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The Effect of Real Efffective Exchange Rate Volatility on Uganda's Trade Balance (1993-2015)

Dennis Mahebe[1] ,Francis Wasswa[2] and Willy Kagarura[3]

[1]Economist, National Planning Authority (NPA), Kampala-Uganda;

[2]Senior Lecturer, School of Economics, Makerere University, Kampala-Uganda;

[3]Senior Lecturer, School of Economics, Makerere University, Kampala-Uganda.

ABSTRACT

This paper investigated the effect of Real Effective Exchange Rate (REER) volatility on Uganda's Trade Balance for the period 1993Q4 to 2015Q4 by employing the GARCH and ARDL methodology. The ARDL results revealed a negative relationship between the trade balance and the volatility of the real effective exchange rate in the short run. The Impulse Response Function results show evidence of the J-Curve on Uganda's Trade Balance. Also, the results on the REER indicate that the Marshal-Lerner Condition holds for Uganda's case. The study therefore recommends that developing a well-developed hedging facility like forward markets and institutions is critical in protecting exporters against exchange rate risk in the short run by reducing volatility of the real effective exchange rate with the aim of improving Uganda's trade balance.

Keywords: REER-Volatility, Trade Balance, GARCH, ARDL, J-Curve, Marshal-Lerner Condition

Disclaimer; The views expressed in this paper are those of the authors and do not reflect the position and Policies of their respective institutions.

***Correspondence to Author:**
Dennis Mahebe
Economist, National Planning Authority (NPA), Kampala-Uganda;

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Introduction

Uganda through its vision 2040 which is a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years envisions a consistent growth rate target of over 8.2 percent per annum. However, achieving this growth requires continued implementation of fiscal, monetary and exchange rate policies.

Much as Uganda adopted a flexible exchange rate system in 1993 with the aim of controlling and managing its exchange rate, the country has still experienced rising deficits over the years as shown in figure 1.2. Some of the factors responsible for the growth in trade deficit include but not limited to strengthening of the dollar globally and weak economic fundamentals domestically such as export of mainly primary agricultural products like coffee and tea which are of low value and poor structure of the private sector which is dominated by the services sector[1]. Although Uganda's market for exports has grown over the years with increasing demand from COMESA, European Union, North America, Middle East, Asia and from other African countries, the country's import bill has also been growing by an even greater margin as seen from figure 1.2 thus leading to unfavorable trade balance.

Even though Uganda has undertaken numerous measures to improve the country's external trade performance including providing private credit to exporters; elimination of all quantitative restrictions; reducing on the time of issuance of an export permit to only 24 hours, providing export finance support to non-traditional exporters through Bank of Uganda among others Milner, Morrissey, and Rudaheranwa (2000), persistent foreign exchange rate volatility coupled with price fluctuations among others have undermined these efforts as these reduce on Uganda's exports and discourage exporters from producing for exports thus, resulting into a continued deficit which erodes the country's competitiveness and hamper economic growth and the attainment of its vision targets Milner, Morrissey, and Rudaheranwa (2000).

The aim of this study therefore was to examine the effect of real effective exchange rate volatility on Uganda's trade balance while specifically investigating whether Marshall-Lerner condition and J-curve hypothesis hold for Uganda.

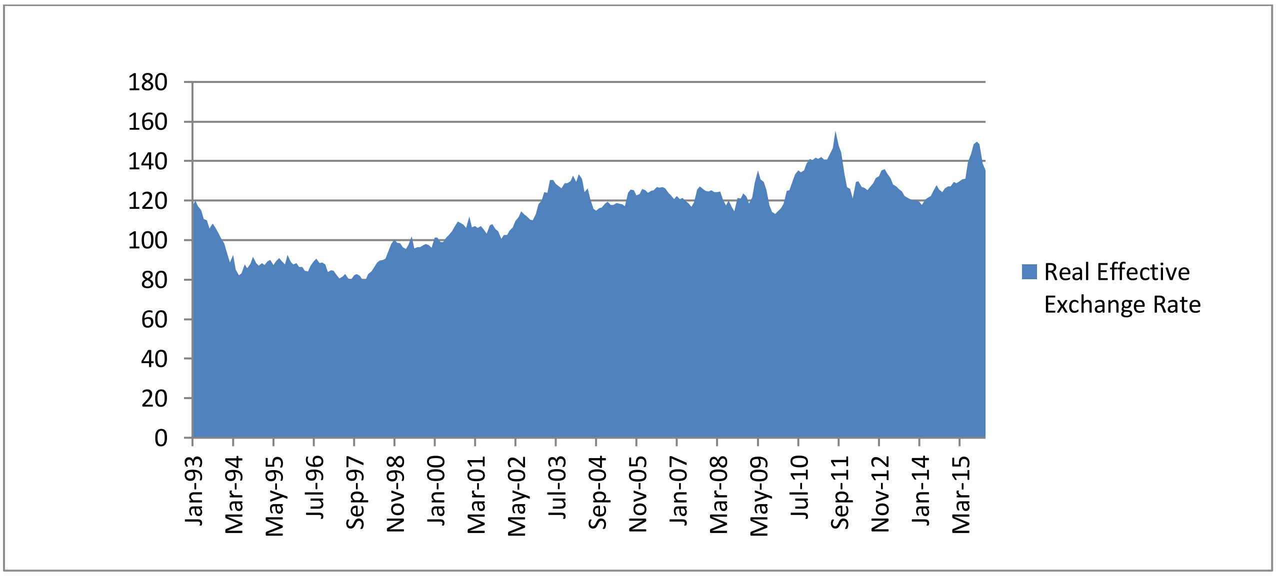

Figure 1. 1: Monthly Real Effective Exchange Rate (1993-2015)

