



**NATIONAL BANK OF RWANDA  
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## **Foreword**

*In acknowledgement of the importance of policy oriented studies for forward-looking and evidence-based monetary policy, the National Bank of Rwanda (BNR) publishes twice a year its Economic Review in which recent BNR findings on the Rwandan economy are disseminated and shared with different economic actors and the general public. In this ninth volume of the BNR economic review, five research papers are published.*

*The first paper on financial innovation and monetary policy is aimed at assessing whether the various financial innovation that have taken place over the past years pose difficulties on the conduct of monetary policy in Rwanda. In the context of the current monetary policy framework, this assessment starts by examining whether the velocity of money and money multiplier are stable before proceeding to test for the stability of the money demand function. The study also examines the link between M3 and nominal GDP to verify whether a long run relationship between the two macroeconomic variables exists. Results show that M3 and GDP have a long run relationship though the structural change in the relationship between the two variables as a result of financial innovations may reduce the effectiveness of the monetary aggregate framework. Results also show that financial innovations do not play an important role in determining money demand in the long run and that a shock on credit impacts real GDP and CPI. Another interesting finding is that real GDP reacts to a shock on the treasury bills rate, implying that Rwandans consider investment in Treasury bill as a way of alternative saving, in addition to commercial banks' term deposits. Thus, BNR needs to improve the use of the central bank rate to impact money market rates, particularly the Treasury bill interest rate as the first stage of improving the interest rate pass through.*

*In our last issue of February 2016, we published a paper on "Interest Rate Pass-through in Rwanda" as part of the roadmap towards adopting the use of interest rate as our operating target by 2018. This issue proposes another paper that falls within the same context but extended at the EAC level. The paper examines and compares the degree of interest rate pass-through in EAC*



countries. It concludes that even with the achievements in developing our financial sector, the interest rate pass-through is still incomplete at low levels in all countries but varies within a country and evolves with time. The paper offers a framework for policy makers' discussions on key issues to address before 2018.

In view of the current exchange rate depreciation and cognizant of the impact of exchange rate on external sector competitiveness, the third paper assesses the impact of exchange rate on external sector competitiveness and based on exchange rate misalignment and Lerner-Marshall condition indicators, the paper concludes that though exchange rate impacts on trade balance, both the exchange rate misalignment and Lerner- Marshall condition are not substantial to prompt loss in external sector competitiveness. The paper therefore recommends effective monitoring of exchange rate developments to avoid higher levels of volatility which could lead to poor performance of Rwanda's tradable sector as well as putting in place better and sustainable strategies to increase production in Rwanda to avoid higher import prices induced by the exchange rate depreciation.

Mindful of the fact that the actions of fiscal and monetary policies are interdependent in macroeconomic management, the fourth paper examines the effects of fiscal policy on inflation and money market interest rates in Rwanda. This paper uses structural autoregressive models over the period from 2006Q1 to 2015Q4. Indeed, the results show that both the government spending and government tax revenues affect positively and significantly nominal GDP and inflation but does not significantly affect interbank rate. In both cases, the effect on interbank rate is found less responsive to fiscal shocks in Rwanda due to shallow financial markets. The study therefore recommends policy makers to boost the development of financial markets to respond to changes in macroeconomic fundamentals for efficient monetary policy transmission mechanism.

Recognizing that economic policy in general and monetary policy in particular needs forward-looking dimension, the fifth paper on the determinants of aggregate demand constructs a medium-size macroeconometric model for



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*Rwanda and use the model to explain the main drivers of aggregate demand in the Rwandan economy. The proposed macroeconometric model can also be used for forecasting and simulation analysis, provide a consistent framework to analyze the impact of exogenous shocks on the Rwandan economy, and, help to have structured monetary policy discussions. The in-sample forecasts show that the model tracks well the path of key demand side macroeconomic variables (i.e. the components of domestic and external demand). However, more sector specific analysis is needed to develop Near Term Forecasts (NTFs) and sector-specific assumptions to help in derivation of forecasts over longer time horizon*

*I wish to express my sincere appreciation to our team of researchers who have contributed to this publication and also those whose comments have contributed to improve the quality of the papers.*

*Comments and questions can be sent to the Office of The Chief Economist ([tkigabo@bnr.rw](mailto:tkigabo@bnr.rw), [thkigabo@yahoo.fr](mailto:thkigabo@yahoo.fr)) and/or the Monetary Policy and Research Department, KN 6 Avenue 4, P.O Box 531 Kigali-Rwanda or on [Monetary\\_Policy\\_Res\\_Group@bnr.rw](mailto:Monetary_Policy_Res_Group@bnr.rw).*

**John Rwangombwa**  
**Governor**







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## **Financial innovations and monetary policy in Rwanda**

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**Key words:** Financial innovation, monetary policy, velocity, money multiplier, money demand function

**JEL Classification Number:** E41, E43, E52 and E58

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### **Abstract**

*The objective of this paper is to assess possible impacts of financial innovations on the conduct of monetary policy in Rwanda, focusing on the stability of money multiplier and velocity of money as financial innovation may lead to instability of the two economic variables. Empirical results show that there exist a long run relationship between M3 and nominal GDP indicating that BNR may influence the development of nominal GDP (and in price) through the control of M3. However, the structural change in the relationship between the two variables as results of financial innovation may reduce the effectiveness of the monetary aggregate framework. In addition, estimated impulse response functions in the sub sample starting in 2008, where much change in monetary and financial sectors happened in Rwanda, indicate that a shock on credit to the private sector has an impact on real GDP and CPI. More interestingly, real GDP reacts to changes in Treasury bill rate. This has very important policy implications as it shows that economic agents in Rwanda consider investment in Treasury bill as a way of alternative saving, in addition to commercial banks' term deposits. Thus, BNR needs to improve the use of the central bank rate to impact money market rates, particularly the Treasury bill interest rate as the first stage of improving the interest rate pass through.*



## **1. Introduction**

The primary function of the financial system is to facilitate the optimal allocation economic resources, both across economic sectors and across time, in an uncertain environment. This function, in turn, involves a payment system with a medium of exchange; the transfer of resources from savers to users of the resources and the reduction of risk through insurance and diversification (Merton 1992, p. 12). To operate, a financial system must incur real resource costs generated by labor, materials and capital used by financial intermediaries and by financial facilitators, such as stock brokers, market makers and financial advisors. In addition, since time periods, such as maturity of financial instruments, are an inherent characteristic of financial activities, there are uncertainties about future states of the world that generate risks.

Thus, financial innovation involves new and improved products, processes, and organizational structures that can reduce costs of production, better satisfy customer demands, and yield greater profits.

The term financial innovation refers to a wide range of changes and developments affecting financial markets, such as the introduction of new financial instruments, changes in the structure and depth of financial markets, changes in the role of financial institutions, the methods by which financial services are provided and the introduction of new products and procedures (Esman Nyamongo et.al 2013). In a broader sense, financial innovation can be defined as the emergence of new financial products or services, new organizational forms, or new processes for a more developed and complete financial markets that reduce costs and risks, or provide an improved service that meets particular needs of financial system participants. It is the act of creating and then popularizing new financial instruments as well as new financial technologies, institutions and markets (Frame and White, 2002).

The financial sector, in a broad sense, has developed an array of new financial instruments and techniques to adopt the ever-changing global environment. Progress in information technology affects all aspects of banking sector and



can be regarded as one of the main driving forces generating changes in the sector.

Technological innovation and falling costs in computing and telecommunications, have particularly contributed to the most recent innovations in electronic payments. In the midst of the technological advance in the banking industry, internet banking or online banking is considered as one of the financial innovations that has received high popularity. The innovation makes possible either a reduction in costs or an increase in revenues, or both. The ATMs, which reduce banks' operating costs by efficiently executing much of a teller's duty over the retail counter, is one of the renowned innovations that has benefited from technological advances.

Technological innovation contributes to the efficiency of the financial sector, which ultimately affects the overall growth of the economy. It reduces significantly the costs of information management and information asymmetries in financial transactions; it is an important strategic tool for banks to safeguard long term competitiveness, cost efficiency and improve their profitability. For customers, technological innovation improve the access to banking services by introducing automated channels for supplying and delivering various banking services and activities.

The spread of the financial innovations vary between countries, partly due to differences in factors such as regulatory frameworks and readiness of telecommunication infrastructure. While payment services based on the internet and mobile phones are widely used in the advanced economies, in some of the emerging and low-income economies, the pace and development of e-payments is slow and uneven. However, in the recent years, mobile technology has contributed to a remarkable development of mobile money in some developing countries. The money transfer services are available to millions of previously underserved people, allowing them to safely send money and pay bills for the first time without having to rely exclusively on cash (World Bank, 2014).



By affecting the structures and conditions of financial markets, financial innovations have the potential to exert an effect on the transmission mechanism of monetary policy. Indeed, advances in information technology influence the structure of (financial) markets, the (financial) behavior of economic agents and the types of (financial) products traded; that is, the entire monetary transmission mechanism which describes the way monetary policy actions of central banks affect aggregate demand and inflation (Angeloni, et al, 2003; Noyer, 2008).

In addition, the transformation of the payments mechanism for goods and services has started to have a large impact on the demand for money and its role in the economy. Indeed, new financial products and new intermediaries tend to blur the distinction between monetary and non-monetary assets and to modify the financial behavior of economic agents (Noyer, 2008). Furthermore, changes in technology which affects preferences of economic agents in terms of financial products affects also their portfolio management which in turn influences money multiplier (Goodhart, 1989; Kigabo; 2014).

In the above context, the objective of this paper is to assess the possible impacts of financial innovations on the conduct of monetary policy in Rwanda. BNR implements its monetary policy under the monetary targeting regime which assumes that the money multiplier and money demand are stable. However, as indicated, financial innovations may lead to instability of the two economic variables. Instability of the money multiplier and money demand can lead to the breakdown of the link between BNR operating target (base money) and intermediate target (M3) on one side, and, between the intermediate target and the final objective of monetary policy (inflation). In other words, the instability of the money multiplier and money demand weakens the current monetary transmission mechanism in Rwanda, which runs from base money to inflation through M3. For BNR, the stability of money demand is important, because if the money demand is not stable, it becomes hard to determine the optimal level of money supply required to meet the demand for money, which is crucial for achieving the goal of price stability.



