D(LREER)_t + C_4 D(INF)_t + C_5 ECT_{t-1} + \epsilon_t \dots\dots\dots 32$$

**Table 4.11 Estimated error correction model**

Coefficient	Std. Error	t-Statistic	Prob.
C(1)	354.301254.764	2.363124	0.0253
C(2)	-0.038049	0.0567310.670701	0.5079
C(3)	0.4004540.098591	-4.0617850.0004	
C(4)	-2.664253	9.257829	-0.2877840.0056
C(5)	-0.7569210.229524	-3.389235	0.0021
R-squared: 0.442189		Mean dependent t var: -743.8757	
Adjusted R-squared: 0.342580		S.D. dependent var: 2410.667	
S.E. of regression: 1954.603		Akaike info criterion: 18.15255	
Sum squared resid: 1.07E+08		Schwarz criterion: 18.42190	
Log likelihood: -302.5933		Hannan-Quinn criter.: 18.24441	
F-statistic: 4.439247		Durbin-Watson stat: 2.003274	
Prob(F-statistic): 0.004205			

As we see from the fitted error correction model:-

- The coefficient of first ordered difference of real effective exchange rate (0.400454) and inflation rate (-2.664253) are statistically significant at 1 % level of significance. This indicates that REER has a positive and inflation rate has a negative short run impact on the change in balance of trade.

- Real gross domestic product does not have short run effect on balance of trade since the coefficients of their first order difference are statistically insignificant at 5 % level of significance.
- The coefficient of the error correction term equals -0.756921. This indicates that about 75.7 % of shock (short-run disequilibria) will be adjusted within the same quarter.

#### 4.2.2.2 Granger Causality Test

Granger causality test is considered a useful technique for determining whether one time series is good for forecasting the other. Table 4.12 presents results from the pair wise Granger-causality tests.

**Table 4.12 Pair-wise Granger Causality Tests**

<b>Null Hypothesis:</b>	<b>Obs.</b>	<b>F-statistic</b>	<b>Probability</b>
LTB does not Granger Cause LREER LREER does not Granger Cause LTB	83	0.67982 1.73716	0.6885 0.0149
LRGDP does not Granger Cause LTB LTB does not Granger Cause LRGDP	83	2.65319 1.45065	0.1174 0.1999
LTB does not Granger Cause INFLATION INFLATION does not Granger Cause LTB	83	1.92793 0.56427	0.0784 0.0023
LREER does not Granger Cause INFLATION INFLATION does not Granger Cause LREER	83	0.07245 3.08621	0.9994 0.0570
LRGDP does not Granger Cause INFLATION INFLATION does not Granger Cause LRGDP	83	1.82451 1.00374	0.0966 0.4365
LRGDP does not Granger Cause LREER LREER does not Granger Cause LRGDP	83	1.53017 0.71499	0.1720 0.6595

The result shows that real effective exchange rate granger causes trade balance. This indicates that, the change in real effective exchange rate leads to change in trade balance. That is, real effective exchange rate provides important information to forecast future value of the trade balance. The result also shows that inflation rate granger causes trade balance. That is, inflation rate provides important information to forecast future values of the trade balance. All the

otherpairs do not Granger-cause each other. For example, real gross domestic productdoes not Granger-causeinflation rateand trade balance.

## 5. Bound Testing For Co-integration

When time series data are not in the same order of integration, i.e. some variables are I(0) that means the independent variables LREER and INF are stationary at level with intercept which is indicated at appendices (2.3,2.6,2.9,2.12) and the others I(1) conventional co-integration tests can not be used. Therefore, we use the bounds testing approach to investigate the co-integration relationship of the study variables. We follow the procedures outlined in Peseran et-al (2001) as they are implemented by the *Eviews*software program. We start by determining the optimallag length. As suggested by Pesaran andShin (1999) and Narayan (2004), since the observations are made on quarterly basis, wechoose 4 as the maximum order of lags in the ARDL and estimate for the period 1993Q1 to 2015Q2.

**Table 5.1 Optimal Lag Length Selectioncriteria**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-23.08556	NA	0.103193	0.566719	0.595456	0.578278
1	-21.60901	2.883608	0.102043	0.555506	0.612980	0.578624
2	-8.523857	25.24665	0.076789	0.271150	0.357361	0.305826
3	-1.401733	3.104060	0.066490	0.127100	0.255514	0.173335
4	0.247299	13.57393*	0.065486*	0.111828*	0.242048*	0.169623*

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5%level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

According to the result of Table 5.1 the optimal lag length that minimizes LR, FPE, AIC, SC and HQ information criteria's is four.

**Table 5.2 The estimated unrestricted ECM model after selecting optimal lags**

Dependent Variable: D(LTB)				
Included observations: 85 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.678374	1.058766	-0.640721	0.5240
LTB(-1)	-0.343040	0.120735	-2.841277	0.0060
LREER(-1)	0.231635	0.126236	1.834942	0.0712
LRGDP(-1)	-0.070844	0.068889	-1.028376	0.3076
INF(-1)	-0.004241	0.003449	-1.229778	0.2233
D(LTB(-1))	-0.134671	0.135526	-0.993690	0.3241
D(LREER(-1))	-0.906279	0.332978	-2.721739	0.0084
D(LRGDP(-1))	0.030929	4.697374	0.006584	0.9948
D(INF(-1))	0.001932	0.004244	0.455232	0.6505
D(LTB(-2))	-0.260230	0.126773	2.052718	0.0442
D(LREER(-2))	0.212122	0.336394	0.630578	0.5306
D(LRGDP(-2))	9.536522	5.883050	1.621017	0.1099
D(INF(-2))	0.000902	0.004235	0.213084	0.8319
D(LTB(-3))	-0.209397	0.113253	-1.848930	0.0691
D(LREER(-3))	-0.742761	0.326248	-2.276678	0.0262
D(LRGDP(-3))	-23.95127	5.872062	-4.078852	0.0001

D(INF(-3))	0.007407	0.004047	1.830208	0.0719
D(LTB(-4))	0.329416	0.103123	3.194390	0.0022
D(LREER(-4))	0.393027	0.229094	1.715575	0.0911
D(LRGDP(-4))	16.61426	4.422225	3.756992	0.0004
D(INF(-4))	0.001484	0.004188	0.354348	0.7242
R-squared	0.671996	Mean depend.var		-0.005063
Adjusquared	0.569494	S.D. depend.var		0.319363
S.E. ofreg.	0.209544	Akaike info crite		-0.077421
Sum squar.resid	2.810143	Schwarz criter.		0.526058
Log likelihood	24.29039	Han-Quinnrcriter.		0.165315
F-statistic	6.555966	Durbin-Wat.stat.		1.976147
Prob(F-statistic)	0.000000			

We can estimate Equation (13) according to the results of Table 5.2. A key assumption in the ARDL / Bounds Testing methodology of Pesaran *et al.* (2001) is that the errors of equations estimated above must be serially independent and the model is dynamically stable. This requirement may also be influential in our final choice of the maximum lags for the variables in the model. Once an apparently suitable version of the above estimated Equations has been estimated, we should use the LM test to test the null hypothesis that the errors are serially correlated, against the alternative hypothesis that the errors are not serially correlated. To check whether the errors of this model are serially correlated, serial correlation LM test is used.