Source: Bank of Uganda

[1] EPRC, 2015

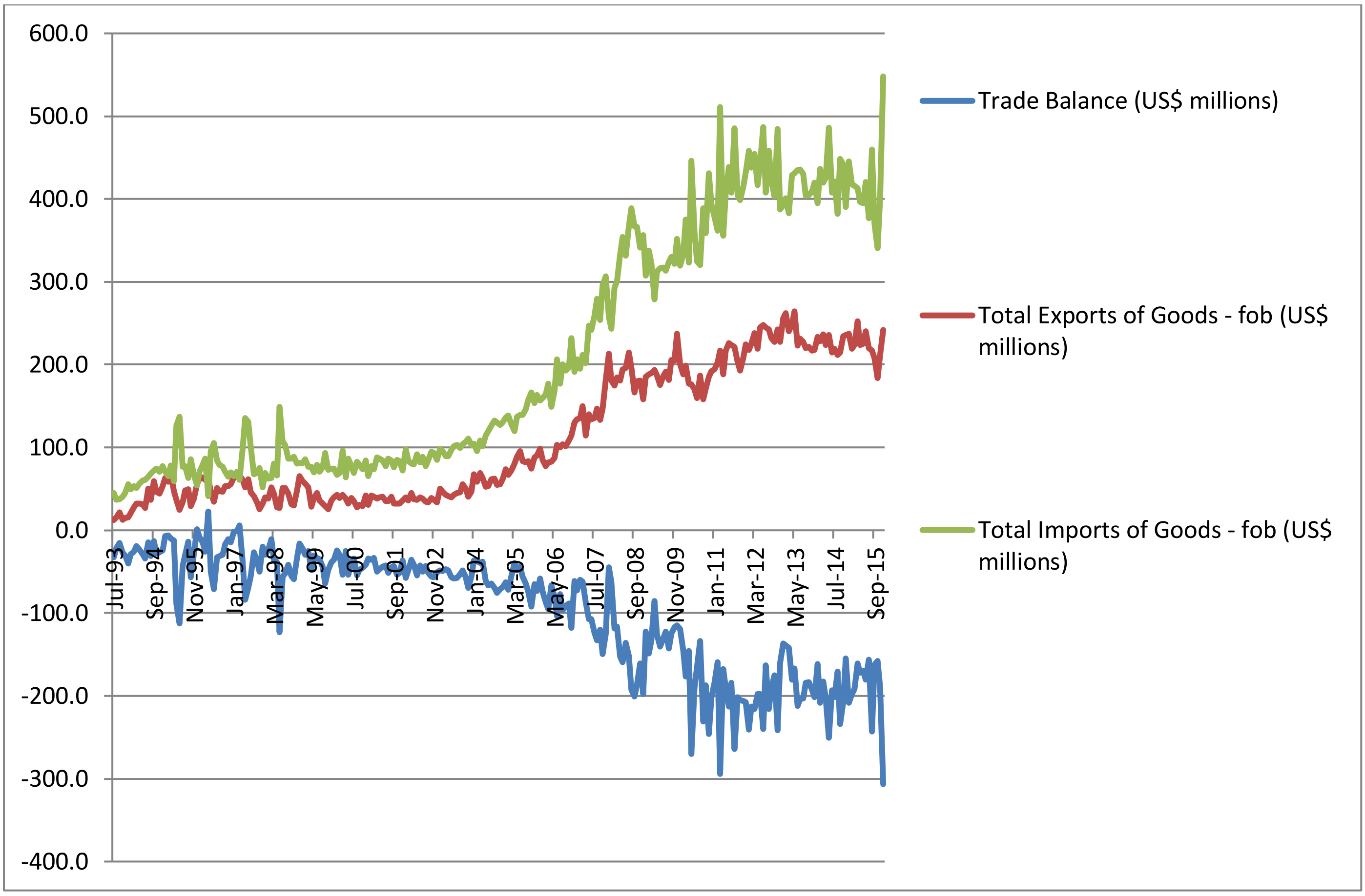

Figure 1. 2: Total exports, imports and the trade balance 1993-2015 (US $ Millions) ***Source: Bank of Uganda***

The effect of exchange rate volatility on foreign trade has received less attention in developing countries and this may be partly due to lack of sufficient time series data to aid econometric analysis (Ziramba and Chifamba, 2014 Sekantsi,2009, Takaendesa et al.,2006). However, there have been efforts to investigate the effect of exchange rate volatility on trade in developing countries including Sub-Saharan African countries (see for example, Kamoto, 2006; Umoru and Eboreime, 2013; Bahmani-Oskooee and Gelan, 2012). Kamoto (2006) investigated the J-curve effect on the trade balance in Malawi and South Africa using the VECM and the generalized impulse response function. This study found a positive long-run relationship between the real effective exchange rate (REER) and the trade balance a sign that a real depreciation will improve the trade balance in the long run for both Malawi and South Africa. The study also finds evidence of the J-curve for the South African trade balance which does not exist for Malawi's case.

In Uganda, Okot and Nyanzi (2014) examined the impact of exchange rate volatility on flower exports using VECM approach for the period 2001m7 to 2012m12, their results revealed a positive long run but negative short-run relationship between the flower exports and exchange rate volatility in Uganda. However, the authors noted that the magnitude of the impacts varies depending on the measures used for REER volatility.

The contributions of this study are mainly twofold. First, contributes to the existing empirical literature on the effect of exchange rate volatility on trade in Uganda. Second, contributes on the existing debate in this area by analyzing the relationship between real effective exchange rate volatility and the trade balance where different studies such as Kamoto (2006) in Malawi and south Africa, Arabi and Abdalla

(2014) in Sudan among others have different findings in this area, therefore it implies that there is still debate in this area of study which this study contributes to by adding new knowledge to this area specifically for Uganda's case where literature on this topic remains scanty.

The rest of the paper is organized as follows. Section Two presents the literature review of selected studies on exchange rate volatility and trade balance, particularly those done in developing countries including Sub-Saharan Africa region. Section Three presents the Methodology. The estimation results are presented in Section Four. Finally, a conclusion of the study is provided in Section Five.

2.0 Literature

2.1 Theoretical Approaches

The relationship between exchange rate and trade balance is explained by various theoretical approaches such as the elasticity approach, absorption approach, monetary approach and the two-country imperfect substitute model approach as explained below.

2.1.1 The Elasticity Approach

This approach is based on the effects brought about by consumption and production and the substitution effect that is as a result of the adjustment in exchange rate. The model assumes a partial equilibrium of the two countries and the two goods model and it assumes the existence of perfect competition in the foreign market in the analysis of the effect of exchange rate adjustments on trade balance. The elasticity approach is analyzed by the separation of the markets for imports and exports while considering the income of both the foreign and domestic economy Shao (2008). However, in this model, the real exchange rate is measured by the terms of trade and also domestic and foreign price are assumed to be constant or are exogenously determined. Consequently, the devaluation/depreciation is expected to increase the volume of home country's exports and lower the imports by the home country hence improve on trade balance Jha (2003).

The Elasticity approach is further explained by the; The Marshall-Lerner Condition[2] and the J-curve[3].

2.1.2 The Absorption Approach

The absorption approach was developed by Alexander in 1952 and was elaborated further by Johnson, who defined trade balance as the difference between aggregate domestic income and aggregate domestic expenditure. This definition shifts away from the definition of the trade balance as the difference between exports and imports (Johnson 1972). The approach further stipulates that devaluation increases net exports if real income is increased or decreased basing on the assumption that government spending is fixed. Further, the approach highlights that devaluation/depreciation improves trade balance if the economy is not at full employment and conversely, if the economy is at full employment, then devaluation or currency depreciation may not improve trade balance Stonecash, Gans, King, and Mankiw (2011). The approach also considers the Keynesian income expenditure assumption that volumes of exports are independent of the national income and that national income affects positively the level of imports. However, the approach treats devaluation as a single policy that could be implemented without incorporation of other policies which may be relevant to achieve desired effect of improving trade balance Johnson (1972). The approach also considers the economy from the aggregate expenditure side; especially it stipulates that the exchange rate has a direct effect not only on

[2] Devaluation/ depreciation of a currency will improve a country's trade balance in the long-run if the sum of absolute values of imports and exports demand price elasticities exceeds unity.

[3] The J-Curve effect to trade balance stipulates that a country's trade balance measured in home currency units may be expected to deteriorate in the short run after the depreciation of the home currency and then in the long run, trade balance may improve.

relative prices, absorption and income, but also on trade balance (Duasa, 2007).

2.1.3 The Monetary Approach

The monetary approach considers the supply and demand of money, where the supply of money is managed by the government through the central bank. If there is more domestic demand of money more than what the central bank is able to supply, then there would be need for the money from the foreign countries to fill the gap of the excess demand and as a result, trade balance may be favorable (Duasa, 2007). On the contrary, in the situation of having more money supply in the domestic economy by the monetary authority than is demanded, then there would be excess money supply and this may result in outflow of money outside the economy and hence there may be decline in trade balance. Therefore, this approach considers excess money demand and money supply as having an effect on the trade balance.