The rest of the paper is structured as follow: In section 2 we present an overview of financial innovations and monetary policy in Rwanda. Section 3 summarizes the literature review on the link between financial innovations and monetary policy. The methodology is presented in section 4, empirical results are presented in section 5 and thereafter, a conclusion is given.

## **2. Overview of financial innovations and monetary policy in Rwanda**

This section highlights the financial innovations that have taken place in Rwanda during the last decade and how these have affected the financial system and monetary aggregates. The section presents some key indicators that can be used to measure the impact of financial innovations on monetary aggregates.

### **2.1. Financial innovations and financial system development in Rwanda**

In the last decade, different innovations were introduced in the banking system in Rwanda such as the creation of new financial institutions, extension of the banking sector network and the introduction of new financial products. The establishment of

UMURENGE SACCOs in 2009 was one of the key recent innovations in the financial sector in Rwanda. By enabling the establishment of least one financial institution in each sector (UMURENGE) country-wide, this helped to bring financial services closer to the population and thus leading to more financial inclusion. It is important to note that before the establishment of UMURENGE SACCOs, around 52% of sectors were without any financial institution.

In addition, the modernization in the financial supervisory framework, high growth in economic activities as well as conducive business environment in Rwanda have facilitated the entry of regional banks in Rwanda as well as the extension of the banking sector network across the country, with the creation of bank branches and agent banking. Total network increased from 408 in 2011 to 3,085 in 2015



**Table 1: Development in banks branches and outlets**

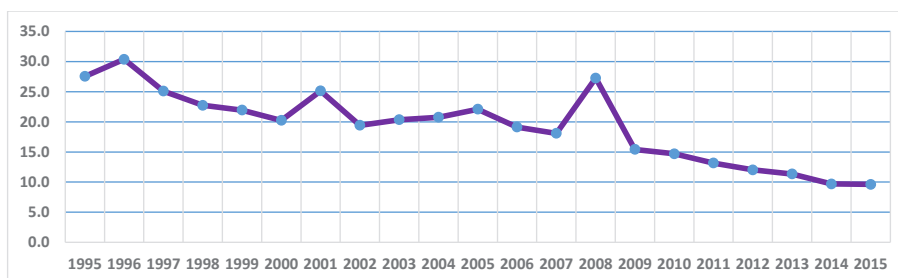
	2011	2012	2013	2014	2015
<b>Total branches &amp; outlets</b>	408	438	471	515	530
<b>BANKS' AGENTS</b>	0	844	2,047	2,499	2,555
<b>Total Network</b>	408	1,282	2,518	3,014	3,085

**Source:** BNR, Financial Stability Directorate

These developments contributed to increased competition in the banking sector as indicated by the Herfindahl- Hirschman Index (HHI). Developments in the HHI indicate that the competition in the Rwandan banking sector has been improving over time, from high concentration (between 2002 and 2009) to moderate concentration since 2010 (Kigabo, 2014).

Technological innovation has also contributed to the financial sector development with the introduction of Automated Teller machines, mobile banking and internet banking. The number of ATMs increased from 167 machines in 2011 to 280 in 2015 while the number of transactions using ATM and POs merchants increased to 7.5 million from 1.9 million and to 373,029 from 38,440 respectively from 2011 and 2015. In the same period, the number of transactions using mobile payments, mobile banking and internet banking increased to 168.6 million, 5.6 million and 556,152 respectively from 4.3 million, 527,300 and 1,493 (see details in tables 1 and 2 in appendix).

These developments have contributed to deepen the banking sector in Rwanda. Currency in circulation (CIC) as percentage of M3 has significantly dropped from 27.3% in 2008 to 9.6% in 2015 (figure 1) which contributed to have more deposits in the banking sector and to the increase in commercial banks loans to the private sector.

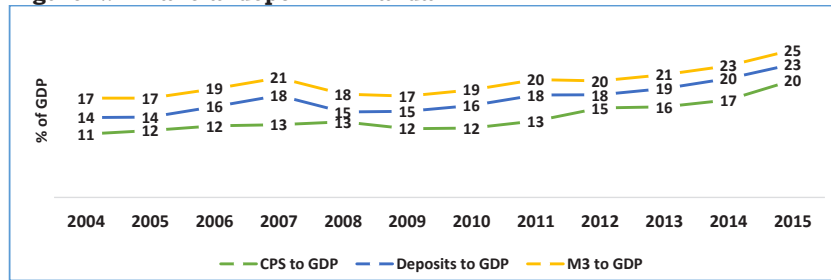
**Figure 1: Currency to M3**

**Source:** BNR, Monetary Policy Directorate



Both ratios of deposits and credit to private sector (CPS) to GDP increased respectively to 23 percent and 20 percent in 2015 from 14 percent and 11 percent in 2004. The ratio of broad money (M3) to GDP which stood at 17 percent in 2004 increased to approximately 25 percent in 2015.

**Figure 2: Financial depth in Rwanda**



**Source:** BNR, Monetary Policy Directorate

Another important change in the financial system in Rwanda was the creation of capital market in 2008. While the market remains nascent, it is becoming progressively active since 2014 after BNR and MINECOFIN decided to issue treasury bonds on quarterly basis. This offered an alternative way of saving for non-bank savers. The share of retail investors in Government bonds has increased from almost 0% in 2013 to 15% in May 2016. During the same period, the ratio for institutional investors increased from 10% to 50.34% while the share of commercial banks declined from 90% to 35%.

## 2.2. Financial innovation and monetary policy in Rwanda

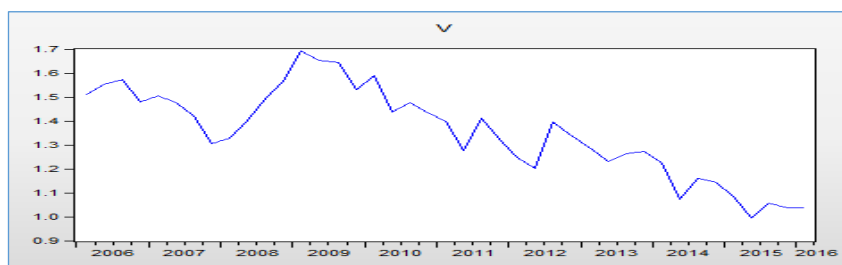
The developments presented in subsection 2.1 indicate that financial innovation in Rwanda has progressively affected the financial environment in which BNR conducts its monetary operations as well as the financial behavior of economic agents.

According to Fry (1988) the sign of association between the velocity of money (which is defined as the proportion of nominal GDP to money supply,  $GDP/M$ ) and income depends on the stage of financial development. At earlier stages, the velocity of money may fall due to high increase in the monetization of the economy and relatively fast monetary expansion. However, at advanced stages with financial innovation and technological progress that guarantee the

accessibility and use of money substitutes and provide a variety of money substitutes, the velocity of money is expected to increase. In addition, an increase in interest rates which represent the opportunity cost of holding money will lead to a fall in money demand and as consequence velocity of money goes up.

As shown in graph 3, the velocity of money in Rwanda decreased since 2008 due to the high increase in the monetization of the economy as result of developments in the financial sector which contributed to increased financial inclusion in Rwanda.

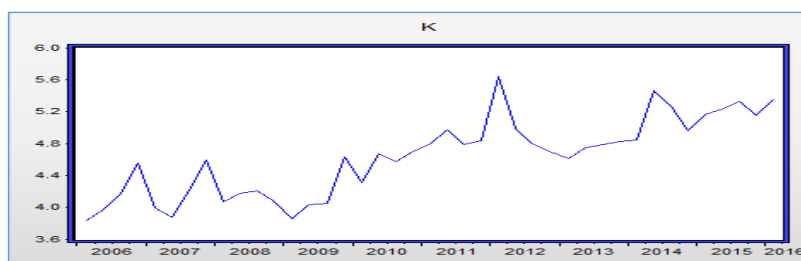
**Figure 3: Velocity of money**



**Source:** BNR, Monetary Policy Directorate

Different factors explain the development in reserve money in Rwanda which has been increasing since 2006. It increased from 3.8 in the first quarter of 2006 to stand at 5.4 in the first quarter of 2016. They include the reduction in reserve requirement ratio to 5% from 8% in 2009. Indeed, the currency ratio, which is the ratio of currency to demand deposits, has been declining overtime on the back of the increase in economic activities.

**Figure 4: Money multiplier**



**Source:** BNR, Monetary Policy Directorate



### **3. Literature Review**

The literature on financial innovation is still evolving as new financial instruments and financial services continue to enter the market. The existing literature has mainly focused on evolution of the financial system in the developed world with few studies focusing on developing countries. Existing studies have analyzed the linkages between general financial innovation and monetary policy, growth and inflation and linkages between specific financial innovation products, macroeconomic variables and monetary policy transmission mechanisms. This section briefly presents a survey of theoretical and empirical work with a bias towards developing economies. The first strand of literature analyses the impact of electronic money on the central bank's ability to control money supply. This literature is controversial on this aspect, with one line of thought arguing that increased usage of electronic money would make it difficult for central banks to supervise and measure the monetary base (Kobrin 1997, Friedman, 1999). The other strand holds a more optimistic view and notes that the fears for the future of monetary policy may have been overstated (Bert, 1996; Helleiner, 1998; Freedman, 2000; Goodhart, 2000; and Woodford, 2000).

There exist an extensive literature exploring the effect of financial innovation on the stability of the money demand function, with a general consensus that evolution of new financial products creates instability in the traditional money demand function. Arrau and De Gregorio (1993) examined the money demand equations in Chile and Mexico. Their results suggested that there is an important permanent component in the demand for money not captured by traditional variables but by financial innovations, which is modeled as an unobservable shock that has permanent effects on money demand.

Using the market share of credit cards as an indicator of financial innovation, Viren (1992) empirically examined the relationship between financial innovations and currency demand. The results showed that credit card transactions have a strong offsetting effect on currency demand.



A similar study by Al-Sowaidi and Darrat (2006) examined the effects of financial innovations in Bahrain, the UAE and Qatar on the long-run money demand. The study found no undue shifts in the equilibrium money demand relationship despite the fast pace of financial innovations experienced in the three countries. The findings were robust to different measures of the money stock.

In Korea, Cho and Miles (2007) found a downward trend in velocity which was attributed to monetization of the economy. It is expected that velocity should increase over time as payment systems evolve or cash management improves. The basic argument in the perverse sign observed in the Korean case is based on the fact that, there is increased willingness to hold money as income increases. The coefficient of real GDP was more than unity indicating a high level of monetization in the Korean economy.