Table 5.3 LM-test results of ARDL (3, 4, 0, 1) model

Lag length	LM	prob.
10.09	0.99	
20.14	0.87	
30.84	0.48	
41.04	0.39	

The LM-test result of Table 5.3 shows that the estimated model has no evidence to serial correlations of the residuals. This implies that the model has no serial correlation.

**Table 5.4 ARDL Bound Test of Co-integration**

Asymptotic critical value bounds for the F-statistic								
0.100		0.050		0.025		0.010		
K	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61

Computed F-statistics: **5.8541**

Notes: Critical values are from Pesaran et al. (2001) Table CI(iii) Case III.

The calculated F-statistics for the co-integration test is displayed in Table 5.4. The calculated F-statistic using Wald test of coefficient restriction (F-statistic = 5.85) is higher than the upper bound critical value at 1, 5, 10 percent level of significance (5.61, 4.35 and 2.72) using restricted intercept and no trend. This implies that the null hypothesis of no co-integration can be rejected at 1 percent, 5 percent and 10 percent level and therefore, this confirms there is a co-integration or long run relationship among the variables.

### 5.1 Autoregressive Distributive Lag (ARDL) Model

After the existence of co-integration has been established by the use of bounds testing, we should proceed to estimate the long run coefficients implied by Equation (12) by employing the Autoregressive Distributed Lag (ARDL) model. In the ARDL model  $(p+1)^k$  number of regressors are estimated to determine the optimal number of lags for each variable. As mentioned above we set  $p$  equal to four since we have quarterly data, and because we have three independent variables  $k$  is set to three. Optimal number of lags is selected through the Akaike information criterion (AIC). Table 5.5 shows results from estimation of the model, ARDL (3,4,0, 1), selected out of  $(4+1)^3 = 125$  regressions.

**Table 5.5 Autoregressive Distributed Lag Estimates**

Regressors	Coefficient	T-Ratio [Prob]
LTB (-1)	-0.2424151	1.9247[0.0583]
LTB (-2)	-0.526087	-5.438383[0.0000]
LTB (-3)	-0.343036	-3.387722[0.0012]
LREER	0.022660	2.206495[0.0306]
LREER (-1)	-1.015205	-3.040634[0.0033]
LREER(-2)	-0.238830	-0.727314[0.4694]
LREER (-3)	-0.873041	-2.634391[0.0103]
LREER(-4)	-0.018633	-0.083541[0.9337]
LRGDP	-4.446019	-1.486340[0.1416]
INF	0.0015470	0.656553[0.5136]
INF(-1)	-0.002023	-0.473155[0.6376]
CONST	0.2312691	1.264303[0.2103]
R-Squared	0.566164	
R-Bar-Squared	0.486729	
S.E. of Regression	0.228801	
F-stat. F( 11, 75)	7.1273 [0.000]	
Akaike Info. Criterion	0.037513	
Schwarz Bayesian Criterion	0.439832	
DW-statistic	1.811341	
<b>Diagnostic Tests</b>		
Test Statistics	LM Version	
A:Serial Correlation	CHSQ(4) = 6.1613 [0.187]	
B:Functional Form	CHSQ(1) = 0.0028385 [0.958]	
C:Normality	CHSQ(2) = 0.36490 [0.833]	
D:Heteroscedasticity	CHSQ(1) = 0.028336 [0.866]	

Notes: ARDL(3,4,0,1) selected based on Akaike Information Criterion

Dependent variable is LTB. A total of 85 observations used for estimation from 1993Q1 to 2015Q2

A:Lagrange multiplier test of residual serial correlation

B:Ramsey's Reset test using the square of the fitted values

C:Based on a test of skewness and kurtosis of residuals

D:Based on the regression of squared residuals on squared fitted values

The long-run coefficients in Equation (12) calculated from the model results are given in Table 5.6. The results indicate that real effective exchange rate (LREER) has a positive impact on Ethiopian trade balance (LTB). A one per cent increase in real effective exchange rate increases trade balance by about 0.19 per cent. This result is somehow consistent with a study Waliullah et al. (2010) which found that exchange rate has a significant impact on change in trade balance in case of Pakistan. But the results are inconsistent with a study by Kim-sen Liew et al. (2003) and Rose (1991) which found that the role of exchange rate is rather insignificant in initiating changes in the trade balances in the case of Malaysia, Singapore, Thailand and the Phillipines and major five OECD countries respectively. The coefficient of real gross domestic product (LRGDP) is also significant at 10 % level. Meaning that the real gross domestic product has negative effect on trade balance in the long-run. The impact of inflation rate (INF) on trade balance is statistically significant. The results of the long-run model show a negative relationship between inflation rate and trade balance.

**Table 5.6 Estimated Long Run Coefficients**

Regressor	Coefficient	T-Ratio	[Prob]
LRGDP	-0.119380	-0.873661	[0.0847]
LREER	0.186206	2.378178	[0.0196]
INF	-0.98222	-0.477468	[0.0000]
CONST	1.6196561	1.344546	[0.1823]

Notes: ARDL(3,4,0,1) selected based on Akaike Information Criterion, Dependent variable is LTB and 85 observations used for estimation from 1993Q1 to 2015Q2.

Note that the long run coefficient of INF seems unreasonably large (indicating that a one percent point increase in the inflation rate decreases trade balance by about 98 percent in the long

run, that means inflation rate has a great impact on Ethiopian trade balance. This also implies that when the inflation rate rises, trade balance will decrease or trade balance will not be improved.

## 5.2 Error Correction Model (ECM)

In order to examine the short-run dynamics of the model, error correction model (ECM) has to be employed. ECM is the one period lagged value i.e. ECT (-1) of error terms which guides variables in the system to restore back to the long-term equilibrium relationship which shows the eliminated rate of the short-run disequilibrium in the long-run. Precisely, ECM correct disequilibrium and its coefficient should be negative and significant statistically after estimation which subsequently validates there is long-run equilibrium relationship among the variables.