2.1.4 The Two Country Imperfect Substitute Model Approach

This approach shows the nature of the relationship of real exchange rate on trade balance in both short and long run. It stipulates that depreciation of the real exchange rate improves trade balance. Besides, the model assumes that there are no perfect substitutes in the imports and exports for the locally produced goods and services Rose and Yellen (1989). The model assumes also the following; first that price elasticities of demand and the domestic and foreign income elasticities are positive. Secondly, the income in the foreign or importing country may influence the level of exports by the domestic economy besides the price of domestic substitutes and the price of the imported goods. The model is expressed as the partial reduced form of the domestic trade balance which is a function of the real exchange rate, domestic and foreign income. The advantages of this model are that a single equation is adopted in the analysis process. Also, there is no need of the structural parameters and as a result it is likely to give the desired or undesired relationship /effect of the real exchange rate on the trade balance Flood, Rose, and Mathieson (1991). However, the model in-corporates variable from other approaches and hence is not 'standalone' model. These variables as outlined are RER, domestic income and foreign income. Other variables may also be included in the model. The model will also adopt the analysis of the Marshall-Lerner condition. In addition, the model will analyze the existence of the J-curve effect on trade balance following currency depreciation.

The theoretical approaches discussed show various effects of real exchange rate and other variables like money supply, domestic and foreign income on trade balance. According to Bahmani-Oskooee (1992), the real exchange rate was identified by the elasticity approach as having a major effect on trade balance and hence supports the policy of currency devaluation to improve trade balance. The monetary approach stipulates that money supply may be used as a tool to improve trade balance but excess money supply may lead to trade deficit. Also, Bahmani-Oskooee (1992: 85) highlighted that domestic income is advocated by the Keynesian approach to affect the trade balance and advised that contractionary fiscal policy was favorable to improve trade balance. On the other hand, the two-country imperfect substitute model relates the real exchange rate between two bilateral countries/trading partners and the trade balance of the home country.

2.2 Empirical literature

Empirical evidence concerning the effect of exchange rate volatility is inconclusive as some studies have found a negative relationship between exchange rate volatility and trade flows (Bhattarai and Armah, 2005; Vergil, 2002), while other studies like Kamoto (2006) find a positive relationship.

Baharumshah (2001) employes an unrestricted VAR model for bilateral trade balane of Thialand and Malysia with the United States and Japan for the period 1980 to 1996. He finds support for a stable and positive long-run relationship between trade balance and the exchange rate. A delayed J-curve seems to apply to Thialand data, whilist no support for the J-curve was found in Malysian data. In addition, Bahmani-Oskooee and Kantipong (2001) using the ARDL model tested on disaggregated data for the J-curve between Thialand and her main trading partners for the period 1973 to 1997. They found evidence of the J-curve in bilateral trade with the US and Japan.

Stucka (2004) used a reduced form model to estimate short and long-run response of trade balance to domestic currency depreciation in Croatia. The results showed evidence of negative impact in the short-run but in the long-run, a permenent depreciation improved trade balance by one percent on the average. The author also finds evidance of a J-Curve. However, another study conducted by Cota and Erjavec (2006) on Croatia was at variance with Stucka's findings; using multivariate framework the study tested for the short-run and long-run exchange rate impacts on trade balance, the authors found that changes in real exchange rate impacted negatively on trade balance both in the short and long-run. Aziz (2008) while examining both the short run and long run efects of real effective exchange rate on Bangladesh's trade balance using Engle-Granger and Johansen techniques found evidence of a postive relationship between REER and the trade balance.

Kamoto (2006) investigated the J-Curve effect on the trade balance in Malawi and South Africa using a VECM. The results suggested the existence of a long-run equilibrium relationship among the variables for both Malawi and South Africa. From the results, there is a positive relationship between the trade balance and the real effective exchange rate indicating that a real depreciation improves the trade balance in the long run. The study finds evidence of the J-Curve on the South African trade balance. However, Malawi does not exhibit a statistically significant J-Curve phenomenon. In the case of South Africa, Moodley (2011) finds mixed results while examining the J-curve on South Africa's bilateral trade with the BRIC countries over the period 1994Q1 to 2009Q4 from an ARDL model. The author concludes that devaluation/depreciation does not necessarily lead to long term improvement of the trade balance and therefore no evidence of the J-curve was found. While in Malawi Kwalingana, Simwaka, Munthali, and Chiumia (2012) while examining the short-run and long-run trade balance response to exchange rate changes using the multivariate cointegration framework. Their results show that a real depreciation is not significant enough to change the trade balance pattern in the long-run.

Ogbonna (2010), investigated the effect of exchange rate devaluation on Benin's trade balance for the period 1950 to 2008. He employed co-integration, VECM and causality tests to determine the long run, as well as short-run dynamics, between the exchange rate and the trade balance for Benin. The key findings of the empirical exercise are that there is some limited evidence of an insignificant pass-through of exchange rate devaluation to trade balance, and evidence from generalized impulse response function suggests that the hypothesis of No J-curve effect cannot be rejected for Benin Republic. VECM estimates suggest the Marshall Lerner condition holds for Benin in the long run.

Bahmani-Oskooee and Gelan (2012) test the J-curve hypothesis for nine African countries[4]. Using the bounds testing approach to cointegration and error-correction modeling. Their results of the short-run indicate that at 10% level of significance there is at least one coefficient of the differenced real effective exchange rate that is significant in the cases of Burundi, Egypt, Mauritius, Nigeria, and Tanzania. These short-run effects translate into significant long-run positive effects in the results for Egypt, Nigeria, and South Africa. This finding

[4] Burundi, Egypt, Kenya, Mauritius, Morocco, Nigeria, Sierra Leone, South Africa, and Tanzania

suggests that a real depreciation is expected to improve the country's trade balance in the long-run. In the remaining countries the long-run coefficient for the real effective exchange rate is insignificant or negative. Their study does not find support for the J-curve in all countries.

Katusiime, Agbola, and Shamsuddin (2015) In their study on Exchange rate volatility–economic growth nexus in Uganda for the period 1960-2011 using an ARDL model and the GARCH model as a measure of exchange rate volatility; their results indicated that exchange rate volatility positively affected economic growth in Uganda in both the short run and the long run.

Arabi and Abdalla (2014) estimated the existence of a J-Curve for the Sudanese trade data using VECM. The Marshal Learner Condition was met for the elasticity of the real exchange rate while that of demand for imports and exports were not achieved. It also showed that the real income of the Euro-Zone had a positive impact on trade balance in the short-run and the long-run while the real income of Sudan and Arab countries had negative impact on the trade balance.

Bakhromov (2011) on the exchange rate volatility and the trade balance in Uzbekistan for the period 1999 to 2009 using the Johansen cointegration test showed that an increase in the exchange rate volatility adversely affected demand for both exports and imports and had an overall positive impact on the trade balance.

A study by Ng, Har, and Tan (2008) investigated whether the Marshal Lerner Condition and J-curve effect of the real exchange rate on the Malaysian trade balance exist in the short run and long run using VECM, their results indicated that depreciation improved the trade balance in the long run and showed the existence of the J-curve for Malaysia which is also supported by Baharumshah (2001).

Onafowora (2003) investigated the exchange rate-trade balance relationship for East Asia. His findings suggest that there are short run J-Curve effects for Indonesia and Malaysia in their Bilateral trade to both the US and Japan, and for Thailand in its bilateral trade to the US. with a real depreciation there is about 4 quarters but this is followed by an improvement in the long run. Thialand has the opposite movement in its bilateral trade to Japan; a real exchange rate devaluation shock initially improved then worsen and the improved the trade balance.

Using the generalized impulse response function from the VECM to examine the existence of J-curve for Japan, Korea and Taiwan, Hsing (2005) found that Japan's aggregate trade provided evidence of the J-curve phenomenon while Korea and Taiwan did not show any presence of the J-curve effect. He argues that this may be attributed to a small open economy effect[5].

Loto (2011) using OLS tested the existence of the M-L condition for Nigeria. Results from the study showed no evidance of the M-L condition. But Ogbonna (2011), using a data set covering the period 1970-2005, employed Johansen and Juselius cointegration approach and found that the M-L condition holds for Nigeria.