A few number of studies exist focusing on the examination of the linkages between financial innovation and the stability of the money demand function in Africa. Using Granger causality and VAR methodologies, Kovanen (2004) examined the determinants of currency demand and inflation dynamics in Zimbabwe. The author measured financial innovation as the ratio of broad money to currency and the results from the VAR estimation for financial innovation are not significant. Lungu et al (2012) did a similar study using Malawian data but in this case financial innovation has a significant effect on the demand for money in the short run.

Sichei and Kamau (2012) conducted a similar study using Kenyan Data. They used the number of ATMs as a proxy for financial innovations. Their results did not indicate any significant effect of innovations on the demand for money. The insignificant effect of financial innovations could be due to the fact that the used measure of financial innovation is not widespread across the country. While acknowledging that the data for other more inclusive measures such as M-Pesa may not have been available and adequate in terms of observations to allow plausible empirical investigation, the authors did not explore other financial innovation measures used in previous studies. They, however, demonstrated the instability of money demand post 2007.

Studies conducted on Kenya in the 1980s and 1990s (Dharat 1985; Mweya, 1990; Adam, 1990) show that money demand was stable at the time. Of particular interest is a study by Dharat (1985), where special attention was paid to the model specification, its dynamic structure and to its temporal stability. Following this approach the study showed that for both conventional definitions of money (the narrow and broad), the theoretical model fits the Kenyan data quite well, and the variables were all statistically significant and with the anticipated signs. Based on a battery of tests, the results suggested that the estimated money demand equation for Kenya was temporally stable. Turning to the open-economy nature of the money demand model, it was found that the foreign interest rate plays a significant role in the Kenyan money demand equations.

#### **4. METHODOLOGY**

To investigate the effect of financial innovations on the conduct of monetary policy in Rwanda we first assess the stability of money demand but before doing this, we examine the stability of the velocity of money and the money multiplier in Rwanda as these are key underlying assumptions of BNR monetary policy. Second, we investigate whether or not the innovations have impacted on money demand and the monetary policy transmission mechanism in Rwanda.

##### **4.1. Stability of velocity of money and money multiplier**

To test for the stability of the velocity of money and money multiplier, we first use a simple model used in other recent papers on the same topic (Nyamongo et al, 2013):

$$Z_t = \beta_0 + \beta_1 trend_t + \varepsilon_t \quad (1)$$

Where  $Z$  is either income velocity  $V=PY/M3$  or the money multiplier  $k=M3/B$ ;  $B$  is the base money,  $M3$  the broad monetary aggregate,  $P$  is the price and  $Y$  is the real GDP;  $trend$  is a trend term and  $\varepsilon$  is the error term.



Considering the effects of financial innovations,  $\beta_1$  is expected to be negative and significant when the dependent variable is the income velocity and positive and significant when the dependent variable is the money multiplier.

A recent paper by Kigabo (2014) using Gregory – Hansen cointegration and Hansen (1992) tests shows that the long-run relationship between M3 and Reserve money holds over some period of time, and then has shifted to a new long-run relationship after 2010 as a result of changes in monetary policy framework and financial sector development. The paper also concluded that the structural change in the relationship between the two variables may reduce the efficiency of the money multiplier model and limit the controllability of money supply by BNR using reserve money as the operational target.

In this paper, we focus more on the stability of the velocity of money using unit root tests and cointegration techniques which allow taking into consideration possible structural breaks. Considering the simple quantity theory, if the velocity  $V$  of money is stationary, M3 and nominal GDP (PY) are either stationary or cointegrated. Non stationarity of  $V$  indicates that the long-run relationship between M3 and PY has broken and that one of the three variables M3, P and Y is moving separately from others.

#### **4.2. Stability of money demand**

To assess the stability of money demand, we estimate the money demand function in line with the portfolio management theory. This allows for the comparison of returns on alternative ways of economic agents to save their money with returns on deposits in financial institutions. For the choice of variables in a money demand equation, we follow Sriram (1999) and Kigabo (2011). In order to measure the impact of financial innovations on money demand, we augment the money demand function for Rwanda by including a proxy for financial innovations and check if the corresponding coefficient is statistically significant and negative.

Different measures of financial innovation have been used in research on the effect of financial innovations on money demand. They include M3/M2, ATM concentration, bank concentration and private sector credit as percentage of GDP. For robustness of our results we will use all those variable expect ATM concentration due to data unavailability.

The money demand function is specified as follows, with data running from 2006 quarter 1 to 2016 quarter:

$$\ln rm3_t = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 (tb - dr)_t + \alpha_3 (\inf - dr)_t + \alpha_4 \ln e_t + \varepsilon_t \quad (2)$$

Where  $\ln rm3$  is the natural logarithm of the broad money aggregate in real terms,  $\ln y$  is the natural logarithm of real GDP,  $tb$  is the treasury bill rate which is the opportunity cost of holding money;  $dr$  is the deposit rate which is the return of money  $\inf$  is the inflation rate, which is the expected return from holding goods and  $e$  is the exchange rate between Rwandan franc (FRW) and USD, defined as number of FRW for one USD. In this case, an increase (decrease) in exchange rate corresponds to the depreciation (appreciation) of Rwandan franc.

$\alpha_1$  is expected to be positive,  $\alpha_2$  and  $\alpha_3$  are expected to be negative while  $\alpha_4$  may be positive or negative. If  $\alpha_4$  is positive, this means that a depreciation of FRW leads to the substitutability of domestic currency for foreign currency and if it is negative, a depreciation of the FRW leads to an increase in foreign assets by domestic residents.

The level and stability of the demand for money has recently received enormous attention in the literature because an understanding of its causes and consequences can usefully inform the setting of monetary policy. The demand for money is found to be a major determinant of liquidity preference. When money demand (which is the people's preference for cash instead of assets) is stable, the central bank can reasonably predict the level of money supply in the economy. Poole (1970) argued that the rate of interest should be targeted if liquidity preference is unstable. Thus, knowing if money demand is stable or not is necessary to select the correct monetary policy instruments.





A number of studies, including Bahamani-Oskooee and Bohl (2000, 2001), Bahamani-Oskooee and Barry (2000), have examined the stability of money demand function in the context of cointegration analysis, considering that if money demand is cointegrated with its major determinants, then the money demand is stable.

However, different studies have shown that the existence of cointegration is not necessarily an evidence of the stability of money demand when other tests are used. For example, Bahamani-Oskooee and Barry (2000), investigated the stability of the M2 money demand function in Russia. They found evidence of cointegration between the series in the system. While the plot of the cumulative sum of recursive residuals (CUSUM) provided evidence of stability, the plot of the cumulative sum of squares of recursive residuals (CUSUMSQ), on the other hand, revealed that the demand function M2 was not stable.

In this study, we also use CUSUM and CUSUMSQ tests developed by Brown et al. (1975) to test the stability of money demand. The CUSUM and CUSUMSQ test statistics are updated recursively and plotted against break points in the data. For stability of the short-run dynamics and the long run parameters of the real broad money demand function, it is important that the CUSUM and CUSUMSQ statistics stay within the 5 percent critical bound (represented by two straight lines whose equations are detailed in Brown et.al, 1975).

#### **4.3. Financial innovations and monetary policy**

To investigate the effect of financial innovations on monetary policy we follow a standard VAR framework based on 5 variables following this order: the log of GDP; the log of the price level (CPI); the log of money supply (M3); the short-term interest rate; the nominal exchange rate (NEER). This particular ordering has the following implications: (i) Real GDP does not react contemporaneously to shocks from other variables in the system; (ii) CPI does not react contemporaneously to shocks originating from all factors except real GDP; (iii) money stock (M3) does not react contemporaneously to real GDP but is affected contemporaneously by short-term interest rate and nominal effective exchange rate; (iv) the interest is affected contemporaneously by all shocks in

the system, except those from the nominal effective exchange rate; (v) the nominal effective exchange rate is affected contemporaneously by all shocks in the system.

Following Hamori (2008), we extend the traditional money demand specification as shown in equation (2), by including financial innovation (FINOV).

$$\ln m_{3t} = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 (tb - dr)_t + \alpha_3 (\inf - dr)_t + \alpha_4 \ln e_t + FINOV_t + \varepsilon_t \quad (3)$$

We use M3/M2 as of proxy measure of financial innovation, particularly for developing economies due to data limitation.

Using the impulse response functions, the speed and effectiveness of monetary policy is assessed in two separate periods 2000-2006 and 2006-2016 and compare the results for the two periods. The objective is to assess if financial innovations introduced since 2008 has contributed to improve the transmission mechanism in Rwanda.

## 5. EMPIRICAL RESULTS

We first use ADF unit root test to identify stochastic properties of all used variables and we found that they are all I (1) are reported on Table 1 below.

**Table 1: Unit root tests**

	Level	First difference	Conclusion
	ADF statistics t	ADF statistics t	
M3	4.3	-4.3*	I(1)
RY	7.5	-8.3*	I(1)
Tb-dr	-1.7	-5.2*	I(1)
Inf-dr	-2.3	-4.2*	I(1)
e	5.1	-3.9*	I(1)
V	1.3	-4.3*	I(1)
NY	4.3	-4.3*	I(1)

**Source:** Authors' estimations

**V: velocity of money; NY: nominal GDP**

### 5.1. Testing the stability of velocity of money and money multiplier

The table below summarizes the results of regression of both the velocity of money (V) and money multiplier (MM) in Rwanda. The results reveal that



during the period under review, both the velocity of money and money multiplier have significant trends at 1% level of testing. They also indicate that every quarter the velocity of circulation declined by 0.01% on average while the money multiplier increased by 0.03% on average.

**Table 2: Estimation results of velocity of money and money multiplier**

<b>Trend</b>	<b>VM</b>	<b>MM</b>
<b>Trend</b>	<b>-0.01*</b>	<b>0.03*</b>
<b>C</b>	<b>1.6</b>	<b>3.9</b>
<b>R-square</b>	<b>0.68</b>	<b>0.72</b>

**Source:** Authors' estimations

We focus then on a further assessment of the stability of velocity of money using Perron and unit root test as well as Gregory-Hansen cointegration (1992) test to assess if there is cointegration between M3 and nominal GDP (ny). As mentioned, the same analysis is done for the money multiplier in Kigabo (2014). The table 1 shows that the velocity of money (V) is not stationary using ADF test. However, it is well know that this test has low power when there is structural breaks in the series.