To proceed with the short-run estimates we employed error correction representation for the selected ARDL Model to estimate equation (14).

**Table 5.7 Error Correction Representation for the Selected ARDL Model**

Regressors	Coefficients	T-Ratio [Prob]
dLTB1	-0.24336	-2.6933 [0.009]
dLTB2	-0.13517	-1.6513 [0.103]
dLREER0	0.022660	1.6566 [0.092]
dLREER1	-0.016140	-1.1455 [0.256]
dLREER2	-0.065619	-4.5423 [0.000]
dLREER3	-0.020869	-1.3922 [0.168]
dLRGDP	-0.0029687	-0.56704 [0.572]
dINF	-0.16379	-2.6521 [0.010]
CONST	1.4205	5.2179 [0.000]
ECM (-1)	-0.79988	-5.4188 [0.000]
List of additional temporary variables created:		
dLTB = LTB-LTB(-1)		
dLTB1 = LTB(-1)-LTB(-2)		
dLTB2 = LTB(-2)-LTB(-3)		
dLREER = LREER-LREER(-1)		
dLREER1 = LREER(-1)-LREER(-2)		

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dLREER2 = LREER(-2)-LREER(-3)
dLREER3 = LREER(-3)- LREER(-4)
dLRGDP = LRGDP-LRGDP(-1)
dINF = INF-INF(-1)
ECM = LTB -0.186206*LREER + 0.1193880*LRGDP+ 0 .98222*INF -1.619656*CONST
R-Squared 0.47625
R-Bar-Squared0.39943
S.E. of Regression0.028200
F-stat. F( 9, 77) 7.5775 [0.000]
Akaike Info. Criterion 181.4612
Schwarz Bayesian Criterion 166.6658
DW-statistic 2.0438

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Notes: ARDL(3,4,0,1) selected based on Akaike Information Criterion, Dependent variable is LTB and 85 observations used for estimation from 1993Q1 to 2015Q2.

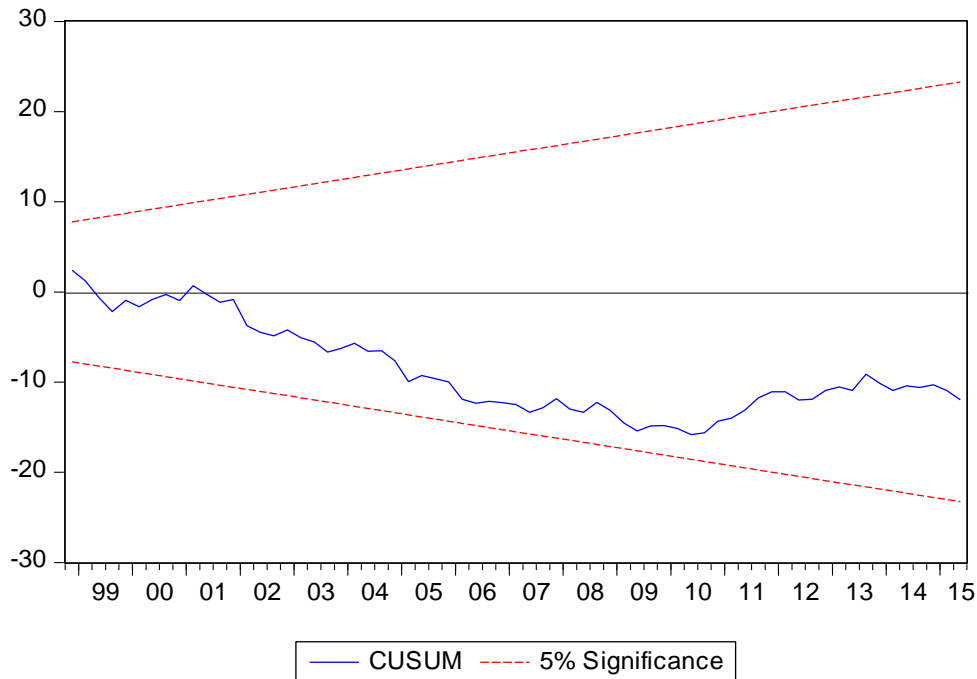
Table 5.7 shows the results from the short-run model for the estimates of the model of equation (13). Change in real effective exchange rate (dLREER) and change in inflation rate (dINF) are the only variables that exert a statistically significant impact (at the 10 per cent and 5 percent level of significance respectively) on the change in trade balance (dTb) in the short-run. Real gross domestic product does not have an effect on trade balance in the short-run. The short run result is not consistent with monetary theories and Marshall-Lerner condition. This implies that all variables do not affect trade balance in the short run. The lagged error correction coefficient, ECM (-1), is negative and statistically significant. The measurement of the speed of adjustment back to long-run equilibrium following a shock, its coefficient of -0.79988, implies that nearly 80 percent of the previous quarter's shock adjusts back to long-run equilibrium in the current quarter i.e., the deviation from long-term equilibrium is corrected by 80 percent over each quarter.

### 5.3. Stability Condition

Checking the stability conditions of the model is to indicate that the model satisfies or does not satisfy the stability conditions. Therefore, if the model satisfies the stability condition, then it could be employed. For this study Brown et al. (1975) cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) methods were applied in order to validate the model. The null hypothesis of all coefficients in the regression models should be contemplated stable and

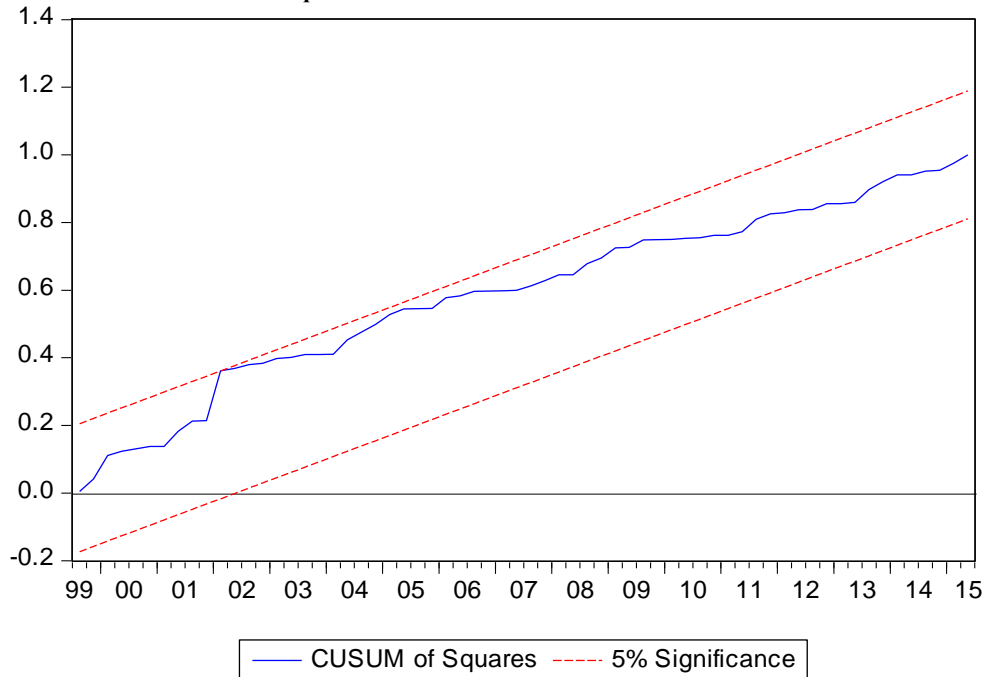
cannot be rejected if the two plots of the CUSUM and CUSUMSQ are stable by lying within the critical bounds of a 5% significance level.