In summary, numerous studies, theoretically and empirically, have attempted to find the nature of the relationship between exchange rate volatility and trade balance. The empirical evidences have been mixed with some reporting positive while others suggest negative relationships. At best, these findings can be described as country and research method specific because none of the researchers have been able to identify a common thread as to when a relationship would exist between the trade balance and the exchange rate. This study expands the knowledge by specifically investigating the effect of real effective exchange rate volatility on the trade balance in Uganda for the period 1993 to 2015.

3.0 Material and Methods

[5] In small open economies like Korea and Taiwan, both imports and exports are invoiced in foreign currency as a result and the short run effect of real devaluation is hedged and the trade balance remains unaffected.

3.1 Theoretical Framework

The modeling of the trade balance in this paper follows similar equation chosen from Álvarez-Ude and Gómez (2006), Baharumshah (2001) and Ng, Har, and Tan (2008) by adopting a two-country imperfect substitute model developed by Rose and Yellen (1989) which emphasized an exchange rate on bilateral trade balance evidence.

Equilibrium goods market in an open economy can be described by the following equation:

$$Y = C\Big(\underset{+}{Y - T}\Big) + I\Big(\underset{+}{Y}, \underset{-}{r}\Big) + G - IM\Big(\underset{+}{Y}, \underset{-}{\varepsilon}\Big) + X\Big(\underset{+}{Y^*}, \underset{+}{\varepsilon}\Big)$$

Where Y represents total domestic income, C represents consumer spending, and T represents income tax, I represents investment, r represents interest rate, G represents government spending, ε represents real exchange rate, IM represents import, X represents export, and Y^* represents foreign income.

Signs in bracket (below the equation) indicate the relationships for respective factors. Consumers spending (C) which is a function of total income subtract income tax, which is known as disposable income $(Y - T)$. Higher disposable income leads to higher consumer spending. Investment (I) is a function of total income and interest rate. Nations would invest more with increase in total personal income. Thus, it shows positive relationship between investment and total income. Besides that, interest rate might affect investment decision. Lower interest rate reduces cost of capital, thus attracts more investors to come and invest in the country. For that reason, it shows negative relationship between investment and interest rate. In other words, higher interest rate would decrease total domestic investment. Real exchange rate is defined as nominal exchange rate (E)[6] multiply the foreign price level (P^*) and divide by the domestic price level (P) giving:

$$\varepsilon = \frac{(EP*)}{P} \qquad (1)$$

Import (IM) is influenced by domestic income or output(Y). Higher domestic income leads to high imports. So, it shows positive relationship. Quantity of import also depends on the real exchange rate (ε). Higher (ε) leads to lower quantity of imports because of the foreign goods being relatively more expensive. Export (X) depends on the foreign income (Y^*) and real exchange rate(ε). High foreign income leads to increase in foreign demands for all goods and services as a result exports increase. On the other hand, increase in real exchange rate, the relative price of foreign goods in terms of domestic goods also leads to increase in export. It is showing positive relationship between trade balance and foreign income, real exchange rate. As the objective is to examine that trade balance (Net export, NX) and exchange rate, other variables are assumed constant. The net export is:

$$NX \equiv X - IM \qquad (2)$$

[6] Nominal exchange rate (E) is defined as the number of unit domestic currency exchanged for one unit of foreign currency.

By substituting the function of export and import into equation (2), it gives

$$NX \equiv X(Y^*, \varepsilon) - IM(Y, \varepsilon)\ldots\ldots(3)$$

Substituting equation (1) into equation (3)

$$NX = X\left(Y^*, \frac{EP^*}{P}\right) - IM\left(Y, \frac{EP*}{P}\right)\ldots\ldots(4)$$

We can rewrite equation (4) as

$$NX = NX(Y, Y^*, \varepsilon)\ldots\ldots(5)$$

3.2 The Empirical Model

Therefore following the theoretical model, the study adopts an emperical model that expressse the trade balanec as a function of the level of domestic and foreign income and the real effective exchange rate as follows;

$$TB = f(Y, Y^*, REER, X)\ldots\ldots(6)$$

Where TB is trade balance, Y is the domestic income, Y^* is the foreign income, REER is the real effective exchange rate and X is a vector of other regressors.

Incorcoporating Broad money supply $(M2_t)$ and volatility of the real effective exchange rate $(VREER_t)$ as the control variables gives equation (7)

$$TB_t = \beta_0 + \beta_1 Y_t + \beta_2 Y_t^* + \beta_3 REER_t + \beta_4 M2_t + \beta_5 VREER_t + \mu_t\ldots\ldots(7)$$

In general time series variables are not normally distributed and according to Maddala and Lahiri (2009), if variables are not normally distributed, one can consider transformation of the variables using natural logarithm so that they become normally distributed therefore, in logarithm form, equation (7) becomes;

$$ln\,TB_t = \beta_0 + \beta_1\, ln\,Y_t + \beta_2\, ln\,Y_t^* + \beta_3\, ln\,REER_t + \beta_4\, ln\,M2_t + \beta_5\, ln\,VREER_t + u_t\ldots\ldots(8)$$

Where ln represents natural logarithm, u_t is assumed to be a white –noise process, and trade balance TB_t, is expressed as the ratio of exports to imports which allows all variables to be expressed in logarithm form and removes the need for appropriate price index to explain the trade balance in real terms.

Following classical theory, the sign of β_1 could be either positive or negative. If the estimate of β_1 is negative, it means an incraese in uganda's real income Y_t increases import volume. However, if the estimate of β_1 is postive, it means an incraese in Y_t is due to an increase in the production of import-substituted goods or due to rise in productive capacity. Similary, the estimate of β_2 could be either positive or negative. The sign of β_2 depends on whether the supply side factors dominate demand side factors. Marshall- Lerner Condition holds when β_3 is positive. However this is expected to be negative in the short-run. β_4 is expected to be negative because increase in money supply is expected to increase imports which worsens the trade balance. Trade theory is not clear about the sign of β_5 which is the main basis for this emperical research. Therefore this can either be positive or negative.

The inclusion of REER, Y and $Y*$ is given in the two country imperfect substitute model and have also been tested in other empirical studies in different countries (Bhattarai & Armah, 2005). The inclusion of broad money supply (M2) is a control variable. The variable (M2) was adopted in a study by Bahmani-Oskooee and Malixi (1992) in the USA to establish the effect of monetary policy.

3.3 Data Sources

The study uses quarterly time series data for the period 1993 to 2015, obtained from different sources mainly the World Bank's, WDI and Bank of Uganda. Data for Trade Balance, real effective exchange rate and money supply was sourced from the Bank of Uganda while data on domestic income and foreign (Kenya's) income was sourced from the World Bank's WDI and finally data for the volatility of the real effective exchange rate was generated using the GARCH model. The start period of 1993 was preferred because it coincides with the time the government adopted a market based flexible exchange rate system Kuteesa et al. (2010) with the aim of providing a more efficient and reliable mechanism for determining the official exchange rate and allocating scarce foreign exchange resources.

3.3.1 Dependent Variable

Trade balance (lnTB)

This paper measures trade balance as a ratio of export value (X) to import value (M). The ratio of X to M (i.e. X/M). This ratio is preferred because it is not sensitive to the unite of measurement and can be interpreted as nominal or real trade balance. This was measured in terms of the US dollars.

3.3.2 Independent Variables

Real Effective Exchange Rate (lnREER); is the weighted average of a country's currency relative to an index or basket of other major currencies adjusted for the effects of inflation. The formula for the REER is as highlighted in Appendix 1. The weights are determined by comparing the relative trade balances in terms of one country's currency with each other country within the index.

