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Empirical Analysis of Exchange Rate Determinants in Rwanda (2000–2015)

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Abstract

This study examined the determinants of exchange rate behavior in Rwanda for the period of 2000Q1-2015Q4. The econometrics approach was focused on the extent at which exchange rate correlated with the macroeconomic factors and some elements of non parity determinants of exchange rate. Special emphasis is placed upon the short and long run impact of the regressors. The relationship was investigated by means of the regression analysis. The ordinary least square (OLS) was used to analyze data and confirmed the positive effect of broad money, discount rate, external government debts and real gross domestic products on exchange rate except trade balance, with an adjusted R squared of 94.6% and F statistics of 224.4694 with a very low probability of 0.0000.

The study employed the Co-integration Technique and Error Correction Modeling proposed by Engle and Granger (1987), which provides mechanisms to deal with the problems of Unit Root faced in the time series data. Evidences support the view that, there was one co-integrating equation which normalized the coefficient of log exchange rate. By applying ECM technique the speed of adjustment of the model was 1.3% with an error correction model coefficient of -0.013028 which means that 1.3% of errors realized in previous quarter are corrected in the current one, and each quarter 1.3% of disequilibrium errors was corrected due to any change from the equilibrium.

While analyzing the determinants of exchange rate in Rwanda, most of the test confirmed that explanatory variables are statistically significant in short run at 5% level of significance, and many variables driving long run include broad money and trade balance with a coefficients of 0.969885 and 0.119752 respectively. The highest probabilities indicated by granger causality test confirmed undirection causality between variables. The impulse response function indicated the highest short run effects of discount rate where variance decomposition of log exchange rate supports the evidence of long run relationship between exchange rate and three explanatory variables (money supply, external government debts and trade balance).

Keywords: *Exchange rate, non parity elements, Macroeconomic factors, econometric approach*

1. Introduction

1.0. Background information

The exchange rate is an important useful indicator of economic performance. High fluctuations in exchange rates create uncertainty about the profits to be made on different economic activities.

The choice of exchange rate regime has always been one of the most important subjects in international macroeconomics. Since the publication of Robert Mundell's theory of Optimum Currency Area", we have seen a large amount of literature trying to tackle this crucial issue to identify how countries choose their exchange rate regimes. According to the theory of optimum currency areas, this choice is made on the basis of some structural and macroeconomic factors such as the size, the degree of openness or the level of economic development of a particular country. (Mundell, 1961)

Before 1995, the Government of Rwanda has adopted a fixed exchange rate regime. From 1970 to 1990, the foreign exchange rate was 1$ for nearly 82 RWF. However, the war period 1990-1994 saw many devaluations, especially that of 1991 with 51.5 % and that of 1994 of 91.64% and by the end of 1994, the exchange rate stood at 1$ for 220 RWF. (Dushimumukiza, 2010)

The period of flexible exchange rate was characterized by the fluctuation in exchange rate. As evidence, in January 2003, the average exchange rate stood at 511.2168 RWF for 1$, but by end of the year, the exchange rate was at 574.83RWF for 1$. The depreciation rate stood at 11.6% from one year to another. If we compare the average exchange rate of 2002 and 2008, the index is 115.2 in six years, from the exchange rate of 475.32 FRW for 1$ in 2002 to 547.61 FRW for 1$ in 2008. Indeed, this exchange rate can be compared to 220 RWF for 1$ in 1994. According to NBR ,annual report *July 2012- June 2013*The FRW depreciated by 4.9%, trading between 612.42 end June 2012 and 642.67 end June 2013 against a depreciation of 2.2% recorded for the last fiscal year

201/2012. In the same period, the FRW depreciated by 2.0% and 11.3% against the GBP and EURO respectively. Similarly, the FRW depreciated against KES and TZS respectively by 2.6% and 3.0%, while appreciated against Ugandan shilling and Burundian franc by 0.1% and 3.5% respectively. Following an appreciation recorded in the second half of fiscal year 2011/2012, the Real Effective Exchange Rate (REER) has depreciated during the first half of fiscal year 2012/2013 then remained quite stable in the second half of 2012/2013. The moderate bilateral depreciation against USD, EURO and GBP recorded during the period has been offset by a moderate inflation differential with most of Rwanda's trading partners. (NBR, Annual Report, 2008)

It is in the recognition of that this study is taken on the analysis of key drivers of exchange rate fluctuation in Rwanda because the uncertainty of exchange rate fluctuations can reduce the incentive for firms to invest in export capacity. However exchange rate becomes one of the main essential engines for investment promotion & economic development in any given imports based economy.

1.1 Statement of the problem

The exchange rate fluctuation implicates an up down movement of currency value of any given country. The depreciation of currency in any imports based economy decreases capital inflow and increases capital outflow. Hence, exchange rate stability becomes one of the main factors influencing foreign (direct and portfolio) investments, price stability and stable economic growth. Many authors include Jhingan posited that to maintain both internal and external balance, a country must control its exchange rate. (Nelson, December 2013)

Changes in exchange rate have pervasive effects, with consequences for prices, wages, interest rates, production levels, and employment opportunities. Fluctuations in the value of currencies of different economies have increased after the collapse of Bretton Woods System. Especially short term variability has dramatically increased following the shift from fixed to flexible exchange rate in early 1970's and after. High volatility and sudden changes in exchange rate is one of the hurdles for the success of macroeconomic policy, hence a model with theoretical and empirical validity needs to be developed.

The Rwandan Franc depreciated against all major currencies, since April 2010 the Rwf depreciated by 3.7 percent against the US$, a larger movement than observed over the entire year 2009 (2.2 percent). Throughout 2010 the Rwf showed a mix of movements against other major international currencies (the Euro and the British Pound) which originated in the strengthening of the US$ during that period. By end 2010, the Rwf had depreciated by 1.6 percent against the Euro and by 6.0 percent against the British pound. (W.Bank, April 2011)

In addition, the previous studies on the analysis of major determinants of exchange rate, its volatility and causes on the Rwandan economy found that the Rwandan francs exchange rate is highly volatile and is affected by news. In the analysis of data researchers used Garch model in order to find out the realistic impact of news on exchange rate but they did not include macroeconomic variables and the key elements of parity and non parity determinants of exchange rate. (Warren Tibesigwa, July 2014)

Moreover the current study used the regression based approach in order to find out the effect of macroeconomic variables and key elements of non parity variables that determine exchange rate like money supply, interest rate and government debts that have not been incorporated by the authors in the analysis of factors affect exchange rate in Rwanda. After considering these issues the question that comes to mind is to analyze the key drivers of exchange rate fluctuation in any imports based economy. The present study also is attempting to find out the extent at which exchange rate tends to be correlated with its major determinants in Rwanda during the concerned period.