The Perron test shows that the velocity of money (V) is stationary with breakpoint in quarter 4, 2008 (with t- statistics -5.50 smaller than the critical value of -4.83 at 5%). We then conclude that the velocity of money is stationary but with a break in its trend.

**Table 3: Perron Unit root tests with structural breaks**

Null Hypothesis: VM has a unit root with a structural break in trend  
Chosen break point: 2008Q4

	t-Statistic
Perron Unit Root Test	-5.504608
1% critical value:	-5.45
5% critical value:	-4.83
10% critical value:	-4.48

The structural change in the relationship between broad money (M3) and nominal GDP (ny) is confirmed by cointegration tests. On one side, using

Engle Granger test of cointegration, we find that the two variables are not cointegrated.

**Table: 4 Cointegration Test - Engle-Granger**

	Value	Prob.*
Engle-Granger tau-statistic	-0.723269	0.9424
Engle-Granger z-statistic	-2.501291	0.9063

\*MacKinnon (1996) p-values.

However, using Gregory Hansen test to allow structural breaks to be taken into consideration, results show that the two variables are cointegrated with a structural break in 2009 quarter 4.

**Table 5:** Gregory-Hansen Test for cointegration with Change in Regime and Trend

Test	Breakpoint Statistic	Date	Asymptotic Critical Values 5%	
ADF	-7.58	2009q4	-6.02	-5.50
Zt	-5.58	2009q4	-6.02	-5.50

## 5.2. The stability of the money demand

To assess the stability of the money demand function we first test if there is a long run money demand function using Johansen test in Rwanda. Both trace and max-eigenvalue tests indicate one cointegrating equation at 1 percent level. This means the variables are cointegrated and therefore have long run relationship.

**Table 6: Unrestricted Cointegration Rank Test (Trace)**

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.686218	91.81809	69.81889	0.0003
At most 1	0.465912	46.61484	47.85613	0.0651
At most 2	0.314220	22.15422	29.79707	0.2900
At most 3	0.153348	7.443462	15.49471	0.5267
At most 4	0.024097	0.951287	3.841466	0.3294

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

**Table 7: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.686218	45.20325	33.87687	0.0015
At most 1	0.465912	24.46062	27.58434	0.1195
At most 2	0.314220	14.71076	21.13162	0.3097
At most 3	0.153348	6.492175	14.26460	0.5509
At most 4	0.024097	0.951287	3.841466	0.3294

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

The following is the estimated long run money demand function for Rwanda

$$\ln m_{3t} = -12.4 + 1.4 \ln r_{yt} + 0.9 \ln neer_t - 0.02(tb - dr)_t - 0.0003(\inf - dr)_t$$

(-8.8)    (36.1)    (2.5)    (-2.4)    (-0.12)

The estimated coefficient for real income is positive and significant at 1 percent level of significance, and greater than unity (1.4), suggesting that during the period under study real income induced higher than proportionate changes in real money balances, which is a reflection of financial development and monetization of the Rwandan economy.

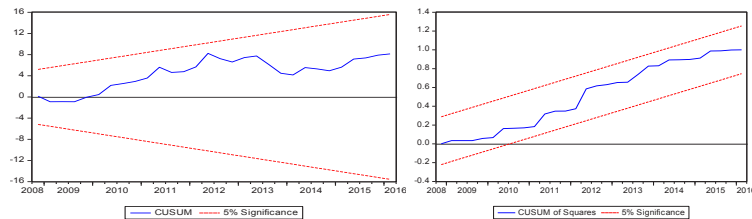
The estimated coefficient of interest rate (spread between Treasury bill rate and deposit rate) is found to be significant and negative indicating that economic agents in Rwanda consider investment in Treasury bill as an alternative way of saving their money in addition to their term deposits in commercial banks.

The coefficient of exchange rate is positive and significant at 1 percent level of testing, indicating that depreciation increases the demand for money. This finding suggests that movements in the exchange rate have a significant impact on the demand for broad money in Rwanda. The spread between inflation and deposit rate is not statistically significant mainly due to the fact that in Rwanda the inflation was kept low and stable in the period under review.

After establishing the existence of cointegrating relationship, the second step was to check if the long-run demand for money function is stable or not. We use different tests to accomplish this task.

The stability test in figure 5 below shows that neither the CUSUM nor CUSUMSQ plots cross the 5 percent critical lines. Therefore we can conclude that the estimated parameters for the money demand in Rwanda are stable and useful for policy decision. The result is confirmed by Chow breakpoint test (with break in 2009 quarter 4 identified in the relationship between M3 and the nominal GDP).

**Figure 5:** Plot of CUSUM and CUSUM squares



**Table 8: Chow Breakpoint Test: 2009Q4**

Null Hypothesis: No breaks at specified breakpoints

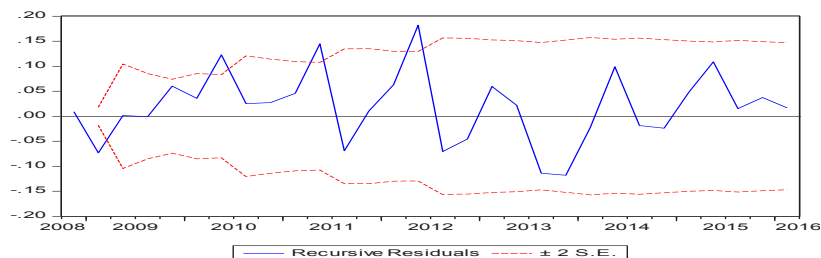
Varying regressors: All equation variables

Equation Sample: 2007Q3 2016Q1

F-statistic	1.215273	Prob. F(5,25)	0.3310
Log likelihood ratio	7.615013	Prob. Chi-Square(5)	0.1788
Wald Statistic	6.076367	Prob. Chi-Square(5)	0.2989

However, the recursive residuals test indicates some instability in money demand function.

**Figure 6:** Plot of recursive residuals



The results of the estimation of equation (2), after including financial innovation as an explanatory variable of money demand suggest that financial innovations do not play an important role in determining money demand in



the long run. The coefficient of M3/M1 is negative but not significant, showing that financial innovation has not yet led individuals to move away from more liquid assets to less liquid assets.

$$\ln m_{3t} = -11.9 + 2.2 \ln r_{yt} + 0.8 \ln neer_t - 0.02(tb - dr)_t - 0.0007(\inf - dr)_t - 0.2(m_3 / m_1)_t$$

(-6.5)      (22.7)      (1.9)      (-2.2)      (-0.23)      (-1.4)

### 5.3. Financial innovation and monetary transmission mechanism

To assess the possible impact of financial innovation on monetary transmission mechanism in Rwanda, we have estimated impulse response functions in two separate samples: the total sample and the sub sample starting in 2010 as previous analysis indicated a structural change in the relationship between Money and price or nominal GDP in the last quarter of 2009. Estimated impulse response functions show that in the total sample, both real GDP and price levels react to a shock on M3. However, when restructured to the last sub sample, there is clear change in the transmission mechanism, particularly with real GDP and CPI reacting also on changes in the exchange rate. Furthermore, using credit to the private (CPS), impulse response functions indicate that in the sub sample, a shock on credit to the private sector has an impact on real GDP and CPI. And more interestingly, real GDP reacts to changes in the Treasury bill rate. This finding has very important monetary policy implications given that economic agents in Rwanda consider investment in Treasury bills as an alternative way of saving, in addition to their term deposits in commercial banks. Thus, BNR needs to improve the use of the central bank rate to impact money market rates, particularly the Treasury bill interest rate as the first stage of the interest rate pass through.

## 6. CONCLUSION

The objective of this paper is to assess the possible impacts of financial innovation on the conduct of monetary policy in Rwanda, focusing on the stability of money multiplier and velocity of money as financial innovation may lead to instability of the two economic variables. Instability in money



multiplier and in money demand breaks the link between BNR operating target (base money) and intermediate target (M3) on one side, and, between the intermediate target and the final objective of monetary policy (inflation). In other words, instability of the money multiplier and money demand weakens the current monetary transmission mechanism in Rwanda, which goes from the base money to inflation through M3.

Empirical results show that both the velocity of money and money multiplier have significant trends at 1% level of testing. They also indicate that every quarter the velocity of circulation declined by 0.01% on average while the money multiplier increased by 0.03% on average. In addition, Perron unit root test indicates that the velocity of money is stationary but with break in trend. Gregory Hansen test confirms that there is a long run relationship between M3 and nominal GDP but with changes in the trend after 2009 in quarter 4, mainly due to high increase in the monetization of the economy.

About the stability of money demand, the cointegration test, CUSUM test and Chow break test indicate that money demand in Rwanda is stable. However, recursive residuals indicate some sign of instability in the money demand. About the impact of financial innovation on money demand, results indicate that that financial innovation has not yet led individuals to move away from more liquid assets to less liquid assets, though the negative sign is in line with expected link between money demand and financial innovation. The break in the relationship between M3 and nominal GDP is more explained by the increase in the level of monetization of the economy as result of financial sector development than the use of new financial products.

In terms of policy implications, the existence of the long run relationship between M3 and nominal GDP indicates that central banks may influence the development of nominal GDP (and in price) through the control of M3. However, the structural change in the relationship between the two variables as a result of financial innovation may constrain the conduct of monetary policy and thus reduce the effectiveness of the monetary aggregate framework. In addition, estimated impulse response functions in the sub sample starting in 2008, where much change in monetary and financial sectors happened in





Rwanda, indicate that a shock on credit to the private sector has an impact on real GDP and CPI. And more interestingly, real GDP reacts to changes in Treasury bill rate. This result is very important in terms of policy implication as it indicates that economic agents in Rwanda consider investment in Treasury bill as an alternative way of saving, in addition to commercial banks' term deposits. Thus, BNR needs to improve the use of the central bank rate to impact money market rates, particularly the Treasury bill interest rate as the first stage of improving the interest rate pass through.