Domestic income (Y); This is the total value of goods and services produced domestically within a period of time. The study uses a proxy of real gross domestic product as a measure of Uganda's domestic income.

Foreign Income (Y^*); It is the total aggregate value of goods and services produced by trade partners within a period of time. The study uses a proxy of real gross domestic product (RGDP) of Kenya approximated in the US dollars. The Real GDP of Kenya was chosen as a representative of the foreign income because Kenya is currently Uganda's major export destination.

Broad Money Supply (M2); This paper uses M2 as a measure of Money Supply. According to Appleyard (2014), under the monetary approach to the BOP, the presence of excess cash balances means that individuals will spend more money on goods and services. This pushes up the prices of goods and services. Furthermore, if the economy is not at full employment, the level of real income rises. Additionally, if part of any new real income is saved, then the level of real wealth in the economy increases. A rise in the price level will lead to increased imports as home goods become relatively more expensive compared to foreign goods. The rise in the price level will also make it more difficult to export to other countries. Additionally, the increase in real income induces more spending, and some of that spending will be on imports. Finally, the increased wealth enables individuals to purchase more of all goods, some of which are imports and some of which are goods that might otherwise have been exported. Thus, the excess supply of money generates pressures leading to a current account deficit. Therefore β_4 is expected to be negative as an increase in money supply is expected to worsen the trade balance.

Real Effective Exchange Rate Volatility (VREER)[7]; this is unobservable and therefore there is need to generate it using the appropriate methodology. Although different statistical measures of exchange rate volatility have been proposed in the literature, two measures have widely been used. These are the simple standard deviation method and a volatility measure generated from a generalized autoregressive conditional heteroscedasticity (GARCH) process. However, the standard deviation has been criticized for wrongly assuming that the empirical distribution of the exchange rate is normal and for ignoring the distinction between predictable and unpredictable elements in the exchange rate process Sekantsi (2009); Takaendesa, Tsheole, and Aziakpono (2006).

3.3 Data Analysis Techniques

3.3.1 The Augmented Dickey Fuller (ADF) unit root test

The study first checks the time series properties of the variables used in the analysis by employing the ADF unit root tests Dickey and Fuller (1979). This enables us to ascertain whether the variables are non-stationary and integrated of the same order. The ADF regression is based on the following equation;

$$\Delta y_t = \alpha_0 + \pi y_{t-1} + \sum_{j=1}^{\rho} \beta_j \Delta y_{t-j} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where y_t represents the variable whose time series properties are being investigated, Δ is the difference operator and ε is the error term and is $\approx iid\left(0,\delta^2\right)$ with t=1…n and was assumed to be Gaussian white noise. The Augmented terms were added to convert the residuals into white noise without affecting the distribution of the test statistics under the null hypothesis of a unit root against the alternative of trend stationarity.

3.3.2 Phillip Perron Test

Phillips and Perron (1988) suggested a non-parametric method of controlling for higher order autocorrelation in a series. This approach relaxes the assumptions about autocorrelation and heteroscedasticity as compared to its ADF counterpart. It is advantageous over the ADF in that PP tests are robust to general forms of heteroscedasticity in the error term and the user does not have to specify a lag length for test regression. Besides, the PP test deals with potential serial correlation in the errors by employing a correction factor that estimates the long run variance of the error process with a variant of the Newey-Weat formula. The test therefore was based on the following first order Auto-regressive [AR (1)] process;

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

[7] Exchange rate volatility refers to a statistical measure of the tendency of exchange rates movements of one currency against other currencies to rise or fall sharply within a short period.

Where y_t is the variable of interest, D_t is the deterministic component (constant or constant and trend) and ε is I (0) and may be heteroscedastic. The PP test corrects for any serial correlation and heteroscedasticity in the errors. In our case, this estimation is based on Barlett Kernel. The optimum bandwidth in the PP equation was selected based on Newey-West (1994) method. The critical values tabulated by Mackinnon (1996) are used in making inferences regarding the time series properties of the variables.

3.4 ARDL- Specification

ARDL are standard least squares regressions which includes lags of both the dependent variable and explanatory variables as regressors, Greene (2008). ARDL are usually denoted with the notation ARDL (p, q_1, ….., q_k) where p is the number of lags of dependent variable and q_1 is the number of lags of the first explanatory variable and q_k is the number of lags of the k^{th} variable.

An ARDL can be written as;

$$y_t = \alpha + \sum_{i=1}^{p} \gamma_i y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j} x_{j,t-i}{}' \beta_i + \varepsilon_t \qquad (11)$$

Where; y_t= Trade balance indicator

$x_{j,t-i}$= Volatility of the real effective exchange rate and other control variables

Some of the explanatory variables may have no lagged term in the model (q_1=0).

3.5 Other Tests

3.5.1 Impulse Response Function (IRF)

According to Pesaran and Shin (1998), the impulse response function traces out the responses (and direction of responses) of current and future values of each of the variables to a unit increase in the current value of the VAR errors. The analysis assumes that the error returns to zero in subsequent periods and that all other errors are equal to zero. These shocks affect several periods in the future and the implied thought experiment of changing one error while holding the others constant makes most sense when the errors are uncorrelated across equations. To include the level of significance, suggested error bands to indicate the level of significance. It was suggested that: if the error bands are both lying in the same positive quadrant, that implies a significant positive relationship but if the error bands are both lying in the same negative quadrant, it implies a significant negative relationship; otherwise the relationship was insignificant

3.5.2 Variance Decomposition Function (VDF)

Variance decomposition is a measure used to study the relative importance of shocks in explaining the variations in the response variable at different time horizons Narayan (2006). it is used to identify the most fundamental variables that explain the behavior of the dependent variable in question and the variable that generates the highest percentage is more fundamental in explaining a phenomenon. Sims (1980) Concluded that in the analysis of variance decomposition as a measure, the last time horizon is preferred and that, if own shock contributes about 95% in variations in that variable in question. Then the variable is said to be exogenous, otherwise, it is endogenous. However, the limitation with this measure is that the conclusions are prone to variable ordering but the study adopts this measure because of its reliability in measuring the percentage of the variance of the error made in forecasting a variable due to a specific shock at a given time horizon and it is equivalent to partial R^2 in the VAR framework.

3.6 GARCH model for estimation of REER volatility

This study adopts the Autoregressive Conditional Heteroscedasticity (ARCH) or generalized ARCH (GARCH) developed by Bollerslev (1986) as a measure of real effective exchange rate volatility, because its parsimonious since it has only three parameters in the conditional variance equation and is used quite often in academic finance literature as a result of its sufficiency in capturing volatility clustering. GARCH (1, 1) model also avoids over fitting and is less likely to breach non-negativity constraints Brooks, Henry, and Persand (2002). Engle (1982) developed the Auto-Regressive Conditional Heteroskedastic (ARCH) model to characterize the observed correlation in asset price volatility. The real effective exchange rate was assumed to follow a first order autoregressive or AR (1) and can be estimated using the following equations;

$$REER_t = \lambda_0 + \lambda_1 REER_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where REER is the natural logarithm of the real effective exchange rate, λ_0 and λ_1 are the parameters to be estimated, and ε_t is the error term that is distributed normally with mean 0 and variance σ_t^2. This ARCH (1, 1) specification is used to determine whether the REER follows the first order autoregressive process using the estimates of the LM test and F-statistics. The ARCH model assumes that this dependence can be captured by an autoregressive process of the form;

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \ldots + \alpha_m \varepsilon_{t-m}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

where σ_t^2 is the conditional variance of the real effective exchange rate, ε_{t-i}^2 for i=1,2….m denotes the squared residual derived from equation (12) and α_i for i=0,1,…..,m are the parameters to be estimated. The restrictions $\alpha_i \geq 0$ ensure that the predicted variance is always non-negative. The ε_{t-i}^2 which represents the ARCH term is a measure of information on the REER volatility in the previous period. This specification illustrates how current levels of REER volatility will be influenced by the past, and how periods of high and low REER fluctuations will tend to persist.