1.2. Objectives

I.2.1.General objective

The main objective of this research is to analyze the determinants of exchange rate in Rwanda since 2000Q1up to 2015Q4**.**

I.2.2.Specific objectives

1. To Determine effect of a change in money supply on exchange rate since 2000Q1 up to 2015Q4
2. To Evaluate the effect of a change in discount rate on exchange rate since 2000Q1 up to 2015Q4
3. To Examine the extent at which a change in trade balance affects exchange rate since 2000Q1 up to 2015Q4
4. To Analyze the effect of external government debts on exchange rate since 2000Q1 up to 2015Q4
5. To Determine the level at which a change in real gross domestic product affects exchange rate since 2000Q1 up to 2015Q4

I.3.Research Hypotheses

The main argument of this study is synthesized into the following hypothesis:

Ho: The overall independent variables are not statistically significant to explain exchange rate

H1: Money supply (**M3)** is statistically significant to explain exchange rate
H2: Discount rate is statistically significant to explain exchange rate
H3: Trade balance is statistically significant to explain exchange rate
H4: External Government debt is statistically significant to explain exchange rate
H5: Real gross domestic product is statistically significant to explain exchange rate

2. LITERATURE REVIEW

2.1. Insights from the empirical literature

Despite the very large volume of empirical studies in this area, there is no clear consensus concerning the analysis of the key determinants of exchange rate in Rwanda. In fact, research results which find positive, negative or no effect of exchange rate fluctuation on the volume of international trade are based on various underlying assumptions but only hold in certain cases.

The first attempts to analyze exchange rates behavior were done by Rudiger Dornbusch in 1973, Richard Meese in 1979 and Kenneth Rogoff in 1983. The Dornbusch (or overshooting) model analyzes exchange rate adjustments considering sticky prices and rational expectations. (Twarowska, 2014)

In the essay on purchasing power parity (1987) Dornbusch made clear that it remains an important concept, though the evidence in recent years is more remarkable for deviations form, than observance of, such parity.

The combination of exchange rate analysis and the factors that determine nominal exchange rates was clearly performed by Philip Lane. He did theoretical and empirical research on long-run exchange rates and built own model. He analyzed long run nominal and real exchange rates of 107 countries in 1974-1992, and added to his model such variables like trade openness, country size, central bank independence and government debt. (Lane, 1999)

Before Lane many works had considered a smaller number of developed countries within less time period. His econometric results show that the most important factor affecting nominal exchange rate is inflation and factors driving long-run inflation. Moreover, openness, output growth and the terms of trade resulted to be significant, but country size was insignificant. In overall, results show that the debt effect is most important for high depreciation/inflation countries. Openness, size, and the stock of nominal government debt variables that affect the tendency to inflation - are significant in explaining the rate of nominal depreciation. However, the results for the terms of trade, another factor that ought to affect the nominal exchange rate via its influence on the real exchange rate, are mixed. For the OECD countries, the factors driving inflation appear to dominate the determination of the nominal exchange rate.

In 1993 David Romer pointed at the great influence of openness on the exchange rate trends. In work titled "Openness and inflation: Theory and Evidence" he conveys correlation between inflation and openness, but it is as important for exchange rates as for inflation. Unanticipated monetary expansion leads to real exchange rate depreciation, and because the harms of real depreciation are greater in more open economies, the benefits of unanticipated expansion are decreasing in the degree of openness . (Gruben, febuary 2001)

R. MacDonald and L. Ricci studied the long-term determinants of real exchange rate including economic openness, capital flows and terms of trade (MacDonald and Ricci, 2003). R.A. Ejaz, A.Abbas and A.R. Saeed showed a direct relationship between exchange rate and budget deficit under the managed floating exchange system. (Khan R. E., 2002)

Some researchers do not agree with the statement that the exchange rate is determined exclusively by fundamentals. J.A. Frankel and K.A. Froot argue that the high value of the US dollar in 1984 and 1985 can best be explained as speculative bubble, based on the self-confirming market expectations driven by the increase in forecasting weight given to the chartist as a result of their previous forecasting success. (Kenneth, 1990)

According to G. Galati and C. Ho news may play an important role in fluctuations of the euro exchange rate against dollar. The results of the study show that good news brings appreciation while bad news depreciates currency. (Parveen, 2012), J.R. Sanchez-Fung also studied the same relationship and stated that exchange rate is more responsive in case of depreciation. (Çağlayan, September,2013)

In the literature, three principal views on the factors determining exchange rate levels have been presented, depending on the time horizon and the main conditions for the functioning of economy. Proponents of the first view indicate that macroeconomic fundamentals play an important role in explaining the behavior of exchange rates. Some authors hold that these fundamentals are important only in the long run but have little to offer in explaining short-term movements, while others believe that macroeconomic fundamentals have explanatory power both in the long- and the short run . (T.Harvey, 2001)

The second approach is applicable in short time horizons and for countries without high inflation. According to this view, exchange rate models that include macroeconomic fundamentals do not perform better than a random walk in out-of-sample forecasting. Exchange rate volatility is imply the standard deviation of the error term. (Rogoff, 1991)

The adherents to the third view think that neither macroeconomic fundamentals nor the random walk model

adequately account for exchange rate behavior at short horizons. Rather, short-run exchange rate movements are attributed to market microstructure factors, including inventory management and information aggregation by foreign exchange dealers. Specifically, the microstructure approach suggests that non-dealers learn about fundamentals affecting the exchange rate, and this knowledge is reflected in the orders they place with dealers. Dealers in turn learn about fundamentals from order flow. The outcome of this two-stage learning process results in the formation of a price. (P.Tylor, May,2001)

Other authors include Mouyad AL S., analyzed the determinants of real exchange rate volatility in Syrian economy over the period 1980-2008, using two estimation techniques, include Vector Error Correction Mode (VECM) and ARCH Model. According to the theoretical literature, there are many elements causing the (RER) volatility (relative productivity, government expenditure, terms of trade, trade openness and net foreign assets). The estimation excluded the last three non-significant variables and included gross capital formation and oil prices which are considered to be important factors in capturing the effect of these non-significant variables. The empirical results confirm the theoretical links between (RER) volatility and its determinants in the Syrian economy. An author excluded some of the main determinants like inflation& interest rate which are high correlated with exchange rate. As the empirical results confirm the theoretical links between (RER) volatility and its determinants in the Syrian economy, an author did not take into account some of the major factors that can allow Syrian economy to adopt an appropriate exchange rate regime. (Samara M. A., November,2009)

The contributions of real (permanent) and nominal (temporary) shocks on the nominal and real exchange rates of the Indian Rupee against the US dollar in the period since 1993, using the long-run structural VAR technique. The paper results showed that the real exchange rate of the Rupee against the U.S. dollar is non-stationary and that real shocks have permanent effects on the exchange rate, thus making exchange rate management at best futile and possibly harmful to the economy. (Shigeyuki, October,2009)