**Figure 2** Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

**Plot of Cumulative Sum of Squares of Recursive Residuals**



The straight lines represent critical bounds at 5% significance level

Figure 2 depicted the stability condition of the model using Brown, et al. (1975) cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests. The plots shown in Figure 2 indicate that the dependent variable (trade balance) and short-run model parameters satisfied the stability condition of the model and the null hypothesis cannot be rejected since both plots of CUSUM and CUSUMSQ lied within the critical bounds of 5% significance levels. Therefore, the entire coefficients in the short-run error correction model (ECM) are stable and can be employed for forecasting.

From an estimated VAR, we compute variance decomposition (VDCs) and Impulse response IRFs, which serve as tools for evaluating the dynamic interactions and strength of causal relations among variables in the system. In simulating VDCs and IRFs, it should be noted that VAR innovations may be contemporaneously correlated. This means that a shock in one variable may work through the contemporaneous correlation with innovations in other variables. The responses of a variable to innovations in another variable of interest cannot be adequately represented since isolated shocks to individual variables cannot be identified due to contemporaneous correlation (Lutkepohl, 1991). Therefore, we use Cholesky factorization which orthogonalizes the innovations as suggested by Sims (1980) to solve this identification problem. The strategy requires a pre-specified causal ordering of the variables. The results from VDC and IRFs may be sensitive to the variables' ordering unless the error terms' contemporaneous correlations are low. The ordering of variables suggested by Sims (1980) starts with the most exogenous variable in the system and ends with the most endogenous variable.

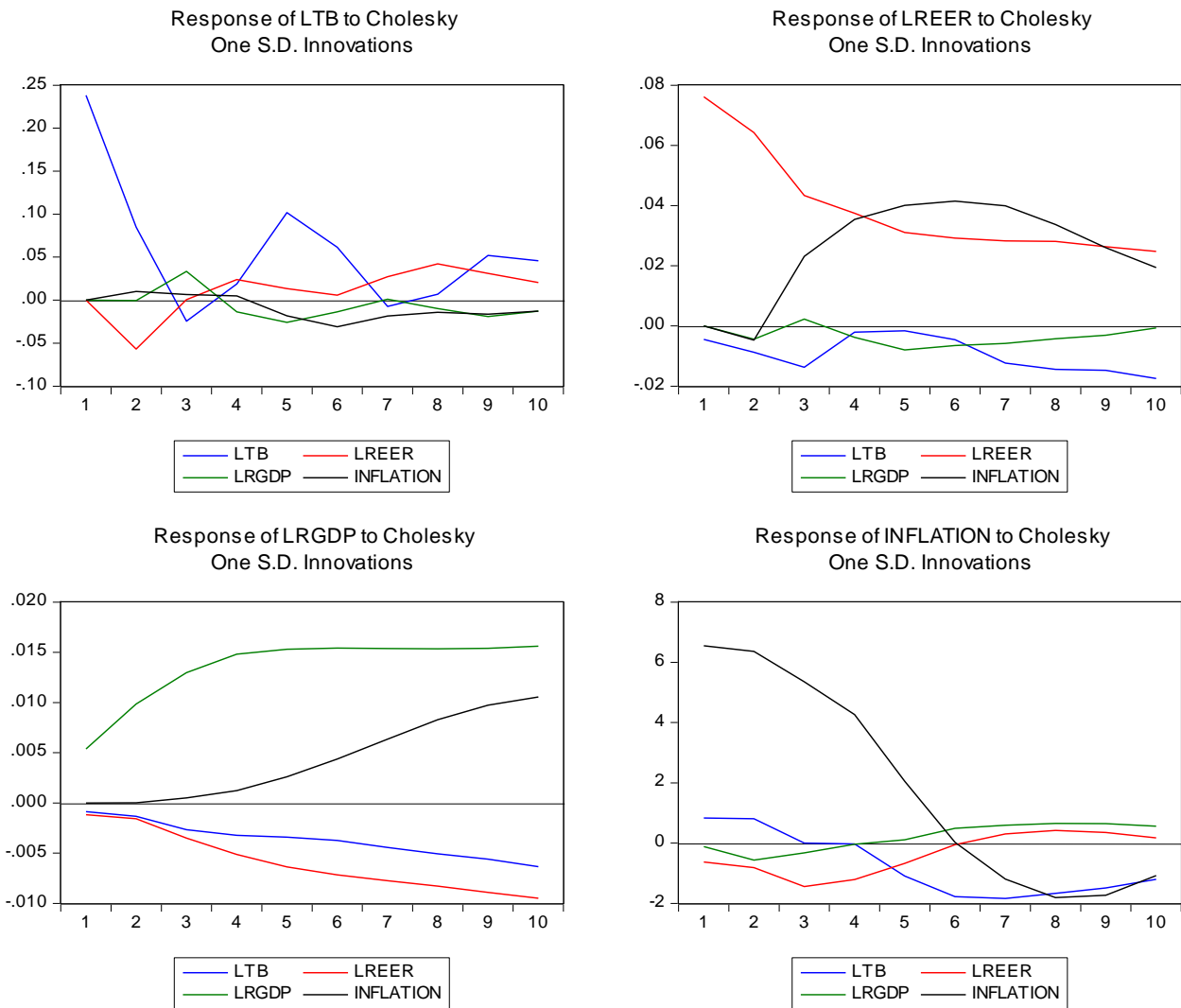
To see whether the ordering could be a problem, the contemporaneous correlations of VAR error terms are checked and displayed in Table 5.8. The results show that there are correlations between REER and INF, and between RGDP and INF. Based on this, we can arrange the variables according to the following order: INF, RGDP, REER, and TB.