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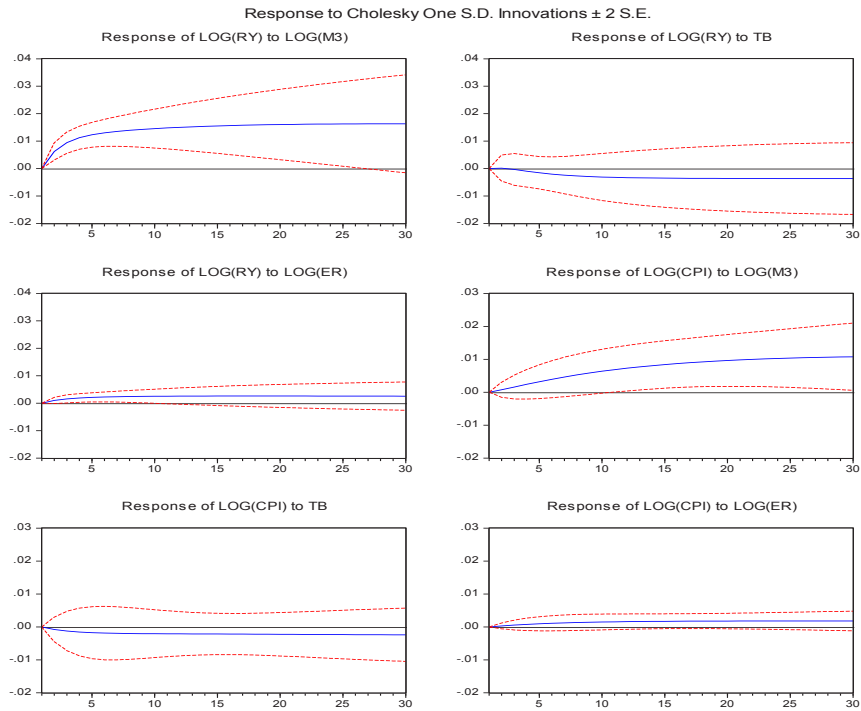
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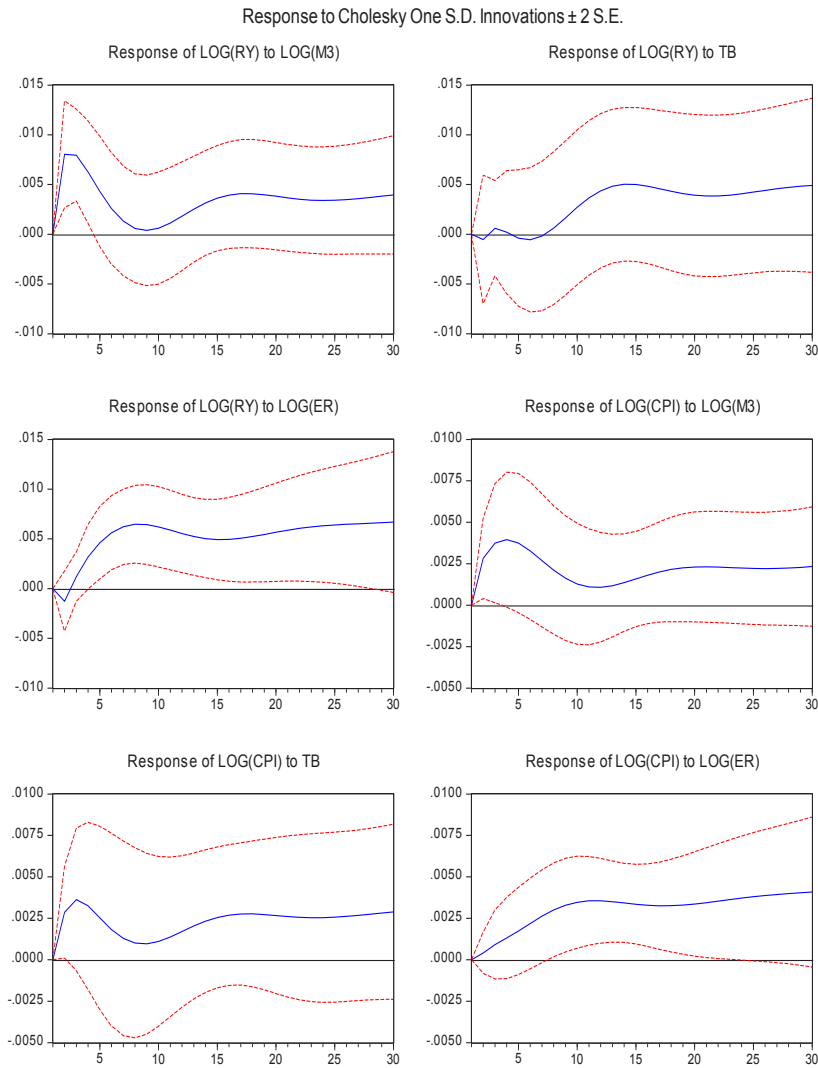
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## APPENDICES

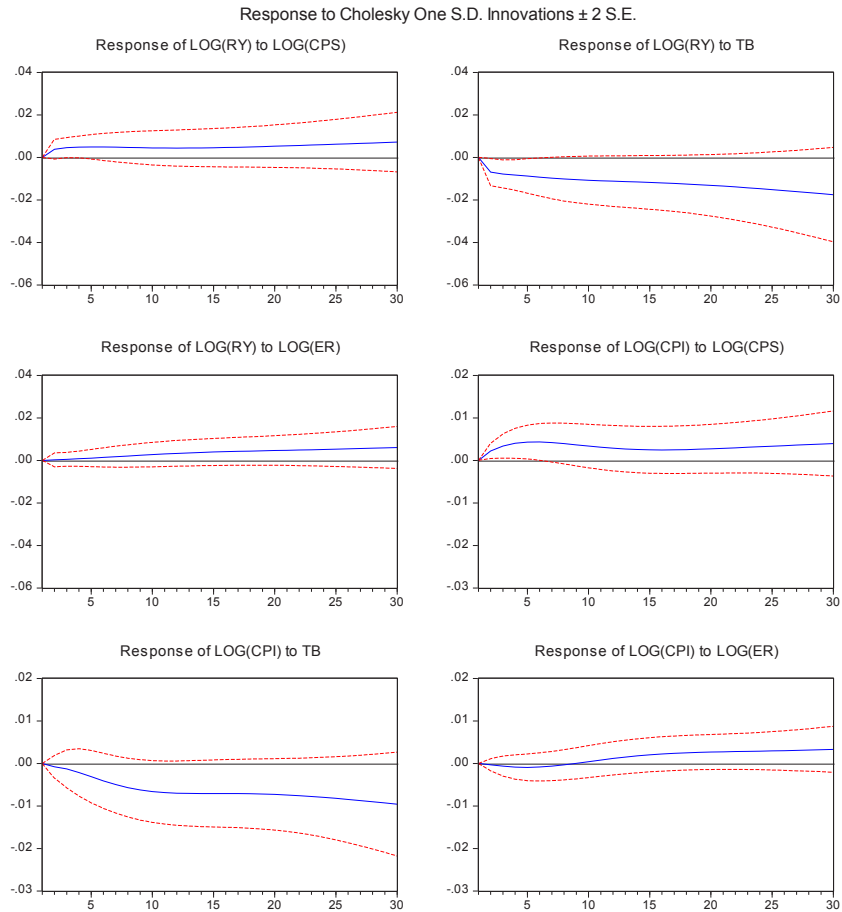
**Figure1: Impulse response in total sample**



**Figure 2: Impulse response with sample starting in 2010**



**Figure 3: Impulse response in the sub sample, using the credit to the private sector (CPS)**



**Table 1: Mobile financial services and internet banking**

	2011	2012	2013	2014	2015
<b>Mobile payment</b>					
Number of subscribers	639,673	1,440,541	2,538,651	6,480,449	7,663,199
Number of Transactions	4,323,490	22,191,674	57,147,777	104,773,115	168,612,455
Value ( FRW million)	51,024	161,808	330,378	691,477	1,093,497
<b>Mobile banking</b>					
Number of subscribers	155,986	297,537	412,007	659,712	828,799
Number of Transactions	527,300	1,458,063	2,538,820	4,637,849	5,617,368
Value ( FRW million)	5,215	3,926	17,459	41,281	48,309
<b>Internet banking</b>					
Number of subscribers	Na	3,411	8,869	29,840	36,597
Number of Transactions	1,493	10,036	89,260	312,264	556,152
Value ( FRW million)	708	12,746	117,147	332,959	581,163

**Table 2: Card based payment system**

	2011	2012	2013	2014	2015
<b>Number of instruments</b>					
Number of Automated Teller Machines (ATMs)	167	292	333	354	280
Number of Point of Sale (POS) terminals for marchants	227	566	946	1,152	1,718
Number of Point of Sale (POS) terminals for Agents			491	1,009	1,422
Number of debit cards	115,200	389,269	487,498	638,869	650,924
Number of credit cards	516	418	845	2,540	3,485
<b>Number of transactions</b>					
ATM	1,976,376	5,753,163	7,774,053	7,488,707	7,505,815
POS Merchants	38,440	63,757	111,570	185,441	373,029
POS Agents		22,425	298,835	482,945	827,130
<b>Value ( FRW million)</b>					
ATM	122,536	180,567	260,585	310,009	354,049
POS Merchants	6,438	9,034	14,718	19,223	26,625
POS Agents		658	11,235	13,069	21,963







## **Interest rate Pass-through in EAC**

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**Key words:** Interest rate, pass-through

**JEL Classification Number:** E43

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### **Abstract**

*As the EAC central banks are in the process of adopting the use of interest rate as an operating target, in this paper we examined and compared the degree of the interest rate pass-through across EAC countries. Our analysis employed various standard approaches in the area using macro level data. The study reveals a limited interest rate pass-through in all countries with divergences on whether it is the lending rate or the deposit rate that is most responsive and on which money market rate has the most influence. The study indicates the effect of country characteristics and time effect on the degree of the pass-through but advancements in the financial sector have to reach a high level of integration to be able to improve it.*



## **I. Introduction**

On the eve of the adoption of the inflation targeting framework by the East African Central Banks by 2018 in which interest rate is used as operating target, the interest rate pass-through is a subject to close scrutiny in the East African Community economies. While these economies are getting ready, the debate continues on whether the adoption of the inflation targeting framework should precede a well-functioning interest rate channel or whether the interest rate channel should first work before a monetary authority think of using interest rate as operating target. For some scholars and practitioners alike, the interest channel may be not working because a country is implementing inappropriate policies (Carare et. al. 2002, Freedman and Otker-Robe, 2010, Dabla-Norris et al. 2007).