The investigated on the sources of real exchange rate fluctuations in Pakistan, and used Structural VAR model to study the relative importance of different types of macroeconomic shocks on fluctuations in real exchange rate. The structural decomposition showed that more than 60 percent of the variance in forecasting the real exchange rate at a horizon of four quarters is due to nominal shocks. Inoue and Hamori (2009) empirically analyzed the sources of the exchange rate fluctuations in India by applying the Structural VAR model. The VAR System consisted of three variables, the nominal exchange rate, the real exchange rate, and the relative output of India and a foreign country. The empirical evidence demonstrated that real shocks are the main drives of the fluctuations in real and nominal exchange rates. (Mostafa, June,2012)

However, There are further studies concerning exchange rate behavior, although mostly they investigate the impact of exchange rate volatility rather than sources of this volatility. Then, besides other things (such as the subject of study), they differ in the way of modeling exchange rate fluctuation. According to this modeling, they can be divided into two groups, the ones that use various modifications of standard deviations and the ones that use modifications of the ARCH approach. Belke and Setzer (2003) belong to the former group, They study the impact of exchange rate volatility on the labor market. In their case, the exchange rate volatility is measured as the standard deviation of the 12 month-to-month changes in the logarithmic of the
spot rate.

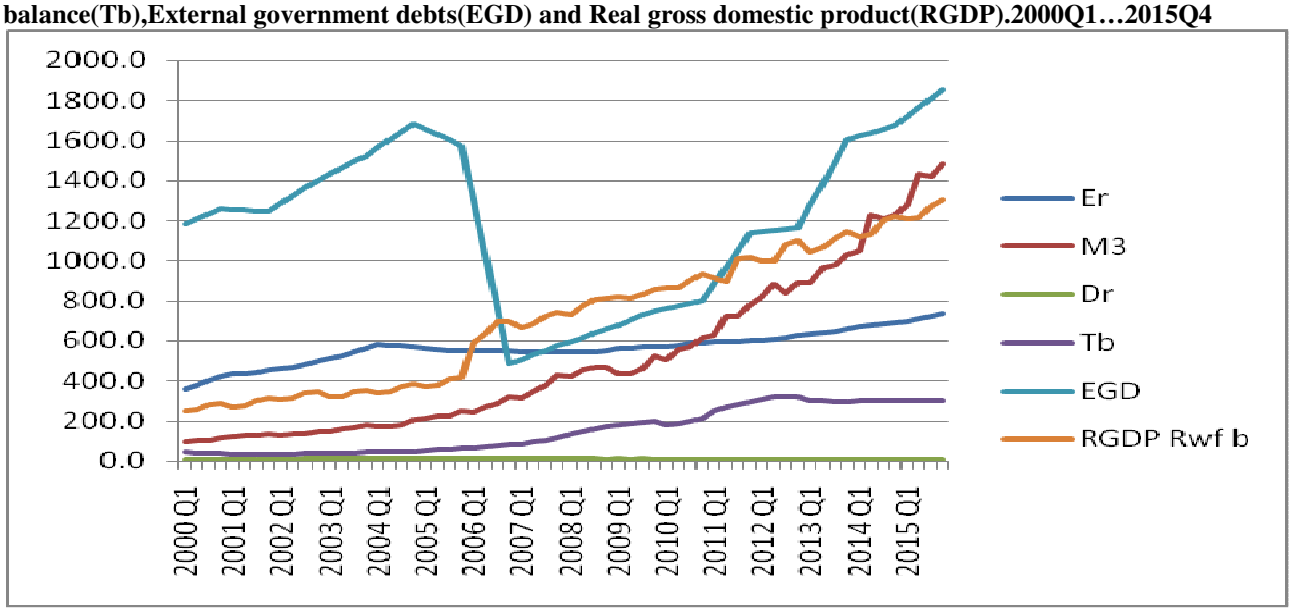
The studies on the effect of exchange rate volatility on bilateral trade. He uses the standard deviation of the first difference of the logarithmic exchange rate as well, but he also employs also two other measures , the sum of the squares of the forward errors and the percentage difference between the maximum and minimum nominal spot rate. (Peter Clark, May 2004)

However, there are studies, such as Kenen and Rodrik (1986); Koray and Lastrapes (1989); and Chowdhury (1993)that model the exchange rate volatility as the moving sample standard deviation of the growth rate of the real exchange rate. On the other hand, Baum et al. (2004),analyzing the impact of exchange rate volatility on the volume of bilateral exports, and Choudhry (2005), investigating the influence of exchange rate volatility on real exports, apply the GARCH model for measuring volatility. Further modification of the ARCH approach can be found, the studies on the impact of monetary policy regimes on lowering inflation and the exchange rate risk premium in Hungary, Poland, and the Czech Republic. The recent analysis on the developments of exchange rate volatility in the Vise grad Group countries and selected EMU countries, suggest a usage of leverage GARCH model. (Prague, 2007)

2.2. Theoretical relationship between exchange rate and its major determinants

Many theories there have been written in respect to the main determinant of future exchange rates. Although the majority of these theories give adequate reasons in order to explain what actually determines the rates between the currencies, we can argue that there are many factors
that may cause a currency fluctuation. Consequently, there is little that can be alleged in respect to the theory that better answers the question of what finally determines the exchange rates. Here below, we referred to the main determinants of exchange rates.

Figure.2.1 Trend of Exchange rate (Er), discount rate (Dr), Broad money (M3), trade balance(Tb),External government debts(EGD) and Real gross domestic product(RGDP).2000Q1…2015Q4



Source: Author'estimation

- A permanent increase in a country's money supply causes a proportional long run depreciation of its currency. However, the dynamics of the model predict a large depreciation first and a smaller subsequent appreciation.

A permanent decrease in a country's money supply causes a proportional long run appreciation of its currency. However, the dynamics of the model predict a large appreciation first and a smaller subsequent depreciation.

In the long run a permanent increase (decrease) in a country's money supply causes a proportional long-run depreciation (appreciation) of its currency against foreign currencies.

The level of the nominal exchange rate is directly associated with the quantity theory of money printed by the central bank, which is one of the key determinants of the exchange rate. (M.Boughton, October 1988)

In Rwanda from 2000, the broad money continues to exhibits a small positive trend up to 2007Q3 and a huge positive one up to 20015Q4. This permanent increase in money supply pushed a researcher to include it among the variables which may cause the exchange rate variability in order to find out the level under which volume of money in circulation influences exchange rate.

- In order to find out the effect of central bank policy rates on exchange rate movement the discount rate was selected by the researcher as one the main drivers of market rates. If a change in the discount rate, when announced is to have the perceptible effect on the current exchange rate. It must transmit (or believed to transmit) some information about the policy intention of central bank. If the markets expect a change in discount rate the effects will be directly reflected by the exchange rate.I (I~HASUES ANI)

As it is shown in the above figure of discount rate trend, In Rwanda the whole period of study was characterized by a small increase from 2000Q1 up to 2003Q4 and the remaining was of a decline.