Bollerslev (1986) extended the ARCH class to produce the Generalized Auto-Regressive Conditionally Heteroskedastic (GARCH) model. If the REER follows an ARCH (1, 1) process, then it permits the use of the GARCH (k, m) series as a measure of REER volatility on the assumption that the error term is not auto-correlated. The variance in the GARCH process is specified as;

$$\sigma_t^2 = \alpha_0 + \beta_1 \sigma_{t-2}^2 + \ldots + \beta_k \sigma_{t-k}^2 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \ldots + \alpha_m \varepsilon_{t-m}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Where σ_{t-j}^2 for j=1, 2…k is the GARCH term representing last period's forecast variance. The simplest specification in this class, and the one most widely used, is referred to as GARCH (1,1) model and is given by;

$$\sigma_t^2 = \alpha_0 + \beta_1 \sigma_{t-1}^2 + \alpha_1 \varepsilon_{t-1}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Where σ_t^2 is the time variant conditional variance of the REER (the GARCH term), δ_{t-1}^2 is the squared residuals obtained from equation (13) (the ARCH term), and the parameters α_0, β_1 and α_1 are to be estimated. Equation (15) gives the conditional variance about the REER volatility for the previous period measured as a lag of the squared residuals for the GARCH process. This study therefore employs equation (15) as the GARCH process.

The results of equation (15) may be interpreted as the prediction of the current period's REER variance, which is measured as the weighted average of the long-term average (the constant term), the GARCH and ARCH terms. Thus, the predicted values of σ_t^2 from equation (15) provides the measure of the REER volatility.

4. Results and Discussions.

4.1 Unit Root Test/Order of Integration

According to the ADF and PP tests, all the variables are integrated of order one i.e. I (1) except for the Trade Balance (lnTB) and the volatility of the real effective exchange rate (lnVREER) that are stationary at levels which implies that the series save for the Trade Balance and the Real Effective Exchange Rate Volatility achieve stationarity after taking a first difference (see the unit root test results in Appendix 2)

4.2 Autoregressive Distributed Lag (ARDL) model

ARDL model approach has been specifically designed to cater for scenario where variables are stationary at different levels. However before running the ARDL, we need to identify the appropriate lags for each variable as one of the first requirements for the ARDL model estimation technique.

4.2.1 Lag Selection

Before running the final regression, we need to determine ARDL model with appropriate lags for each variable. The ARDL is denoted by ARDL (p, q_1, q_2, q_3, q_4, q_5), where in this particular case, p is the lag of dependent variable and q_1 to q_5 are the respective lags of the explanatory variables REER, M2, VREER, Y*, and Y. Appendix 3 shows the selected model using Akaike information criteria (AIC) which suggested ARDL (4,4,3,4,2,4) as the best model out of the top 20 evaluated models since it portrays the lowest AIC value where the dependent variable (lnTB) is to enter the model with lag 4 while other explanatory variables i.e. REER, M2, VREER, Y* Y enter with (4,3,4,2,4) lags respectively

4.2.2 Cointegrating Relationship

Following the Bound F-test procedures, the cointegration test results (See Appendix 4) show the F-statistics value of 5.823, which is above the upper bound (I1) value of 3.79 at 5 percent level. Therefore, we reject the null hypotheses that there is no long-run relationship among the variables and conclude that there is cointegration among the variables in the long-run and this implies that there is a long run relationship among the variables.

Appendix 5 presents the results of the long run cointegrating vector coefficients of the trade balance model. Based on the estimated cointegrating vector and after normalizing the variables by the trade balance, the long run equilibrium equation can be written as;

$$ln\,TB = -73.599 - 1.368\,ln\,M2 + 0.058\,ln\,REER + 0.369\,ln\,VREER + 2.981\,ln\,Y + 0.577\,ln\,Y^* \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(16)$$

4.2.3 Error Correction Model (ECM) results.

Both models used in this study pass the diagnostic and stability tests (which are not reported in this paper) and these include the Breusch Godfrey Pagan test for Hetroskedasticity, the Jarque-Bera Test for

Normality, the Breusch Godfrey test for serial correlation and the Ramsey RESET test for stability.

The results above reveal that the variables are cointegrated and have a long run relationship among them. This is true because all the coefficients of the cointegrating forms are significant at 1-percent levels. The coefficients of ECT (-1) is negative as expected and statistically significant at 5-percent level and this shows the rate of adjustment towards their long run equilibrium.

$$\Delta \ln TB_t = 2.031\Delta \ln TB_{t-1} - 1.757\Delta \ln M2_{t-2} - 0.377\Delta \ln REER_{t-2} - 0.377\Delta \ln - 0.009\Delta \ln VREER_{t-3} + 0.512\Delta \ln Y_{t-1} + 10.784\Delta Y^*_{t-2} - 0.032ETC_{t-1} \ldots\ldots (17)$$

The results of the error correction term (ECT (-1)) shows that the estimated coefficient of the error correction term has the expected sign (negative) and is statistically significant. This is an indication that there is approximately 3.2 percent adjustment of the estimated short run disequilibrium in the variables towards their long run values. This means that if there is a shock that pushes away the trade balance from equilibrium, the shock of the explanatory variables corrects the discrepancy at a speed of 3.2 percent in the first quarter.

Volatility of the real effective exchange rate (VREER) negatively impacts on the trade balance in the short run i.e. a one percent point increase in volatility of the real effective exchange rate leads to 0.009 percent deterioration of the trade balance the following quarter.

Therefore, from the short-run results, our conclusion is that volatility of the real effective exchange rate only has a negative effect on the trade balance in the short-run thus its therefore necessary for the Government to design policies that can help to reduce on the volatility of the real effective exchange rate in the short-run by intervening in the foreign exchange market with the aim of improving the trade balance.

The results on domestic income (Y) from equations 16 and 17 show that the one-period lag domestic income has a positive impact on the trade balance in the short run i.e. a one percent point increase in domestic income leads 0.512 percent improvement in the trade balance the following quarter holding other factors constant. This shows that despite the weak productive base of the economy and high domestic demand for foreign goods, an increase in domestic income improves the trade balance in the short-run. This is consistent with the findings of Adenyi et al (2011) in Nigeria. Also, the long run results show that domestic income has a positive effect on the trade balance i.e. a one percent increase in domestic income leads to improvement of the trade balance by 2.981 a sign that arise in domestic income leads to production of more export commodities that are demanded by Kenyan economy.

Also, from the short run results, foreign (Kenya's) income has a positive impact on the trade balance in the short-run i.e. a one-point increase in foreign (Kenya's) income leads to improvement of the trade balance by 10.784 percent in the following quarter. Therefore, from the results we see that as Kenya's income increases, it also rises their demand for Uganda's products in the short-run which increases exports thus improving the trade balance.

From equations 16 and 17, money supply (M2) negatively impacts on the trade balance both in the short-run and the long-run and these are statistically significant at 1 percent in both cases that is a one percent increase in money supply leads to deterioration of the trade balance by 1.368 percent in the short-run and by 1.757 percent in the long-run a sign that increases in money supply leads to purchase of more goods from abroad and this is consistent with the Keynesian approach to trade balance that increase in money supply leads to purchase of more foreign goods leading to decline in the trade balance.