**Table 5.8 Contemporaneous Correlations of VAR Error Terms**

	TB	REER	RGDP	INF
TB	1			
REER	0.098	1		
RGDP	0.104	-0.016	1	
INF	0.03	0.243	0.44	1

VDC is an alternative method to IRFs for examining the effects of shocks on dependent variables. It shows how much of the forecast error variance for any variable in a system is explained by innovations to each explanatory variable over a series of time horizons. Usually, own series shocks explain most of the error variance, although the shock will also affect other variables in the system. From Table 5.9, the VDC substantiates the significant role played by RGDP, INF, and REER in accounting for fluctuations in the Ethiopia TB. At the two-year horizon, the fraction of Ethiopian's trade balance forecast error variance attributable to variations in REER, INF, and RGDP are 4.8240 %, 0.1502 %, and 0.0003 % respectively. The explanatory power of all variables increases further at the increasing-year horizon, but the percentage of trade balance forecast variance explained by innovations in real gross product is smaller than explained by innovations in other variables. However, the portion of trade balance variations explained by all explanatory variables increases continuously over longer horizons, for which the percentage of forecast variances in the trade balance is largely explained by innovations in inflation among other explanatory variables, maintains higher percentages than the others. Looking along the main diagonal, the results reveal that the own shock is relatively high for all variables of trade balance, real gross domestic product, inflation rate and real effective exchange rate in VDCs, in the short horizon but decreases for the long horizon.

**Figure 3 Impulse Response Function**



**Figure 3** impulse response function (IRFs) shows the change in trade balance highly explained by from its own shock. Similarly, the variation of trade balance is better explained by the innovations in inflation rate among other explanatory variables of real gross domestic product and real effective exchange rate.

**Table 5.9 Results of Variance Decomposition**

% of Forecast Variances Explained by Innovation in				
Horizon (period)	TB	RGDP	INF	REER
A) Variance Decomposition of Trade Balance				
2	95.0255	0.0003	0.1502	4.8240

4	92.0946	2.4028	0.6081	4.8946
6	91.1962	2.4778	1.6730	4.6529
8	90.0844	2.4473	2.0389	5.4294
10	86.8712	2.7661	2.3914	7.9713
B) Variance Decomposition of RGDP				
2	1.9248	95.1297	0.0001	2.9454
4	3.6367	85.8128	0.9829	9.5676
6	4.2173	78.8314	4.3939	12.5574
8	5.1227	70.8639	9.6732	14.3400
10	5.6582	67.3713	11.9060	15.0645
C) Variance Decomposition of INF				
2	1.5676	0.0288	97.5155	0.8881
4	1.1505	0.3750	95.7902	2.6843
6	1.1504	0.3751	95.7904	2.6844
8	6.0253	0.6873	89.8711	3.4163
10	8.6239	1.1494	86.8857	3.3409
D) Variance Decomposition of REER				
2	0.9574	0.1934	0.2226	98.6265
4	1.8840	0.2534	11.8143	86.0483
6	1.5139	0.7044	24.9258	72.8559
8	2.6532	0.7774	31.0478	65.5216
10	4.2330	0.7326	31.6015	63.4329

#### 5.4. Diagnostic Checks

ARDL model passes all diagnostic tests, such as the Lagrange multiplier test of residual serial correlation, Ramsey's RESET test using the square of the fitted values (functional specification), normality test, and Breusch-Pagan-Godfrey test of heteroscedasticity (see Table 5.5). That means all the tests given on the indicated table shows that we cannot reject the null hypothesis which implies that the model has no serial correlation and heteroscedasticity.

## 5.5. Sensitivity Checks

Repeating everything done above by using the Schwarz Bayesian Criterion (SBC) does not change the results. SBC selects the ARDL (1,3,0,0) model, but the estimated model has a serial correlation problem. The long-run coefficients of LREER and INF remain same and significant, and that of LRGDP is not significant. ECM term is also significant and negative.

We run the above ARDL (1,3,0,0) model by using the logarithm of inflation rate instead of the inflation rate. As shown below the magnitude of some of the long-run coefficients obtained from ARDL(3,4,0,2) change but the signs are consistent with the ones obtained from the model used above. Error correction model results are also quite similar to the one reported above.

**Table 5.10 Estimated Long Run Coefficients For ARDL(3,4,0,2)**

Regressor	Coefficient	T-Ratio [Prob]
LRGDP	-0.110030	-0.474261 [0.1315]
LREER	0.356206	-2.378178 [0.0196]
LINF	-0.63142	-0.477468 [0.0000]
CONST		34.6151568.344546 [0.2023]

Notes: INF=LINF, ARDL(3,4,0,2) selected based on Akaike Information Criterion, Dependent variable is LTB and 85 observations used for estimation from 1993Q1 to 2015Q2.

The results reported above are obtained by using data that are not seasonally adjusted. Since TB, RGDP, and REER do not appear to exhibit seasonality (judging by the plots) we seasonally adjust INF and repeat the above analysis. X-13ARIMA SEATS seasonal adjustment software developed by the United States Census Bureau has been used to seasonally adjust INF (using this software to seasonally adjust TB, RGDP, and REER yielded back the original series). We find that there is co-integration between the variables when seasonally adjusted INF is used to run

Equation (5) (the optimal lag length selected is one, there is no serial correlation, but there is heteroscedasticity). After establishing co-integration we go ahead with the ARDL model, which yield the results reported in Tables 5.11, 5.12, and 5.13 (we report the results from the model selected by Schwarz Bayesian Criterion because it satisfies the CUSUM and CUSUMSQ tests). The long run coefficients reported in Table 5.12 shows that the coefficient of the seasonally adjusted INF is positive and significant, that is, the coefficient of the inflation rate variable

changes sign and magnitude. Another important change is that long run coefficient of LRGDP becomes significant. The results from the error correction model are similar, that is, ECM term is almost the same as before (see Tables 5.7 and 5.13).