- A traditional criticism of flexible exchange rate regimes is that flexible rates increase the level of exchange rate uncertainty and thus reduce incentives to trade. However, Mundell's (1961) optimal currency area hypothesis suggests an opposite direction of causality, where trade flows stabilize real exchange rate fluctuations, thus reducing real exchange rate volatility. The theories of international trade imply the existence of a standard identification problem, if there is a correlation between trade and exchange rate. (Romalis, 2003)

In Rwanda, there is a huge difference between imports and exports, the country continues to grow its economy but imports run more than exports. As illustrated by the above figure in 2007 a curve of trade balance realized a high trend rather than previous period. This big difference motivated researcher to include the variable among the other determinants in order to find out its short and long run effect on exchange rate.

- A continuous increase in public expenditures, and low capital formation in many developing countries, many governments have resorted into borrowing either or both within and outside the country. However, most borrowings come with interest attached, which results in debt servicing. Serving external debt may involve demand for foreign currency which tends to affect the exchange rate of the country. (Sani, 2015)

Similarly to Rwanda also, the external public debts grow more since 2000 up to 2004, from 2004 there was a decline until 2006 and then after the curve reinitialized up to now. The variable was selected in order to analyze if the external government debts are favorable for the exchange rate stability.

- Just to clarify the terminology, output refers to a country's real gross domestic product (GDP). Because real GDP is adjusted for the changes in inflation (in other words, it has no price effect in it), it can also be referred to as output.

The monetary approach to exchange rates, predict that higher growth rates in a country lead to an appreciation of this country's currency. As Rwandan economy continues to grow in terms of GDP, Real gross domestic product was used in order to clarify the relationship between exchange rates and output, usually the percent change in output.

- In the fiscal year 2014/2015, the RWF has depreciated by 5.4% against USD, trading between 682.54 by end June 2014 and 719.54 by end June 2015 against a depreciation of 6.2% recorded for the fiscal year. In the same period, RWF appreciated by 2.5% and 13.2% against euro and GBP respectively.

Similarly, the RWF appreciated by 6.6% 10.6% and 16.7% against Tanzanian ,Kenyan fiscal year and Ugandan shillings respectively, but depreciated by 4,8%versus the Burundian francs.
The RWF effective exchange rate (REER) has gradually appreciated during the whole fiscal year 2014/2015. It has appreciated by 3.0% by the end June 2015 compare to the same period of last year mainly driven by the weakening of the Euro and regional currency against USD. (NBR, Annual Report, June 2014-July 2015)

3. RESEARCH METHODOLOGY

3.1. Research design

This study investigated the determinants of exchange rate in Rwanda by taking into account some elements of non parity variables. Regression modeling technique is widely applied to estimate coefficients for independent variables, to test hypotheses and to evaluate the importance of each independent variable in the model. Following the same path this study also used the following theoretical approach to assess the importance of selected variables.

3.2 Factors and model specification

Table 3.19 Variables to be investigated and expected signs

Variables	Expected relationship
Dependent variable/ Exchange rate	
Independent variables : Money supply (M3)	+
Discount rate	+
External Government debts	+
Trade balance	-
Real gross domestic product	+

3.3. The Linear regression based approach

3.3.1. The Linear Regression

To analyze the determinants of exchange rate in Rwanda, the below stated linear regression model will be estimated:

$$Yt = \beta_0 + \beta_1 X_1 t + \beta_2 X_2 t + Ut \quad \ldots\ldots (3)$$

The **t** refers to quarter; **Yt** is a dependent variable and refers to exchange rate (Rwf…Usd) in a particular period (quarter) **t**; the β_0 represents the intercept; **X** represents the selected determinants of exchange rate; β_1 and β_2 are coefficients and **Ut** represents the error term.

3.4. Empirical model

A country's optimal real exchange rate is determined by its macroeconomic fundamentals (i.e. some key macroeconomic variables) and that the long-run value of the real exchange rate is determined by suitable (permanent) values of these fundamentals. (Macdonald, May 1998)
The empirical model to be used in the study is presented as:

$$Er=f(M3, Dr, Tb, EGD, RGDP, U_t)$$

$$Y_t = \beta_0 + \beta_1 M3_t + \beta_2 Dr_t + \beta_3 Tb_t + B_4 EGD_t + \beta_5 RGDP_t + Ut \quad \ldots\ldots (4)$$

Econometrically, the above equation can be stated as:

$$LY_t = \beta_0 + \beta_1 LM3_t + \beta_2 LDr_t + \beta_3 LTb_t + B_4 LEGD_t + \beta_5 LRGDP_t + Ut \quad \ldots\ldots (5)$$

Where:
β_0 : Is a constant term
$\beta_1 \ldots\ldots \beta_n$: Parameters to be estimated
LY_t: Log of real exchange rate in year t
$LM3_t$: Log of Money supply(broad money) for year t

LDr_t: Log of interest (discount) rate for year t
LTb_t: Log of trade balance in a year t
$LEGD_t$: Log of External government debts for year t
$LRGDP_t$: Log of real gross domestic product in a year t

3.5. Estimation procedure

In order to get the relevance estimated equations, Ordinary Least Square method was applied. The OLS method has been used in a wide range of economic relationship with satisfactory result. The method employed a sound statistical technique appropriate for empirical problems; and it has become so standard that, its estimates presented as a point of reference even when result from other estimation technique was used. More so, the reliability of this method lies on its desirability properties which are efficiency, consistency and unbiased. This implies that its error term has a minimum and equal variance. The conditional mean value is zero and normally distributed. (Gujarati, 2004)

3.5.1. Unit Root Test

Conventionally, the universal assumption in building and testing economic models that underlies variables are stationary, but is unfortunately not generally true. Before estimating our model in equation (3), we shall check for the time series properties of the data. This is necessary because time series econometricians such as Granger and New bold, (1974); Eagle and Granger, (1987), Dickey and Fuller,(1981); Enders, (1995); Pindyck and Rubinfeld, (1998),among others, observed that results emanating from most macroeconomic variables are likely to be "Spurious" if the time series properties of such series are not examined. (Dolado, September 2002)
Hence, the time series properties of the data would be examined using Augmented Dickey Fuller (ADF) test and the Engle-Granger co-integration procedure.
The testing procedure for the ADF is as follows:

$$\Delta ER_t=\beta_0+\beta_t+y\Delta ER_{t-1}+\delta_1\Delta ER_{t-1}+\ldots\ldots+\delta_p\Delta ER_{t-p}+U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$\text{Or } \Delta Y_t=\beta_0+\beta_t+y\Delta Y_{t-1}+\delta_1\Delta Y_{t-1}+\ldots\ldots+\delta_p\Delta Y_{t-p}+U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Where
β_0 is a constant, $\beta_t$is the coefficient on a time trend and p is lag order of the autoregressive process and Δ is difference operator.
The unit root test is then carried out under the null hypothesis $y= 0$ against the alternative hypothesis of $y<0$. If the test statistic is greater (in absolute value) than the critical value let say at**5%** or **1%** level of significance, then the null hypothesis of $y= 0$ is rejected and no unit root is present.
From the above discussion our model in equation **(2)** becomes:

$$\Delta Y_t=\beta_0+\Delta Y_{t-i}+\beta_1\Delta M3_{t-i}+\beta_2\Delta Dr_{t-i}+\beta_3\Delta Tb_{t-i}+B_4\Delta EGD_{t-i}+\beta_5\Delta RGDP_{t-i}+Ut\ldots\ldots\ldots\ldots \quad \ldots \quad (7)$$