Though central banks in EAC have generally been effective in attaining their respective objectives within the monetary targeting framework, they have challenges related to the breaking down of its basic assumptions necessitating to move into using interest rate as operating target. However, there are concerns about how these central banks are affecting the bank retail activities before the effect propagate to the real economy. More so, there is no long time that the EAC central banks started using the policy rate and in some cases it is used just as a signal of monetary policy stance but without necessarily influencing the banking pricing behavior.

The most popular channel through which monetary policy actions are transmitted to the economy is the interest rate channel. The channel can be divided in two stages. The first is the interest rate pass-through which describes how markets rates (deposit and lending rates) react to changes in the monetary policy rate. The second stage is related to the impact of nominal interest rate changes on real economy.

This paper focuses on the first stage by analyzing the interest rate pass-through in Rwanda. The policy interest rate pass-through is believed to be slower and limited in Low income countries, including Rwanda due to several factors including a low degree of monetization, underdeveloped financial markets, a structural excess liquidity, exchange rate flexibility, the balance sheet problems in the banking sector, and corporate sectors, institutional

quality and fiscal dominance (Anthoni, Udea, and Braun, 2003, Alexander Tieman, Stephanie Medina Cas, et al, 2011). In addition, the lending policies of banks are often found to be price inelastic with respect to interest rates in the short run, because other, non-interest rate factors, like adjustment costs and, sometimes, directed lending, play a substantial role (see e.g. Cottarelli and Kourelis (1994), Schaechter, Stone, and Zelmer (2000), or Carare et. al. (2002)).

The knowledge of the degree of the interest rate pass-through provides the basis for policy makers to assess how they achieve their objectives. Although there are some studies on interest rate pass-through on EAC individual country, the principal aim of this study is to examine the regional status of the interest rate pass-through as the six EAC countries are planning to start using a common currency in 2024.

The rest of the paper is organized as follows: section 2 gives a brief summary of the literature on interest rate pass through. Section 3 covers the methodology and section 4 analyzes the empirical findings. Section 5 provide the concluding remarks.

## **II. Brief Summary of the Literature**

From the time the research on interest rate pass-through broke out with Bernanke, Blinder and Gertler in 1985 to our days as part of assessing the effectiveness of monetary transmission mechanisms, three features of the interest rate pass-through have been researched on (Chionis and Leon, 2006). The first tread of this research in the literature focused on providing the theoretical explanation of interest rate stickiness. Indeed, interest rates continue to register some rigidities in the short-run. The second one takes a look at cross-country differences especially in a monetary union and the degrees of pass-through and lastly, the literature centers on characteristics of the financial system that bring about the differences in the interest rate pass-through mechanism. This study put emphasis on the second one analyzing the differences in interest rate pass-through among East African Community countries.



The interest rate pass through has been subject of several studies, particularly in developed countries, especially following the adoption of inflation targeting framework for monetary policy. The empirical evidence on features of interest rate pass-through show that the transmission of interest rate is generally not complete and the speed of adjustment as well as the size of pass-through in long run vary across bank products, countries, markets and time period mainly due to differences in macroeconomic conditions and financial market development (Tieman, 2004, Balazs et al, 2006; Nikoloz Gigineishuli, 2011).

About macroeconomic conditions, higher interest rate pass-through to lending and deposit rates is observed during the period of rapid economic growth as well as in the period of high inflation. By contrast, higher interest rate volatility, which is an indicator of macroeconomic instability and uncertainty, weakens the interest rate pass-through (e.g. Nikoloz Gigineishuli, 2011).

The development of financial market plays an important role in monetary transmission. If the demand elasticity for deposits and for loans respectively is inelastic, the pass-through may not be complete. Inelasticity of the demand for deposits and loans may result from imperfect substitution between bank deposits and other money market instruments of the same maturity, between bank lending and other types of external finance due to low level of economic development (equity or bond markets), high switching costs as well as problems related to asymmetric information such as adverse selection and moral hazard (Sander and Kleimeier, 2004), and the competition within the banking sector and in financial sector.

Indeed, when banks have high market power, changes in policy rate as well as changes in banks' costs of funds may impact spreads (difference between lending and deposit rates) rather than market rates by maintaining fixed lending rates when deposit rates declined as result of a reduction in the policy rate, (Sander and Kleimeier, 2004; Catarelli and Korellis, 1994, De Bondt, 2002, Dabla Norris et al., 2007, Stephanie Medina, et al. 2011).

Financial shallowness tends to lead to higher excess liquidity in banks which limit the development of the interbank market and reduce the effectiveness of

interest rate pass-through and limit the central bank rate to opportunity cost of holding liquidity by banks and not a cost of funds. In addition, more developed domestic capital markets, including a secondary market for government securities and long term domestic currency securities, strengthens transmission (Leiderman et al., 2006; Stephanie Medina Cas, et al., 2011).

The health of the financial system may also impact the effectiveness of the interest-rate transmission mechanism. Financially weak banks may respond to an injection of central bank liquidity or lower policy interest rates by building up liquidity or increasing margins in order to raise capital positions and increase provisioning rather than extending credit (IMF, 2010). Holding on to bad loans on the balance sheet may crowd out new loans and limit the impact of lower interest rates (Archer and Turner, 2006).

### **III. Methodology**

In the literature there exist two approaches to study the interest rate pass-through. The cost of funds approach is mostly used if the analysis focuses on how money market rates influence the bank-retail rates. Money market rates are taken as opportunity cost for both banks and depositors. In this approach the maturity is an important criterion; it is better to use rates of the same maturity to avoid mismatch; i.e. mortgage rates versus long-term lending rates. The second approach is the monetary policy approach which is used when the focus is on the effect of monetary policy on bank-retail rates and includes no other explanatory variables.

Empirically, both approaches estimate the following long run function

$$i^M = \alpha + \beta \cdot i^P + \varepsilon \quad (1)$$

Where  $i^M$  is the market rate and  $i^P$  is the policy rate.

Or an autoregressive distributed lag model:

$$i_t^R = \alpha_0 + \sum_{j=1}^p \alpha_j \cdot i_{t-j}^R + \sum_{k=0}^q \beta_k \cdot i_{t-k}^M + \varepsilon_t \quad (2)$$

For the short-run, they both specify an error correction model (ECM) of the form:

$$\Delta i_t^R = \alpha_0 + \alpha_1 \cdot i_{t-1}^R + \beta \cdot i_{t-1}^M + \gamma(i_t^R - \alpha - \beta i_t^M) + \mu \quad (3)$$

For the cost of funds approach, studies that look at the effect of market rates to different bank retail rates in the same model do estimate VAR models. In some studies the term  $\beta \cdot i_{t-1}^M$  in the ECM is not included depending on various reasons. For instance, when the model has to be used for forecasting this term is dropped.

In this study we estimated both models for each single EAC country and conducted an impulse response analysis based on a bivariate VAR to check for robustness. We then carried out a panel analysis to assess if there are country specificities or time effects that influence to evolution of the pass-through.

To sum all, we estimated the following empirical models:

### 1. Single Equation Model

$$br_t = \alpha_1 + \alpha_2 mr_t + \varepsilon_t \quad (4)$$

Where  $br_t$  is the bank-retail rate (loan and deposit rates),  $mr_t$  is the policy rate,  $\alpha_1$  is a markup and  $\alpha_2$  is the elasticity of market rate with respect to policy rate, measuring the long run pass through. The short-run estimates were obtained from estimating the following error correction model:

$$\Delta(br_t) = \alpha_3 + \alpha_4 dbr_{t-1} + \alpha_5 \varepsilon_t + \mu_t \quad (5)$$

The coefficient  $\alpha_5$  indicates the speed of adjustment of the short run dynamics to the long run equilibrium relationship described by the equation (1). A high level of  $\alpha_5$  indicates a faster market response to the policy rate.

### 2. Bivariate VAR Model

For the purpose of checking the robustness of the results of the precedent single equation model, this study estimated impulse responses from the subsequent model based on De Bondt (2002) solved using the cholesky decomposition:

$$Y_t = \beta_1 + \sum_{i=1}^2 A_i Y_{t-i} + \varepsilon_t \quad (6)$$

With:

$Y_t = \begin{bmatrix} \text{market rate} \\ \text{bank rate} \end{bmatrix}_t$ ,  $\varepsilon_t = \begin{bmatrix} \varepsilon^{mr} \\ \varepsilon^{br} \end{bmatrix}_t$ ,  $\beta_t = \begin{bmatrix} \beta^{mr} \\ \beta^{br} \end{bmatrix}_t$ ,  $A_i = \begin{bmatrix} a_i^{mr} & b_i^{mr} \\ a_i^{br} & b_i^{br} \end{bmatrix}_t$   $br_t$  and  $mr_t$  are defined as before.

### 3. The Autoregressive Distributed Lag Model (ARDL)

The Autoregressive Distributed Lag Model is normally used in case variables of interest are integrated of order one. This study estimated the following ARDL model akin to Mishra (2012):

$$y_{it} = \alpha_i y_{t-1} + \beta_i y_{t-2} + \delta_i x_t + \gamma_i x_{t-1} + \sigma_i x_{t-2} + \varepsilon_t \quad (7)$$

Where  $y_t$  is the change in the bank-retail rates and  $x_t$  is the change in the money market rates. The short term effect is given by  $\delta_1$  and the long-term effect is computed as:

$$\frac{\delta_i + \gamma_i + \sigma_i}{1 - \alpha_i - \beta_i} \quad (8)$$

### 4. The Panel Model

In a view of exploring whether there are country-specific characteristics in explaining differences in the degree of pass-through among EAC countries, this study carried out a panel analysis from both the fixed effects model and the random effects model. It starts with pooled OLS of the following form.

$$y_{it} = \alpha + X'_{it}\beta + \varepsilon_{it} \quad (\mu_i = 0) \quad (9)$$

$\mu_i$  represents country or time effect and if it is equal to zero the pooled OLS produces efficient and consistent estimates.

The fixed-effects model is written as:

$$y_{it} = (\alpha + \mu_i) + X'_{it}\beta + v_{it} \quad (10)$$

And the random effects model is thus specified as:

$$y_{it} = \alpha + X'_{it}\beta + (\mu_i + v_{it}) \quad (11)$$

In the fixed-effects model a country and time specific effect is time invariant and considered to be part of the intercept and thus allowed to be correlated





with the regressors while in the random effects model the individual effect is assumed not to be correlated with any regressors.