**Table 5.11 Autoregressive Distributed Lag Estimates For ARDL(1,3,0,2)**

Regressors	Coefficient	T-Ratio [Prob]
LTB (-1)	-0.1158005	0.7354 [0.0791]
LREER	2.1538794	1.137512 [0.0409]
LREER (-1)	-0.312513	-1.400521 [0.0013]
LREER(-2)	-0.325801	-0.432166 [0.5725]
LREER (-3)	-0.975241	-4.562371 [0.0308]
LRGDP	-1.431018	-0.566310 [0.0015]
LINF	0.0032560	0.342154 [0.0093]
LINF(-1)	-0.012064	-0.163173 [0.3621]
LINF (-2)	-0.034055	-0.163173 [0.2335]
CONST	0.6752338	0.321205 [0.3204]
R-Squared	0.575342	
R-Bar-Squared	0.686536	
S.E. of Regression	0.348502	
F-stat. F(9, 77)	5.5476 [0.000]	
Akaike Info. Criterion	0.026514	
Schwarz Bayesian Criterion	0.546732	
DW-statistic	2.321453	
<b>Diagnostic Tests</b>		
Test Statistics	LM Version	
A: Serial Correlation	CHSQ (4) = 8.1232 [0.385]	
B: Functional Form	CHSQ (1) = 0.0034391 [0.792]	
C: Normality	CHSQ (2) = 0.43464 [0.912]	
D: Heteroscedasticity	CHSQ (1) = 0.019556 [0.788]	

Notes: ARDL(1,3,0,2) selected based on Schwarz Bayesian Criterion

Dependent variable is LTB

85 observations used for estimation from 1993Q1 to 2015Q2

A:Lagrange multiplier test of residual serial correlation

B:Ramsey's RESET test using the square of the fitted values

C:Based on a test of skewness and kurtosis of residuals

D:Based on the regression of squared residuals on squared fitted values

**Table 5.12 Estimated Long Run Coefficients For ARDL(1,3,0,2)**

Regressor	Coefficient	T-Ratio [Prob]
LRGDP	-0.213420	-0.564781 [0.0000]
LREER0	0.146043	-1.345156 [0.0166]
LINF	0.46285	-0.366445 [0.0000]
CONST	23.547532	10.254362 [0.1924]

Notes: ARDL(1,3,0,2) selected based on Schwarz Bayesian Criterion, Dependent variable is LTB and 85 observations used for estimation from 1993Q1 to 2015Q2.

**Table 5.13 Error Correction Representation for the Selected ARDL(1,3,0,2)**

**Model**

Regressors	Coefficients	T-Ratio [Prob]
dLREER0	0.35213	-2.5832 [0.018]
dLREER1	-0.14312	-1.4321 [0.215]
dLREER2	0.03157	-1.7326 [0.084]
dLRGDP	1.03758	2.1372 [0.546]
dLINF	-0.27375	-1.7453 [0.031]
dLINF1	-1.00251	-3.1161 [0.015]
CONST	13.00817	10.1054 [0.000]
ECM (-1)	-0.53687	-8.0036 [0.000]

List of additional temporary variables created:

dLTB = LTB-LTB(-1)

dLREER = LREER-LREER (-1)

dLREER1 = LREER (-1) - LREER (-2)

dLREER2 = LREER (-2) - LREER (-3)

$$dLRGDP = LRGDP - LRGDP(-1)$$

$$dINF = INF - INF(-1)$$

$$dINF1 = LINF(-1) - LINF(-2)$$

$$ECM = LTB - 0.146043 * LREER + 0.213420 * LRGDP + 0.46285 * INF - 23.547532 * CONST$$

R-Squared 0.68412

R-Bar-Squared 0.37984

S.E. of Regression 0.042310

F-stat. F ( 7, 79) 8.6856 [0.000]

Akaike Info. Criterion 180.9243

Schwarz Bayesian Criterion 168.0534

DW-statistic 4.0217

Notes: ARDL(1,3,0,2) selected based on Schwarz Bayesian Criterion, Dependent variable is LTB and 85 observations used for estimation from 1993Q1 to 2015Q2.

## 6. CONCLUSION

The objective of this study was to assess short and long run relationships between trade balance and real effective exchange rate, as well as inflation rate using Autoregressive Distributive Lag approach to co-integration and Error Correction Model using time series data from 1993Q1 to 2015Q2. We examined whether a long-run relationship exists between Ethiopian trade balance, real gross domestic product, real effective exchange rate and the inflation rate. We have also examined the short-run dynamics of the model by using the error correction model. The results were validated by the diagnostic tests and stability test of Brown et-al (1975) cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) method. In the time series analysis undertaken by this study it was revealed that real effective exchange rate has both long-run and short-run significant positive relationship with trade balance. In the long-run one per cent increase in real effective exchange rate increases trade balance by about 0.19 percent. It was also noted that inflation rate has significant negative relationship with trade balance both in the long-run and short term. A one percent increase in the inflation rate decreases trade balance by about 98 percent in the long-run.

The results also showed that real gross domestic product has a negative effect on trade balance in the long-run but not in the short-run. But, Singh (2002) study shows that real effective exchange rate and gross domestic product have a very significant effect on Indian trade balance. Under Johansen co-integration approach only one co-integrated equation is obtained. That indicates the presence of long run relationship between trade balance and real gross domestic product, real effective exchange rate, and inflation rate. The error correction model (ECM) shows both the short run and long run relationship among the selected macroeconomic variables. The coefficient of the error correction term indicates that 75.7% of shock (short-run disequilibria) will be adjusted within the same year, but under bound test of co-integration nearly 80 % of the previous quarter's shock adjusts back to long-run equilibrium in the current quarter.

When seasonally adjusted data (inflation rate in this particular case) are used our main result does not change much: In the long-run one per cent increase in real effective exchange rate increases trade balance by about 0.15 per cent. But the results on the inflation rate and the real gross domestic product change. The long run coefficient of the inflation rate, which is seasonally adjusted, becomes positive. The long run coefficient of the real gross domestic product becomes significant.

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## Appendices

### 1. Estimated Long Run Coefficients

Regressor	Coefficient	T-Ratio [Prob]
LREER	-0.119380-0.873661 [0.0847]	
LRGDP	0.186206-2.378178 [0.0196]	
INF	-0.98222-0.477468 [0.0000]	
CONST	1.6196561.344546 [0.1823]	

Notes: ARDL(3,4,0,1) selected based on Akaike Information Criterion, Dependent variable is LTB and 85 observations used for estimation from 1993Q1 to 2015Q2.

### 2. Unit root test for the selected macroeconomic variables

#### 2.1. ADF test for TB at level with intercept

Null Hypothesis: LTB has a unit root

Exogenous: Constant

Lag Length: 7 (Automatic - based on SIC, maxlag=11)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.498511	0.5295
Test critical values: 1% level	-3.512290	
5% level	-2.897223	
10% level	-2.585861	

\*MacKinnon (1996) one-sided p-values.