3.5.2.Co-integration Test

If exchange rate and the explanatory variables are linked by some long-run relationship, from which they can deviate in the short run but must return to in the long run, the residuals obtain from their linear combination will be stationary. If the variables diverge without bound (i.e. non-stationary residuals) we must assume no equilibrium relationship exists. In other words, if exchange rate and any of the explanatory variable(s) are both integrated of order d (i.e. I(d)), then, in general, any linear combination of the exchange rate and any of the explanatory variables will also be I(d); that is, the residuals obtained from regressing exchange rate on the explanatory variable(s) are I(d). Should the residual is stationary it implies there is evidence of long run relationship among the variables.

3.5.3. VAR analysis

Vector auto regression (VAR) models were introduced by the macro econometrician Christopher Sims (1980) to model the joint dynamics and causal relations among a set of macroeconomic variables. VAR models are useful for forecasting. Consider a univariate autoregressive model for example, an

$$AR(1)Y_t=\beta_0+Y_{t-i}+\beta_1M3_{t-i}+\beta_2Dr_{t-i}+\beta_3Tb_{t-i}+B_4EGD_{t-i}+\beta_5RGDP_{t-i}+Ut\ldots\ldots\ldots \quad (8)$$

Our unrestricted vector autoregressive model in reduced form oforder p is presented in equation **(7)** as follows:

$$Y_t=\beta+\Sigma^p_{i=1}A_iY_{t-1}+\varepsilon t\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad .(9)$$

Where $\beta = (\beta 1,\ldots,\beta 6)'$ is the (6×1) intercept vector of the VAR, **A**i is the ***ith*** (6×6)matrix of autoregressive coefficients for i = 1, 2,…, p, and $\varepsilon t=(\varepsilon 1,t\ ,\ldots,\ \varepsilon 6,t)'$ is the (6×1) generalization of a white noise process. The vector autoregressive model is estimated in levels of the variables in natural logarithms. The form of unrestricted VAR system in this study is presented as:

$$\begin{bmatrix} LM3 \\ LDr \\ LTb \\ LEGD \\ LRGDP \\ LY \end{bmatrix} = \begin{bmatrix} \beta 1 \\ \beta 2 \\ \beta 3 \\ \beta 4 \\ \beta 5 \\ \beta 6 \end{bmatrix} + A(L) \begin{bmatrix} LM3\,t-1 \\ LDrt-1 \\ LTbt-1 \\ LEGDt-1 \\ LRGDPt-1 \\ LYt-1 \end{bmatrix} + \begin{bmatrix} \varepsilon 1 \\ \varepsilon 2 \\ \varepsilon 3 \\ \varepsilon 4 \\ \varepsilon 5 \\ \varepsilon 6 \end{bmatrix}$$

The above function describes the dynamics of just one random variable Y_t (exchange rate) as a linear function of its own past. Based on this model, the forecast of exchange rate will depend just on its past history. However, economic variables Money supply (M3), External government debts, trade balance and so on interact with each other. For instance, movements in discount rate affects the level of money supply, which in turn affects the level of exchange rate" ceteris paribus. In this multivariate setting, the forecast of exchange rate will be a function of a larger *information set* that combines not only the history of exchange rate but also the histories of many other variables, such as Discount rate and Money supply. A VAR is the generalization of the univariate autoregressive model to a vector of economic variables.

3.6. Techniques of Results Evaluation

We shall use three basic criteria to evaluate the results obtain from the model; economic (a priori expectations), statistical and econometric criteria. The economic criteria will inform us if the
signs of the variables coefficient conform to the economic theories. While the Statistical criteria shall focus on testing the significance of the variables using T-test, and F-statistic will be used to
assess the joint significance of the overall regression in order to see whether the model is well specified. In the same, the econometric criterion would involve such tests as autocorrelation and
Multi-collinear.The autocorrelation will help to check for the existence of serial correlation among the variables, while the multi-collinear test would help to check if the variables are collinear.

3.7. Model Justification

There are varieties of model available to econometricians/researchers when modeling. However the choice of a particular model is based on reliability, effectiveness and adequacy of the model. Thus among the numerous rival models, we opted for Autoregressive Distributed Lag Error Correction model (ADLMECM).The choice of this model is informed by the fact that, apart from the efficiency of the ADLM, it will also help to draw inferences about dynamic behavior of the variables since it has been established that it take lapse of time for the dependent variables to response to the explanatory variables when modeling. Also, the ECM will be most appropriate and efficient model that can capture the long run behavioral pattern of variables under co-integration situation. (Kennedy, 2011)
Lastly, the model will take care of the problem of the so-called "spurious "regression associated with non-stationary data.

4. RESEARCH RESULTS AND DISCUSSIONS

This is focused on the analysis, presentation and discussion of results. It reflects quantitative approach in order to clarify the key determinants of currency exchange rate in any import based economy like Rwanda. Therefore we describe the available data with their basic properties. We present also the results of stationarity and diagnostic tests, by the end we present the findings of co-integration, Error Correction modeling and VAR analysis.

Table 4.1 Regression result

Dependent Variable: LER
Method: Least Squares
Date: 06/16/16 Time: 23:05/ Sample: 2000Q1 2015Q4
Included observations: 64

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LM3	0.235668	0.049152	4.794713	0.0000
DR	0.044093	0.005109	8.630504	0.0000
LTB	-0.122618	0.028393	-4.318636	0.0001
LEGD	0.078738	0.021477	3.666170	0.0005
LRGDP	0.141234	0.069452	2.033536	0.0466
C	3.520986	0.323376	10.88822	0.0000

R-squared	0.950862	Mean dependent var	6.326074
Adjusted R-squared	0.946626	S.D. dependent var	0.152065
S.E. of regression	0.035131	Akaike info criterion	-3.770388
Sum squared resid	0.071584	Schwarz criterion	-3.567993
Log likelihood	126.6524	Hannan-Quinn criter.	-3.690655
F-statistic	224.4694	Durbin-Watson stat	0.599792
Prob(F-statistic)	0.000000		

Source: Author's estimation

The results from the table above indicated that Adjusted R-squared is 0.946 which means that fluctuation in exchange rate is jointly explained by all independent variables (M3, Dr, Tb, EGD and RGDP) at 95%. The remaining percentage 5% of the exchange rate movement is explained by the variables outside of the model. The higher F-statistic of 224.4694 confirms also the higher level of significance of our existing model.