Before estimations, we tested for stationarity and cointegration of all variables and all were found to be integrated of order one. Estimations were then run on variables that were cointegrated.

For proper comparison of all countries, Interest rates data are monthly weighted. The bank retail rates are lending rates and deposit rates and for money market rates, the study used the treasury bills of 91 days, 182 days and 364 days, the interbank rate and repo rates spanning from January 2005 to January 2016.

#### **IV. Empirical Analysis**

##### **1. Results from the single equation model**

The results from this model are presented in appendix i. They indicate low and incomplete interest rate pass through to deposit rates in all East African countries ranging between 25% and 33% in Rwanda while it is higher in Uganda around 56%\*. In Rwanda, the treasury bills rates and the interbank rate all affect the deposit rates while it is only the interbank that is statistically significant in Uganda for the entire sample of the study. These findings for Uganda are akin to those of Okello in 2013. However, the pass-through from the 364 days treasury bills rates to deposit rates hovered around 40% before the adoption of inflation targeting lite framework in Uganda; there are no cointegration with deposit rates and other treasury bills rates of different maturity. Kenya and Tanzania present similar cases of no cointegration between the deposit rates and all the treasury bills rates.

There is evidence of incomplete interest rate pass through from money market rates to lending rates only in Uganda using interbank rates. But even for Uganda, the parameter has a wrong sign before the adoption of ITL. The parameter is around 30% after but there is presence of serial correlation; thus any inference may be biased. For other EAC countries, the parameters had

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\* Bank of Uganda has adopted what is called lite inflation targeting since 2012

negative signs or were not statistically significant. Generally, the deposit rates seem to be reactive to changes in money market rates in the long-term but it is not so obvious in the short-term with the pass-through effect evolving around 10% with the speed of adjustment ranging between 60% and 80%.

## **2. Results from the Autoregressive Distributed Lag Model (ARDL)**

We got different results when using the ARDL model (see appendix iii). The lending rates seem to be more reactive on changes from money market rates and the treasury bills rates has bigger effects than the interbank rates. In Kenya, changes in interbank may explain 6% changes in lending rate in short-run. Changes in different treasury bills rates may account for 3% to 6% changes in deposit rates in the short-run. In Rwanda and Tanzania, the changes in 364-days treasury bills rates may explain respectively 5% and 4% of changes in lending rate in short-term. For Tanzania, the deposit rates may vary by 2% and 5% from changes happened in interbank rate and the 91-days treasury bills rates respectively in short-term. In Uganda 3% of changes in deposit rate may be accounted for by changes in interbank rate while changes in all treasury bills rates may explain 7% in short-term. Generally, the findings point to even a less interest rate pass-through of around 6% in the short-term across the region. In the long-term, the pass-through remains below 10% and statistically significant only in Kenya and Uganda.

## **3. Impulse response analysis**

The impulse responses are plotted in appendix ii. Except for Rwanda, the impulse response analysis revealed a very minimal contemporaneous effects. For Uganda, a 10% shock to interbank rate induces 0.8% changes in deposit rate that dies out after 15 months. It is 0.4% for Kenya and 0.15% for Tanzania but last longer about 14 months and 28 months respectively. One important conclusion from this analysis is that the changes in bank retail rates triggered by changes in policy rates is minimal but immediate, it is in the same range across different rates with slight differences across countries.



#### **4. Results of from panel estimations**

Using pooled OLS, all treasury bills rates and the interbank rate do not statistically and significantly explain variations in deposit rates. But they are statistically significant in explaining variations in lending rates. The 91 treasury bills rates is statistically significant in explaining the lending rate and the fixed effects model is better. That is, the differences among countries (such as financial development or bank competition) determine how the 91 treasury bills rates rate affects the lending rate.

The 182 and the 634 treasury bills rates are statistically significant in explaining the lending rate and the random effects model is better. That is, country specific characteristics may change overtime and change the effect of the 182 and the 634 treasury bills rates on lending rate. The effects of all treasury bills rates on lending rates is higher (around 23%) than on deposit rates (around 20%). The effects of interbank on lending rates is higher (around 16%) than on deposit rates (around 12%). These results are in contrast with the maturity mismatch challenge where short-term market rates are identified as determinants of longer term bank loan rates. However, this may come from the famous liquidity mismatch issue of financing long-term projects by short-term deposits that is present in the banking system in the region.

#### **5. Single Equation Model: Controlling for Financial Development and Sub-sample Results**

Since the panel analysis revealed country specificities and time effect in explaining the differences in the degree of the pass-through, the study factored in differences in financial development (FD) in EAC economies using the ratio of currency in circulation over money supply as a control variable (Archer and Turner 2006, Giginishuli 2011). This ratio may represent some advancements realized in financial inclusion and in payment system as one of the areas which undergone remarkable improvements in EAC countries.

In the beginning, the standard models of interest rate pass-through to bank retail rates did not factor in other variables apart from the policy rates to

account for countries' heterogeneity in bank products pricing. Indeed, though there may be no big divergences, the EAC countries' financial structures present different features. To accommodate for these differences, the single equation model was transformed as follows and was estimated at different sample periods:

$$br_t = \alpha_1 + \alpha_2 mr_t + fd + \varepsilon_t \quad (12)$$

The estimation results (included in appendix i) of the model suggest that when you control for the effect from the developments taking place in the financial sector, the degree of the pass-through changes with time. In Rwanda the changes are meaningful but the pass-through remains incomplete while in Kenya and Uganda the changes are negligible.

## **6. Summary of the findings**

The findings from the four models suggest some similarities and divergences. The degree of the interest rate pass-through in all EAC economies is incomplete and low and from some models it was found to be even below 10%. For some countries, some models could not even find in the data any statistically significant estimates. There is an immediate but very minor effect of changes in money market rates to bank retail rates.

Nevertheless, some models identified the interest rate pass-through to lending rates but failed to find it to deposit rates and vice versa. Similarly, for some models and countries the pass-through is statistically significant from the treasury bills rates and not from the interbank rates but for others it is the other way around. The study indicates that country differences can explain the different degrees of pass-through found among the EAC countries in the region and specific characteristics within a country may change with time and affect the degree of the pass-through in that country.

## **V. Conclusion**

This paper sought to examine the status of the interest rate pass through at the EAC level using different empirical methods and all point to a limited



degree of the interest rate pass-through. In this case, the immediate conclusion is that other non-considered factors are more important; some may be macroeconomic namely the level of the financial development or microeconomic such as individual bank characteristics. This study included the developments in the financial sector but they do not seem to improve the degree of the pass-through per se in contrast to the conclusions of Kleimeier and Sander (2006) that monetary policy is the main determinant. Corollary, the study suggests that other factors especially bank-specific conditions are key in determining the bank retail rates in all EAC countries.

Generally, EAC countries have to continue putting more efforts in developing their financial system as it was found to have effects in Rwanda. However, these developments have to lead to more financial integration and competition or it may not result in higher pass-through otherwise; i.e. in Uganda and Kenya after some financial system advancements the pass-through improved but stagnated because financial integration was still low. Furthermore, as Tai (2012) pointed out even Asian countries that adopted the inflation targeting with more developed financial systems, the interest rate pass-through remained low because the developments did not yet reach a good level of financial integration especially offering alternative sources of funds for households. Therefore, the EAC countries may adopt the use of interest rate as the monetary instrument even though the degree at which its passed on to bank retail rates is still low.

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## Appendices: Estimations Results

### Appendix i: Single Equation model

\*, \*\*, \*\*\* and ++ mean Significant at 1%, 5%, 10% and not significant respectively.

#### For Rwanda

##### A. Deposit rates:

1. Long-run equation:  $DR = C(1) + C(2) * Policyrate$

2. Short-term:  $D(Dr) = C(1) + C(2) * DDr(-1) + C(3) * e(-1)$

Long-term	Coefficient	R <sup>2</sup>	DW	Short-term	Coefficient	R <sup>2</sup>	DW
Repo rate	C(1) = 7.24 C(2) = 0.33*	0.37	1.2		C(1) = 0.01 C(2) = - 0.3 *	0.4	2.07
Interbank rate	C(1) = 6.7 C(2) = 0.3*	0.48	1.5		C(1) = 0.02 C(2) = - 0.22*	0.47	2.08
Tb91	C(1) = 7.01 C(2) = 0.25*	0.47	1.5		C(1) = 0.02 C(2) = - 0.2**	0.49	2.09
Tb182	C(1) = 6.7 C(2) = 0.28*	0.56	1.7		C(1) = 0.01 C(2) = - 0.1	0.52	2.09
Tb364	C(1) = 6.07 C(2) = 0.33*	0.50	1.5		C(1) = 0.02 C(2) = -0.2*	0.48	2.1

##### B. Lending rates

1. Long-run equation: Lending rate = c(1) + c(2) \* policy rate

2. Short run equation:  $DLR = c(1) + c(2) * DLR(-1) + c(3) * e(-1)$

Long-term	Coefficient	R <sup>2</sup>	DW	Short-term	Coefficient	R <sup>2</sup>	DW
Repo rate	C(1) = 17.7 C(2) = -0.19	0.39	1.06		C(1) = 0.02 (not significant)	0.32	2.16
Interbank rate	C(1) = 17.6 C(2) = -0.09	0.25	1.8		C(1) = 0.001 (not significant)	0.46	1.93





## For Kenya

### A. Time deposit rates

Long-term	Coefficient	R <sup>2</sup>	DW	Short-term	Coefficient	R <sup>2</sup>	DW
Tb364	C(1) = 3.9 C(2) = 0.21	0.54	0.5		C(1) = 0.025 (not significant) C(2) = 0.17 (not significant) C(3) = -0.15	0.27	2.15

### B. Lending rates

Long-term	Coefficient	R <sup>2</sup>	DW	Short-term	Coefficient	R <sup>2</sup>	DW
Tb364	C(1) = 13.7	0.50	0.51		C(1) = 0.026(not significant)	0.25	2.06