#### 2.2.ADF test for TB at 1<sup>st</sup> difference with intercept

Null Hypothesis: D(LTB) has a unit root

Exogenous: Constant

Lag Length: 6 (Automatic - based on SIC, maxlag=11)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.321999	0.0000

Test critical values: 1% level	-3.512290
5% level	-2.897223
10% level	-2.585861

\*MacKinnon (1996) one-sided p-values.

### 2.3 ADF test for REER at level with intercept

Null Hypothesis: LREER has a unit root

Exogenous: Constant

Lag Length: 4 (Automatic - based on SIC, maxlag=11)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.442618	0.0000
Test critical values: 1% level	-3.505595	
5% level	-2.894332	
10% level	-2.584325	

\*MacKinnon (1996) one-sided p-values.

### 2.4 ADF test for RGDP at level with intercept

Null Hypothesis: LRGDP has a unit root

Exogenous: Constant

Lag Length: 7(Automatic - based on SIC, maxlag=11)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	1.882106	0.9998
Test critical values: 1% level	-3.506484	
5% level	-2.894716	
10% level	-2.584529	

\*MacKinnon (1996) one-sided p-values.

### 2.5 ADF test for RGDP at 1<sup>st</sup> difference with intercept

Null Hypothesis: D(LRGDP) has a unit root

Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=11)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.000804	0.0387
Test critical values: 1% level	-3.506484	
5% level	-2.894716	

10% level -2.584529

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\*MacKinnon (1996) one-sided p-values.

## 2.6 ADF test for INF at level with intercept

Null Hypothesis: INFLATION has a unit root

Exogenous: Constant

Lag Length: 3 (Automatic - based on SIC, maxlag=11)

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	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.422094	0.0127
Test critical values: 1% level	-3.506484	
5% level	-2.894716	
10% level	-2.584529	

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\*MacKinnon (1996) one-sided p-values.

## 2.7 PP test for TB at level with intercept

Null Hypothesis: LTB has a unit root

Exogenous: Constant

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

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	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-5.204164	0.0963
Test critical values: 1% level	-3.505595	
5% level	-2.894332	
10% level	-2.584325	

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\*MacKinnon (1996) one-sided p-values.

## 2.8 PP test for TB at 1<sup>st</sup> difference with intercept

Null Hypothesis:D( LTB) has a unit root

Exogenous: Constant

Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

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	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-4.364264	0.0000
Test critical values: 1% level	-3.606685	
5% level	-2.87451	
10% level	-2.4575326	

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\*MacKinnon (1996) one-sided p-values.

## 2.9 PP test for REER at level with intercept

Null Hypothesis: LREER has a unit root

Exogenous: Constant

Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

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	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-5.232032	0.0000
Test critical values: 1% level	-3.505595	
5% level	-2.894332	
10% level	-2.584325	

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\*MacKinnon (1996) one-sided p-values.

## 2.10 PP test for RGDP at level with intercept

Null Hypothesis: LRGDP has a unit root

Exogenous: Constant

Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

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	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	2.904007	1.0000
Test critical values: 1% level	-3.505595	
5% level	-2.894332	
10% level	-2.584325	

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\*MacKinnon (1996) one-sided p-values.

### **2.11 PP test for RGDP at 1<sup>st</sup> difference with intercept**

Null Hypothesis: D(LRGDP) has a unit root

Exogenous: Constant

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

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	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-3.243141	0.0208
Test critical values: 1% level	-3.506484	
5% level	-2.894716	
10% level	-2.584529	

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\*MacKinnon (1996) one-sided p-values.

### **2.12 PP test for INF at level with intercept**

Null Hypothesis: INFLATION has a unit root

Exogenous: Constant

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

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	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-3.181044	0.0244
Test critical values: 1% level	-3.505595	
5% level	-2.894332	
10% level	-2.584325	

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\*MacKinnon (1996) one-sided p-values.

## **2. Serial correlation LM test for ECM**

Breusch-Godfrey Serial Correlation LM Test:

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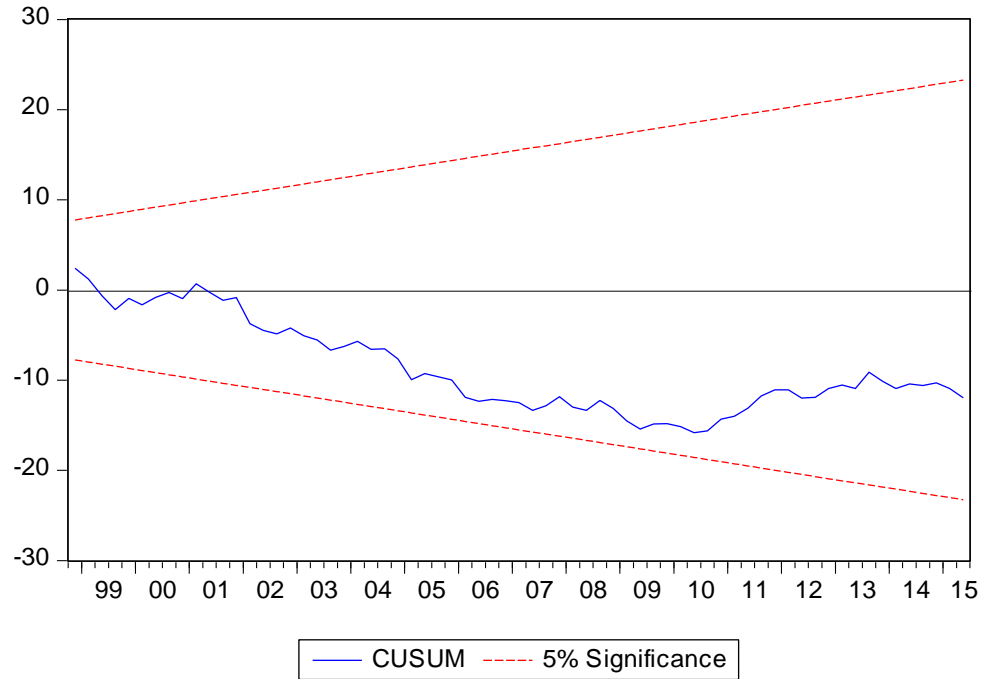
F-statistic	0.903767	Prob. F(4,60)	0.4676
Obs*R-squared	4.830317	Prob. Chi-Square(4)	0.3052