The results from the regression analysis indicate also that some variables include M3, DR, EGD and RGDP were statistically significant with a t statistics of 4.794713, 8,630504, 3,666170, 2.033536 and affected positively exchange rate. By observation any percentage change in one of the above four explanatory variables will affect exchange rate by 0.235668, 0.044093, 0.078738 and 0.141234 percent respectively.

4.2. Data and stationarity

This study uses the quarterly data ranging from 2000q1 up to 2015q4 of exchange rate, broad money (m3), discount rate, trade balance, external government debts and real gross domestic product. The data were transformed into Logarithms In order to test hypothesis and the stationarity. As stated by the econometricians any econometric theory is based under the assumption of stationality. This study used the Augmented Dicky Fuller and Philips Perron statistics in order to show the order of co-integration the order of integration of each time series of the variables under study by avoid the danger of running non sense or spurious regression where the lag length has been established using the Schwarz information criterion.

Table 4.2 Unit root tests results

Variables	**ADF Test**			**PP test**		
	Level	**1st difference**	**I(d)**	**Level**	**1st difference**	**I(d)**
LER	0.012567	-0.224984*	**I(1)**	-0.049810	-0.243767*	**I(1)**
LM3	0.003007	-1.580543*	**I(1)**	-0.001250	-1.346871*	**I(1)**
DR	-0.060260	-0.909189*	**I(1)**	-0.060260	-1.040935*	**I(1)**
LTB	-0.006604	-1.723106*	**I(1)**	-0.000704	-0.387281*	**I(1)**
LEGD	-0.039109	-0.385517*	**I(1)**	-0.011933	-0.345251*	**I(1)**
LRGDP	-0.013900	-1.075372*	**I(1)**	-0.013900	-0.921563*	**I(1)**

Note: *(**) denote significant at 1%, 5% and 10% level of significance respectively.

The augmented Dickey Fuller (ADF) test and Phillips Perron statistics indicate that all variables both dependent and independents are stationary; hence they are all first differenced and integrated for the same level.

However the null hypothesis of the non stationary cannot be rejected at any common level of significance for all series at their levers. As we are confirmed the existence of unit root among the series then we test the co-

integration between the series.

4.3. Co-integration analysis

This study takes into account also the extent at which the exchange rate tends to be correlated with its main determinants in Rwanda within any given time horizon. It is under this framework we test whether the integrated variables exercise any long run relationship. The study used Johansen Co-integration technique in order to clarify the long run relationship. With this technique we confirm one co-integrated equation as it is shown in the following table by both Trace and Maximum Eigen Statistics.

Table 4. 3 Johansen Co-integration results

Hypothesized	Trace statistics	0.05 critical value	P-value	Maximum Eigen Statistics	0.05 critical value	P-value
None *	99.88950	95.75366	0.0252	39.19624	40.07757	0.0126
At most 1	60.69326	69.81889	0.2147	30.61229	33.87687	0.1168
At most 2	30.08097	47.85613	0.7148	13.72471	27.58434	0.8411
At most 3	16.35626	29.79707	0.6870	9.799401	21.13162	0.7632
At most 4	6.556858	15.49471	0.6297	6.492229	14.26460	0.5509
At most 5	0.064629	3.841466	0.7993	0.064629	3.841466	0.7993

* denotes rejection of the hypothesis at the 0.05 level

From the above table both trace and maximum Eigen statistics indicate that there 1 co-integration equation at 5% lever of significant, then the variables are co-integrated. To analyze the long run relationship of exchange rate with its main determinants like broad money, discount rate, trade balance, external government debts and real gross domestic product we use normalized long run co-integrating coefficients. The table below shows the co-integrating equation which normalized the coefficient of log exchange rate and shows how the variables are significant and insignificant to explain exchange rate movement.

Table 4. 4 Long-run Dynamics: Normalized Co-integration coefficients of Log exchange rate

LER	LM3	DR	LTB	LEGD	LRGDP
Coefficients	0.969885	-0.042613	0.119752	-0.584888	-1.994669
(SE)	(0.19320)	(0.01423)	(0.09029)	(0.08192)	(0.31200)
[t-stat]	[5.0201086957]	[2.9945888967]	[1.3263041311]	[7.1397460937]	[6.3931698718]

Source: Author's estimation

$Log(ER)_t$=0.969885Log(M3)-0.042613Log(DR)+0.119752Log(TB)-0.584888Log(EGD)-1.994669Log(RGDP)…….(10)

The above table shows the long run effect of all independent variables on exchange rate, the variables like broad money and trade balance influence positively exchange rate compared to the other variables like discount rate, external government debts and real gross domestic product which are not significant to exercise any long run positive effect on exchange rate. The high positive coefficient of money supply confirms the level at which exchange rate tends to be driven by any unanticipated long run increase in volume of money in circulation. Beside, an issue of policy formulation there is no need of taking into account those factors with a long run negative correlation with exchange rate.

Basing on the above results any increase of 1% from broad money and trade balance affected positively exchange rate by 0.969885&0.119752 compared to a negative effect of discount rate, external government debts

and real gross domestic product that represented a shock of -0.0426,-0.584888&-1.994669 respectively.

4.4. Vector error correction (VECM) model

As the variables were not stationary at their levels but integrated of order I(1) , stationary at the first difference and co-integrated, we analyzed the short run relationship among them by formulating an error correction model. The logic behind that model is to recover the long run information lost by differencing variables by introducing an error correction term. The error correction term gives the proportion of shocks accumulated in the previous period that are corrected in the current period. The results of VECM are presented in the following table.