The real effective exchange rate has a negative effect on the trade balance in the short run which indicates that a one-point depreciation on the REER leads to deterioration of the trade balance by 0.377 percent. However, the long run result on this show that the REER positively impacts on the trade balance i.e. a one percent depreciation on the REER leads to 0.058 percent improvement of the trade balance in the long run though this result is not significant. This show that the Marshal-Lerner Condition holds for Uganda's case and this is consistent with the findings of Ogbonna (2010) and Onafowora (2003).

4.3 Other Tests

From an estimated VAR, we compute the impulse response functions (IRF) and the Variance Decomposition (VDC) which serve as tools for evaluating the dynamic interactions and strength of casual relations among the variables in the system.

4.3.1 Impulse Response Function (IRF)

The IRF helps to show the behavior of the series in response to the shocks in the economic system for further inferences. The IRF shows how a variable is affected by the response of the one standard deviation shock Duasa (2007). In this case, the magnitude of the Trade Balance as the response variable can be observed by the variation in real effective exchange rate, money supply, domestic income, foreign income and volatility of the real effective exchange rate which are the impulse variables.

It can be seen from the graph (Appendix 7) that the trade balance turns negative to the shock on the domestic income (Y) after the first quarter and only improves after the 9th quarter which implies that a shock on domestic income (Y) initially worsens the trade balance and only reduces the trade deficit after the 9th quarter.

Also, the trade balance turns negative to the shock on the foreign income (Y*) after the first quarter and only improves after the 9th quarter which implies that a shock on foreign (Kenya's) income (Y) initially worsens the trade balance and only reduces the trade deficit after the 9th quarter.

The shock on money supply remains negative for the whole period which suggests that increase in money supply does not improve the trade balance but rather increases the trade balance deficit for the whole period under review.

On the other hand, a shock on the volatility of the real effective exchange rate remains positive for the whole period which suggests that real effective exchange rate volatility improves the trade balance for the whole period under review.

Finally, a shock on the real effective exchange rate initially increases the trade balance deficit from the first to the 6th quarter which improves afterwards at the 7th quarter which again turns positive after the 8th quarter. This behavior of the real effective exchange rate shows the existence of the "J-Curve" effect in Uganda's case as seen in the graph of IRF in Appendix 7. Our findings are consistent with those of Onafowora (2003).

4.3.2 Variance Decomposition Function

The variance decomposition decomposes the forecast error variance of the trade balance into parts due to each of the innovations in the system. While impulse response functions trace the effects of a shock to each one of the endogenous variables on target variable in the VAR, variance decomposition separates the variation in the target variable into component shocks to the VAR. thus variance decomposition provides information about the relative importance of each random innovation in affecting variables in the VAR (Shao (2008)), Kamoto (2006).

From Appendix 8, most of the variation in the trade balance is accounted for by its own innovations in the first quarter (100%). However, the proportion explained by other variables increases over time and they explain about 40% 0f the variation after two years, the greatest impact is from the volatility of the real effective exchange rate which accounted for 14.5% after the two years, the real effective exchange rate was the second in importance with 13.3% followed by money supply with 5.36%, Kenya's income (foreign income) accounted for 4.4% and domestic income (Y) accounted 2.5% thus implying that all the variable used in the model are important in explaining the trade balance in Uganda.

5. Conclusion

In this paper, we investigate the effect of real effective exchange rate volatility on Uganda's trade balance for the period 1993: Q4 to 2015: Q4. The volatility of the real effective exchange rate was measured using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH (1, 1)) approach. The study then used the ARDL Bounds testing approach, Impulse Response and the Variance Decomposition to establish the effect of the real effective exchange rate volatility on the trade balance in Uganda.

The ARDL model establishes that volatility of the real effective exchange rate has a negative effect on the trade balance in the short run and a positive effect in the long run. Domestic income had a positive effect on the trade balance in the long-run. Foreign income had a positive effect and hence increased foreign income improves the trade balance. Money supply had a negative effect on the trade balance in the long-run thus implying that expansionary monetary policy cannot be used to enhance better position of the trade balance. Finally, the study also found a negative relationship between the trade balance and the real effective exchange rate in the short-run and a positive though insignificant relationship in the long-run, a sign that depreciation of the Uganda shilling leads to deterioration of the trade balance in the short run and thus there is need for policies to stabilize the Uganda shilling in the short run so as to reduce the trade deficit.

The impulse response function found evidence of the J-Curve effect for Uganda's case. This is observed through the shock on the REER which initially has a negative effect on the trade balance from the first to the 6th quarter and there after it starts to improve up to the 10th quarter as seen in Appendix 7.

Results of the variance decomposition show that the shocks on the volatility of the real effective exchange rate (VREER) and the REER have significant attributes on the trade balance as compared to the shocks on money supply (M2), foreign income (Y*) and domestic income (Y).

From the results, it is observed that for Uganda's trade deficit to be reduced there is need for the government (Bank of Uganda) to develop well-developed hedging facilities like forward markets and institutions that protect exporters against exchange rate risk. This improves the confidence of exporters thus increasing exports of goods and services to major trading partners by manufacturing high quality goods that are competitive and satisfy the needs of the foreign economies.

The government should formulate better fiscal and monetary policies that target improvement in the domestic income (economic growth) and money supply respectively that would significantly improve trade balance.

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Appendices

Appendix 1: Real Effective Exchange Rate (REER) Calculation.

The REER, defined as the NER adjusted for the relative price levels would have been presented as;

$$REER = NER * \frac{P^f}{P^d} \quad \text{.......(21)}$$

Where

NER is the nominal exchange rate

P^f is the indexed unit export price

P^d is the indexed domestic price level

However, we need to use the REER in our aggregate supply block in order to compute the domestic currency value of imported intermediate goods that enter the production function. Consequently, the REER computed above will not capture the actual implications of exchange rates on imports. A REER that affects both the imports and the exports has to be computed as;

$$REER = NEER_i * \left(\frac{\sum_{i=1}^{n} w_i p_i}{p^d} \right) \quad \text{.......(22)}$$

Where NEER is the nominal effective exchange rate for a particular period, defined as;

$$NEER_t = \sum_{i=1}^{n} \left[W_i * NER_{it} \right] \quad \text{.......(23)}$$

W_i = trade weight assigned to the ith trading partner.

P_i = indexed price level for ith trading partner.

P^d = indexed domestic price level.

NER_i = indexed direct exchange rate quota with the ith trading partner

The trading weight W_i is given as;

$$W_i = \frac{X_i + M_i}{X_p + M_P} \quad \text{.......(24)}$$

Where X_i and M_i are respectively, the exports and imports to/from ith trading partners.

X_p and M_p are, respectively, the total exports and imports to/from trading partners.