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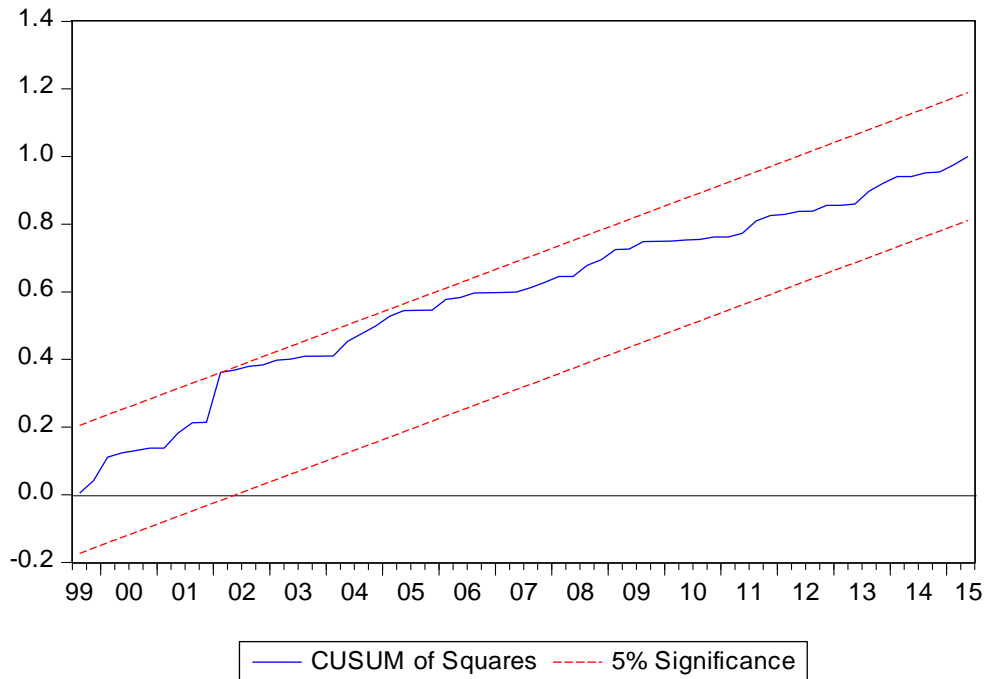
### 3. Stability test

Figure 2 Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

**Table 6 Performance of Ethiopia's Merchandize Trade (value in ETB)**

Year	Values of import	Values of export	Trade Balance
1993 QI	461.0	89.1	0.19
QII	1,461.5	169.3	0.12
QIII	827.5	235.5	0.28
QIV	919.8	308.3	0.34
1994 QI	899.1	205.7	0.23
QII	1,290.3	245.3	0.19
QIII	1,148.7	280.9	0.24
QIV	1,401.9	515.9	0.37
1995 QI	1,582.5	549.7	0.35
QII	1,525.5	725.5	0.48
QIII	1,431.3	468.2	0.33
QIV	2,007.0	988.7	0.49
1996 QI	2,190.3	691.8	0.32
QII	1,893.1	454.2	0.24
QIII	1,799.1	548.7	0.31
QIV	1,825.7	844.2	0.46
1997 QI	1,673.0	684.5	0.41
QII	1,805.3	573.1	0.32
QIII	1,773.5	860.8	0.49
QIV	2,132.1	1,367.3	0.64
1998 QI	1,914.2	758.8	0.40

QII	1,670.8	967.3	0.58
QIII	3,032.0	1,048.2	0.35
QIV	2,031.0	1,368.3	0.67
1999 QI	2,774.5	918.2	0.33
QII	2,954.4	632.3	0.21
QIII	3,233.8	794.2	0.25
QIV	2,739.3	1,166.9	0.43
2000 QI	3,381.1	920.0	0.27
QII	2,919.3	771.6	0.26
QIII	2,468.0	1,041.3	0.42
QIV	2,670.0	1,224.9	0.46
2001 QI	2,600.3	1,040.1	0.40
QII	2,630.0	684.4	0.26
QIII	3,347.1	1,026.4	0.31
QIV	3,736.5	1,115.7	0.30
2002 QI	3,687.9	807.1	0.22
QII	4,575.1	900.8	0.20
QIII	2,976.3	917.0	0.31
QIV	3,246.0	1,239.5	0.38
2003 QI	3,726.1	960.3	0.26
QII	3,952.2	997.7	0.25
QIII	4,106.3	1,072.4	0.26
QIV	4,145.0	1,111.9	0.27

2004 QI	3,322.7	1,118.7	0.34
QII	6,646.6	965.5	0.15
QIII	6,675.1	1,475.7	0.22
QIV	5,651.3	1,616.8	0.29
2005 QI	7,458.3	1,463.4	0.20
QII	6,875.8	1,358.5	0.20
QIII	7,746.4	2,070.4	0.27
QIV	9,353.6	2,438.9	0.26
2006 QI	9,259.8	1,618.5	0.17
QII	9,410.3	1,821.7	0.19
QIII	9,421.1	2,414.4	0.26
QIV	11,781.9	2,830.8	0.24
2007 QI	9,526.6	1,778.2	0.19
QII	11,083.6	2,006.4	0.18
QIII	12,296.4	3,001.2	0.24
QIV	12,219.8	3,671.9	0.30
2008 QI	12,724.4	2,401.9	0.19
QII	14,333.0	2,441.8	0.17
QIII	16,503.1	4,424.9	0.27
QIV	19,586.5	4,374.7	0.22
2009 QI	24,931.9	3,388.4	0.14
QII	19,682.8	2,673.4	0.14
QIII	20,431.4	4,398.8	0.22

QIV	19,631.1	4,748.7	0.24
2010 QI	21,931.9	4,235.3	0.19
QII	29,280.3	4,661.2	0.16
QIII	30,274.9	7,380.5	0.24
QIV	27,469.2	9,838.4	0.36
2011 QI	27,929.4	8,126.8	0.29
QII	36,215.6	9,067.8	0.25
QIII	32,559.5	12,685.6	0.39
QIV	32,988.9	14,645.4	0.44
2012 QI	39,897.6	12,799.3	0.32
QII	45,528.7	10,196.4	0.22
QIII	56,933.1	14,222.2	0.25
QIV	49,227.7	17,276.9	0.35
2013 QI	45,693.9	12,477.4	0.27
QII	59,269.4	12,944.3	0.22
QIII	45,978.7	14,875.8	0.32
QIV	45,929.0	15,716.8	0.34
2014 QI	54,692.57	11,825.1	0.22
QII	66,084.04	12,905.4	0.20
QIII	70,690.42	18,715.0	0.26
QIV	70,370.33	18,797.5	0.27
2015 QI	72,347.87	14,213.8	0.20
QII	87,639.12	13,036.5	0.15

Source:- National Bank Of Ethiopia (NBE).

## DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all sources of materials used for the thesis have been duly acknowledged.

Declared by:-

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Confirmed by Advisor:-

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_