Table 4. 5 Short-run dynamics: Vector error correction model coefficients

Dependent Variable: D(LER)
Method: Least Squares
Date: 06/12/16 Time: 11:36
Sample (adjusted): 2000Q4 2015Q4
Included observations: 61 after adjustments

D(LER) = C(1)*(LER(-1) + 0.969884936398*LM3(-1) - 0.0426134106965 *DR(-1) + 0.11975221005*LTB(-1) - 0.584887955471*LEGD(-1) - 1.99466905007*LRGDP(-1) + 4.8154798754) + C(2)*D(LER(-1)) + C(3)*D(LER(-2)) + C(4)*D(LM3(-1)) + C(5)*D(LM3(-2)) + C(6)*D(DR(-1)) + C(7)*D(DR(-2)) + C(8)*D(LTB(-1)) + C(9)*D(LTB(-2)) + C(10) *D(LEGD(-1)) + C(11)*D(LEGD(-2)) + C(12)*D(LRGDP(-1)) + C(13) *D(LRGDP(-2)) + C(14)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.013028	0.017932	-0.726493	0.4711
C(4)	0.008980	0.028235	0.318026	0.7519
C(6)	0.000385	0.002659	0.144776	0.8855
C(8)	0.000149	0.030937	0.004813	0.9962
C(10)	0.007189	0.020829	0.345142	0.7315
C(12)	-0.005260	0.032714	-0.160800	0.8729
C(14)	0.004959	0.002969	1.670141	0.1015

R-squared	0.661619	Mean dependent var	0.009938
Adjusted R-squared	0.568025	S.D. dependent var	0.013361
S.E. of regression	0.008781	Akaike info criterion	-6.434107
Sum squared resid	0.003624	Schwarz criterion	-5.949644
Log likelihood	210.2402	Hannan-Quinn criter.	-6.244241
F-statistic	7.068983	Durbin-Watson stat	2.049351
Prob(F-statistic)	0.000000		

Source: Author's estimation via Eviews 7

The findings from the table above confirm that only the speed of adjustment of the model is 1.3% with an error correction model coefficient of -0.013028. This implicates that 1.3% of errors realized in previous quarter are corrected in the current one. This means that each quarter 1.3% of disequilibrium errors will be corrected due to any change from the equilibrium.

As the Probabilities of all explanatory variables are greater than 5% , it means that variables are significant to explain exchange variability in short run. Adjusted R-squared of 56% in log exchange rate is attributed to the combined effects of the regressors, then our F-statistic of 7.068983 with a probability of 0.00000 allows us to reject the null hypothesis in favour of the alternative one that overall independent variables are not statistically significant to explain exchange rate variability in Rwanda for the concerned period of study.

4.5. Diagnostic tests

Table 4.6 Diagnostic tests

Test	F-statistics	P-value
1. Normality Jarque-Bera statistic	0.785335	0.675253
2. Serial correlation Breusch-Godfrey serial correlation LM test	2.051924	0.307641
3. Autoregressive conditional heteroscedasticity ARCH LM test	1.188918	0.342282

Source: Author's estimation

Basing on table above, data are normally distributed, serial uncorrelated with an equal variance and the parameters are stable.

4.6. Granger causality

The grange causality method clarified how the variables affect (drive) each other. The results are presented below:

Table 4. 7Grange causality test results

Pairwise Granger Causality Tests
Date: 06/12/16 Time: 12:19
Sample: 2000Q1 2015Q4
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LM3 does not Granger Cause LER	62	3.09116	0.0531
LER does not Granger Cause LM3		0.32310	0.7252
DR does not Granger Cause LER	62	2.01006	0.1434
LER does not Granger Cause DR		1.20478	0.3073
LTB does not Granger Cause LER	62	2.09716	0.1322
LER does not Granger Cause LTB		3.43739	0.0390
LEGD does not Granger Cause LER	62	0.70336	0.4992
LER does not Granger Cause LEGD		1.42390	0.2492
LRGDP does not Granger Cause LER	62	1.34196	0.2695
LER does not Granger Cause LRGDP		2.61339	0.0821

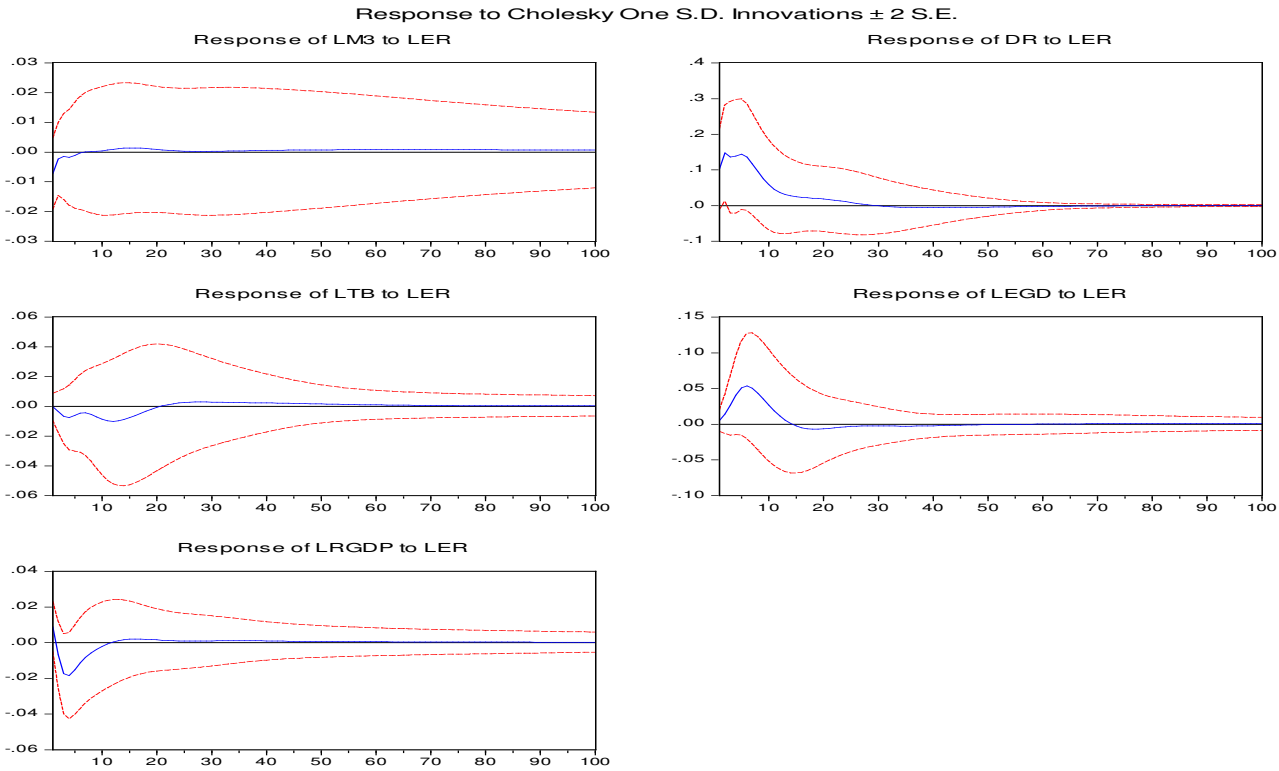
Source: Author's estimation

From the above table of grange causality probability of regressors include broad money, discount rate, trade balance, external government debts and real gross domestic products are greater than 5%. This highest probability confirms the significance and undirection causality. However the explanatory variables will affect exchange rate. They are significant to explain exchange rate movement.