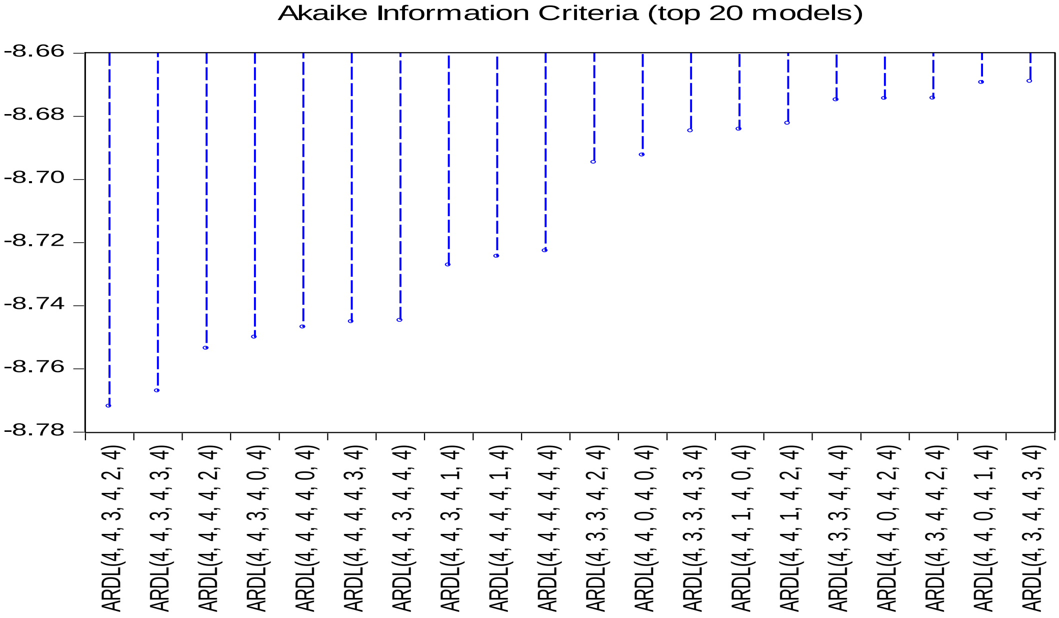
Appendix 2: Unit Root Test results at both Levels and First Difference

	Levels		First Difference	
Variable	**ADF-Test**	**PP-Test**	**ADF-Test**	**PP-Test**
lnTB	-3.805***	-3.752***	-3.104**	-4.919***
ln(Y)	-0.657	-1.255	-1.582	-3.095**
lnM2	-1.816	-1.813	-1.996	-3.679***
lnREER	-1.931	-0.696	-3.384**	-3.277**
ln(Y*)	1.217	-0.678	-1.582	-3.095**
lnVREER	-2.974**	-8.067***	-11.295***	-26.381***

Source: Author's Computations

Note: ***Significant at 1% **Significant at 5% *Significant at 10%

Appendix 3: Model selection summery graph.



Source: Author's Computations

Appendix 4: ARDL Bound F-test for cointegration

Test Statistic	Value	k
F-statistic	5.822703	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Source: Author's Computations

Appendix 5: Results of the Normalized Cointegrating long-run model

Long Run Coefficients			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
lnM2	-1.368***	0.472	-2.895
lnREER	0.058	0.837	0.069
lnVREER	0.369	0.232	1.591
lnY	2.981***	0.875	3.408
lnY*	0.577	0.863	0.668
C	-73.599**	27.822	-2.645

Source: Author's Computations

Note: * Significant at 1% ** Significant at 5% * Significant at 10%**

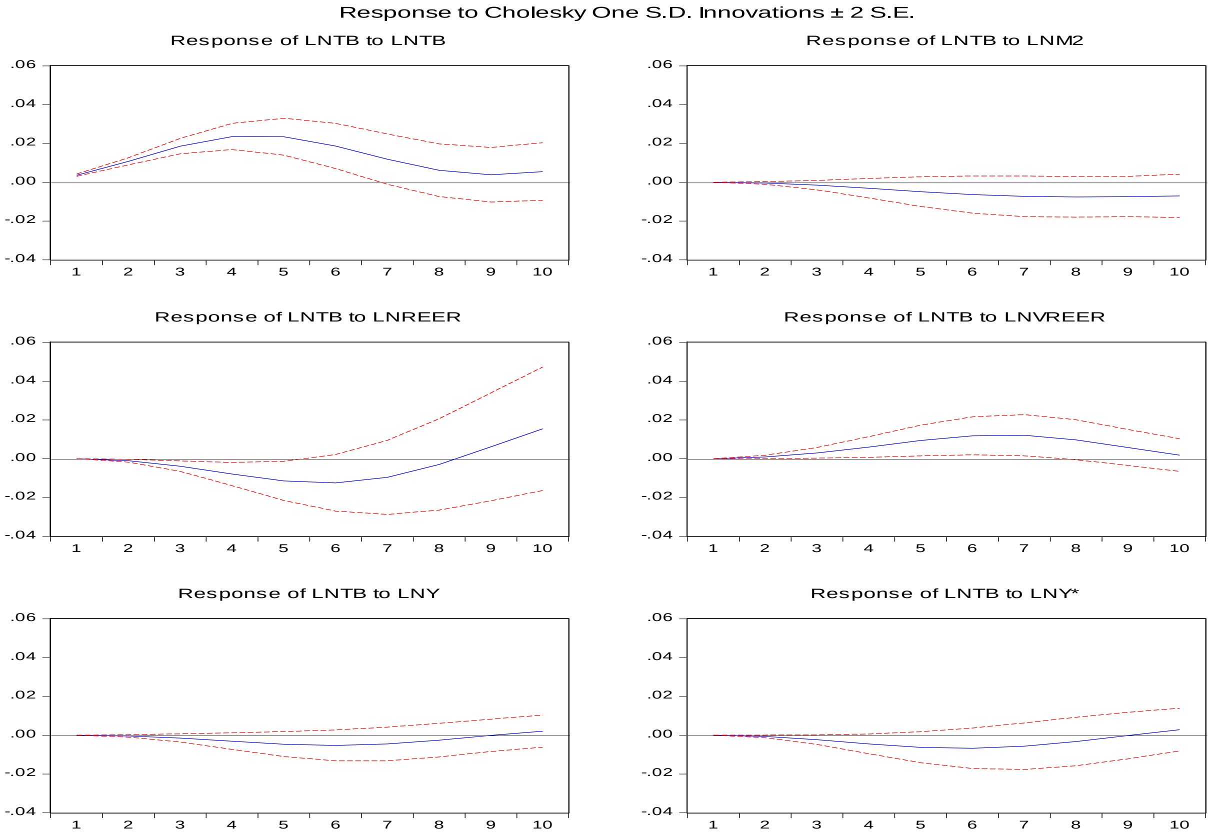
Appendix 6: Results of the Error correction model for the trade balance.

Short Run Coefficients			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**
D(lnTB(-1))	2.030***	0.094	21.502
D(lnM2(-2))	-1.757***	0.504	-3.484
D(lnREER(-2))	-0.377***	0.129	-2.909
D(lnVREER(-3))	-0.009***	0.002	-3.837
D(lnY(-1))	0.512**	0.253	2.024
D(lnY*(-2))	10.784***	2.558	4.215
ECT (-1)	-0.032**	0.017	-1.951

Source: Author's Computations

Note: * Significant at 1% ** Significant at 5% * Significant at 10%**

Appendix 7: Impulse Response Functions (Graph)



Appendix 8: Variance Decomposition

Period	S.E.	LNTB	LNM2	LNREER	LNVREER	LNY	LNY*
1	0.003627	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.011490	97.95463	0.142601	0.877452	0.549610	0.117392	0.358318
3	0.022637	92.77605	0.500997	3.209726	1.899112	0.453073	1.161044
4	0.034715	85.43783	1.033012	6.575830	3.792162	0.984626	2.176540
5	0.045346	76.70534	1.772793	10.24063	6.472557	1.624900	3.183785
6	0.053037	68.41948	2.746275	13.01687	9.675322	2.181599	3.960447
7	0.057422	62.60297	3.963279	13.91543	12.66620	2.484948	4.367171
8	0.059273	59.82679	5.363404	13.30899	14.57180	2.519153	4.409860
9	0.060448	57.92863	6.671004	13.81562	14.92116	2.422384	4.241200
10	0.063140	53.84056	7.360777	18.62226	13.75872	2.326915	4.090763

Source: Author's Computations