4.7. Impulse response function

The impulse response function (IRF) shows the dynamic properties of the model. It facilitates to test the response of dependent variable to unit shock of independent variables. As it is presented in the following tables of IRF the vertical axis shows the deviation from the baseline of targted variable in response to a change in one of the regressors., the horizontal axis also indicates the number of quarters under which the explained variable tends to be affected after any shock from one of the independent variables.

Figure 4. 2.Impulse response function between exchange rate and its main determinants



Source: Author's estimation

Basing on the above tables of Impulse Response Function, only discount rate is statistically significant to explain exchange rate, other variables like external government debts, trade balance and real gross domestic product and money supply are insignificant. Many economic theories include that of M.Boughton (1988) argue that proportion long run depreciation of local currency results from the permanent increase in country's money supply. The intermediate Blues lines indicate the short run relationship and confirms the short run effect of independent variables on exchange rate however the following red lines implicates long run relationship. Generally except discount rate , exchange will react slightly to any shock from others variables like money supply, trade balance, external government debts and real gross domestic product.

4.8. Variance decomposition

As VAR model has been fitted, a variance decomposition or forecast error variance decomposition (FEVD) is used to aid in the interpretation of a vector auto-regression. The variance decomposition indicates the amount of information each variable contributes to the other variables in the auto-regression. It determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. (Lütkepohl, 2016)

In our study we only used variance decomposition of log exchange rate where it shows the percentage at which the lagged regressors affect exchange rate within different periods. The results of exchange rate variance decomposition are presented below with a sample of ten periods.

Table 4.8 Variance decomposition of LEr

Period	S.E.	LER	LM3	DR	LTB	LEGD	LRGDP
1	0.009236	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.016907	99.45551	0.114148	0.288002	0.008124	0.046295	0.087919
3	0.023129	97.25883	1.011093	1.158973	0.017693	0.491962	0.061449
4	0.028086	93.10651	2.612106	2.269328	0.156693	1.773435	0.081929
5	0.032209	87.35470	4.768003	3.149231	0.502322	3.907915	0.317830
6	0.035829	80.79538	7.194156	3.602492	1.046726	6.592877	0.768367
7	0.039112	74.21569	9.641389	3.671983	1.730131	9.437823	1.302981
8	0.042120	68.09225	11.96733	3.497190	2.484947	12.16451	1.793769
9	0.044883	62.59685	14.11174	3.210682	3.254958	14.64655	2.179224
10	0.047428	57.73412	16.05257	2.905217	3.996498	16.85877	2.452830

Source: Author's estimation

At period 1, exchange rate is 100% own shock and 0% from the regressors, at period 2 discount rate is highly statistically significant to explain exchange rate movement of Rwandan franc into USD. Within the first two periods the discount rate continues to drive exchange rate, and this means that the fluctuation in exchange is explained by discount rate in short run. As we approach the long run for example starting from period 8 money supply and external government debts are highly statistically significant to explain the exchange rate movement with a decrease contribution of discount rate. The variables like trade balance and real gross domestic are slightly affect exchange rate.

5.SUMMARY, CONCLUSIONS & RECOMMENDATIONS

This part provides an overall summary of the study and the suggestions of areas for future research. We present also the conclusion of the findings of research's interest.

5.1. Summary

This research aimed to analyze the determinants of exchange rate in any import based economy like Rwanda. The macroeconomic and some elements of non parity variables like money supply (broad money), discount rate, trade balance, external government debts and real gross domestic product were selected by the researcher in order to find out their effect on exchange rate movement of Rwandan francs into United States dollars for the period ranging from 2000Q1 up to 2015Q4.

In order to achieve the main aim of the study, we used Johansen co-integration test by ascertaining the long run relationship between exchange rate and its major selected determinants. An error correction model was used in order to help the identification of short run dynamics among the variables. By the end impulse response function and variance decomposition were used for the purpose of assessing the dynamic of the model and the quantitative effect results to a shock from any one of the selected determinants of exchange rate. As it is confirmed by the above tests, the null hypothesis was rejected at 5% level of significance as the independent variables jointly explain exchange rate variability. This study found also that broad money and trade balance continue to drive the exchange rate of Rwandan francs in long run.

5.2. Conclusion and recommendations

5.2.1. Conclusion

This study examined the key drivers of exchange rate movement in Rwanda over the period of 2000Q1-2015Q4.The results from the estimation of empirical model indicated that all variables except trade balance affect positively exchange rate. A deep analysis with the checking of time series properties of the variables was done in order to avoid the incidence of spurious regression. The results from ADF and Phillip-Perron statistics indicate that the null hypothesis of unit root for the variables was not rejected at levels but rejected at first difference for all variables.

The most key implication of the results as it is indicated in Table 5 of Long-run Dynamics is that in the long run money supply (M3) and trade balance were found to be the most important determinants of exchange rate in Rwanda while other variables like discount rate, external government debts and real gross domestic product insignificantly affect exchange rate. The adjustment of exchange rate to disequilibrium is 1.3% of disequilibrium corrected every quarter.

Dispite the different significant effect of regressors on exchange rate Table 8 of Grange causality test confirms an effect of independent variables on dependent one in any short time horizon as their probabilities exceed 5%. Referring to table 9 of Variance decomposition of LEr, at period 4 exchange movements is driven by broad money, discount rate an external government debts. The variables like trade balance fail to explain significantly exchange rate variability. At 10^{th} period money supply and external government debts continue to exercise more influence on exchange rate. However the discount rate did not continue to affect exchange rate and this shows the effectiveness of central bank in stabilizing its policy rates. By the end impulse response function shows that exchange rate movement mainly took source from its own shock and discount rate while any shock from other regressors insignificantly cause exchange rate fluctuation.

5.2.2. Recommendations

After estimating the function of exchange rate determinants in Rwanda and after analyzing the extent at which broad money, discount rate, trade balance, external government debts and real gross domestic product affect exchange rate for period of 2000Q1-20155Q4, we suggest the following:

- The monetary authority should continue to regulate money supply in accordance with real national income in order to ensure exchange rate stability.
- The monetary authority should also continue to stabilize its policy rates in order to avoid the huge fluctuation on market rates which may turn their effects on currency exchange rate.
- Appropriately reduce the imbalance between import and exports: In Rwanda the difference between exports and imports continues to exercise a positive trend and this put pressures on local currency as well the negative effects of currency fluctuation on the economy as a whole.

- The government must continue to provide incentives to local producers in order to increase production because a weaker currency to any import based economy causes an increase in capital outflow.
- The Government of Rwanda via its Ministry of finance and economic planning must promote internal borrowing by decreasing the level of external public borrowing in order to avoid the long run negative effects of external government debts on the economy.
- The future researchers are recommended to undertake the similar studies by combining both parity and non parity determinants of exchange in order to find out a well fitted model of exchange rate determination in Rwanda because the current one used only some elements of non parity determinants of exchange rate.

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