**For Tanzania**

**A. Time deposit rates**

There was no cointegration with policy rates

**B. Lending rates**

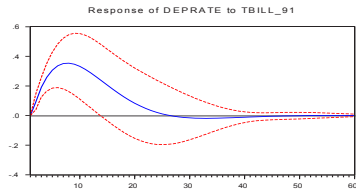
Long-term	Coefficient	R <sup>2</sup>	DW	Short-term	Coefficient	R <sup>2</sup>	DW
Repo rate	C(1) = 15 C(2) = 0.05	0.04	0.28		C(1) = 0.01(not significant) C(2) = -0.22 C(3) = -0.1	0.11	2.0
Interbank rate	C(1) = 15 C(2) = 0.05	10	0.4		C(1) = 0.013(not significant) C(2) = -0.21 C(3) = -0.19	0.12	2.0
Tb91	C(1) = 14.3 C(2) = 0.05	0.24	0.36		C(1) = 0.012(not significant) C(2) = -0.2 C(3) = -0.14	0.13	2.0
Tb182	C(1) = 14.3 C(2) = 0.05	0.35	0.44		C(1) = 0.01(not significant) C(2) = -0.19 C(3) = -0.17	0.14	2.0
Tb364	C(1) = 13.8 C(2) = 0.129	0.35	0.48		C(1) = 0.0126(not significant) C(2) = -0.18 C(3) = -0.16	0.137	2.0

## Appendix ii: Impulse Responses

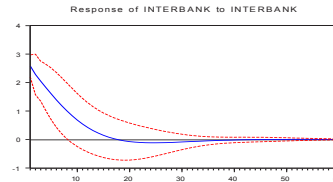
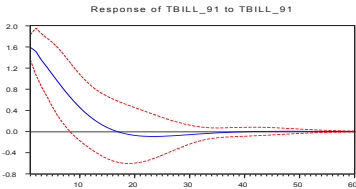
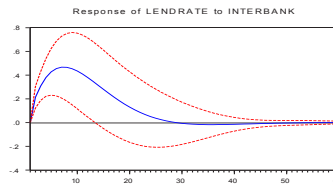
Here we present impulse responses that were statistically significant.

### For Kenya

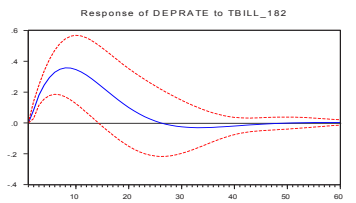
Response to Cholesky One S.D. Innovations  $\pm 2$  S.E.



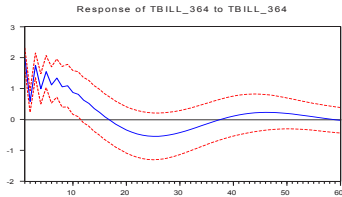
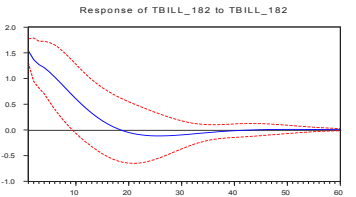
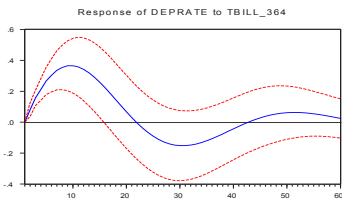
Response to Cholesky One S.D. Innovations  $\pm 2$  S.E.



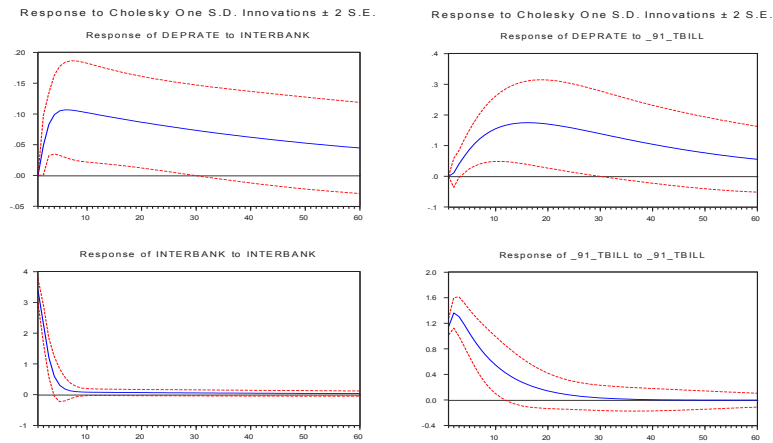
Response to Cholesky One S.D. Innovations  $\pm 2$  S.E.



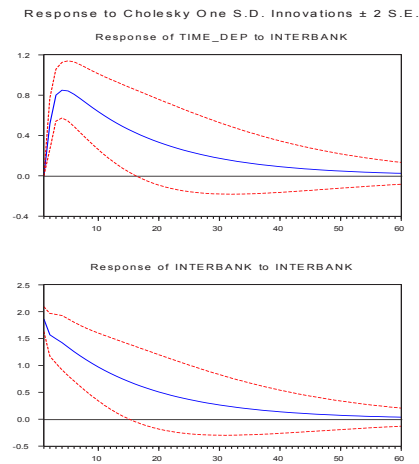
Response to Cholesky One S.D. Innovations  $\pm 2$  S.E.



### For Tanzania



### For Uganda



**Appendix iii: The ARDL Model**

\* Means not significant

**For Kenya**

<b>Lending rate</b>	$\alpha_1$	$\beta_1$	$\delta_1$	$\gamma_1$	$\sigma_1$	$\phi_1$	<b>R-squared</b>
Interbank (A)	0.2	0.28	0.058	0.06	-0.027		0.38
B	0.25	0.12*	0.047	0.07	-0.02*	0.05	
Tbill-91	0.16*	0.05*	0.03*	0.03*	0.09		0.21
B	0.145*	0.04*	0.03*	0.038*	0.09	0.015*	0.21
Tbill-182	0.175*	0.027*	0.021*	0.056	0.07		0.18
B	-						
Tbill-364	0.2	0.01*	0.01*	0.065	0.05(at 10%)		0.16
B	-						
Repo	0.327	0.07*	-0.015*	0.03	0.039		0.31
<b>Deposit rate</b>							
Interbank (A)	0.08*	0.29	0.01*	0.05	0.032		0.37
B	0.07*	0.025	0.009*	0.05	0.03	0.007*	0.37
Tbill-91	0.1*	0.14*	0.06	0.02*	0.07		0.33
B	0.29*	0.07*	0.05	0.029	0.07	0.04	0.36
Tbill-182	0.1*	0.1*	0.06	0.02*	0.07		0.34
B	-						
Tbill-364	0.09*	0.2	0.03	0.05	0.026*		0.23
B	0.03*	0.09*	0.05	0.04	0.05	0.056	0.31
Repo	0.33	0.12*	0.013 at	-0.001*	0.008*		0.21
B	0.265	0.12*	0.019	0.01*	0.025	0.023	0.30

**For Rwanda**

<b>Lending rate</b>	$\alpha_1$	$\beta_1$	$\delta_1$	$\gamma_1$	$\sigma_1$	$\phi_1$	<b>R-squared</b>
Interbank (A)	-0.6	-0.3	-0.03*	-0.03*	0.008*		0.30
B	-0.6	-0.3	-0.02*	-0.01*	0.01*	0.04*	0.30
Tbill-91	-0.6	-0.3	-0.04*	-0.01*	0.07*		0.07
B	-0.6	-0.3	-0.04*	-0.0004*	0.1*	0.01*	0.32
Tbill-182	-0.6	-0.3	0.02*	0.005*	0.05		0.31
B	-0.6	-0.3	0.02*	0.01*	0.06	0.03	0.32
Tbill-364	-0.6	-0.3	0.05	0.01*	0.006*		0.31
B	-0.6	-0.3	0.05	0.02*	0.02*	0.06	0.35
Repo	-0.6	-0.3	-0.03*	-0.04*	-0.05*		0.31
B	-0.6	-0.3	-0.03*	-0.05*	-0.036*	-0.068	0.32
<b>Deposit rate</b>							
Interbank (A)	-0.3	0.04*	0.03*	0.01*	0.06*		0.11
B	-0.3	0.03*	0.03*	0.03*	0.07*	0.04*	0.12
Tbill-91	-0.3	0.01*	0.05*	0.05*	0.1		0.14
B	-0.3	0.005*	0.04*	0.05*	0.2	0.01*	0.15
Tbill-182	-0.3	0.01*	0.06*	0.06*	0.08*		0.14
B	-0.36	0.0002*	0.07*	0.06*	0.1	0.07	0.15
Tbill-364	-0.3	0.04*	0.004*	-0.1*	-0.01*		0.1
B	-0.3	0.04*	0.007*	-0.01*	-0.01*	0.02*	0.11
Repo	-0.3	0.03*	0.07*	-0.05*	-0.01*		0.12
B	-0.3	0.01*	0.08*	-0.14*	0.04*	-0.2	0.14

### For Tanzania

Lending rate	$\alpha_1$	$\beta_1$	$\delta_1$	$\gamma_1$	$\sigma_1$	$\varphi_1$	R-squared
Interbank (A)	-0.29	-0.058*	-0.007*	0.002*	0.0003*		0.08
B	-0.29	-0.056*	-0.007*	0.005*	0.001*	0.006*	0.086
Tbill-91	-0.286	-0.06*	-0.02*	0.02*	-0.03*		0.09
B	-0.28	-0.06*	-0.028*	0.023*	-0.04*	0.05	0.11
Tbill-182	-0.29	-0.06*	-0.03*	0.024*	-0.004*		0.009
B	-0.3	-0.06*	-0.03*	0.02*	-0.009*	0.03	0.08
Tbill-364	-0.28	-0.07*	-0.04	0.01*	-0.18		0.1
B	-0.29	-0.08*	-0.04*	0.02*	-0.01*	0.038	0.1
Repo	-0.3	-0.06*	-0.003*	0.01*	0.02*		0.09
B	-0.3	-0.06*	-0.003*	0.01*	0.02*	-	0.1
<b>Deposit rate</b>							
Interbank (A)	-0.3	0.07*	0.02	0.005*	0.01*		0.14
B	-0.3	0.06*	0.02	0.01*	0.01*	0.01	0.16
Tbill-91	-0.3	0.05*	0.05	-0.02*	0.05		0.16
B	-0.3	0.05*	0.04	-0.02*	0.04	0.02*	0.17
Tbill-182	-0.3	0.05*	0.02*	0.006*	0.03*		0.13
B	-0.36	0.03*	0.009*	0.01*	0.02*	0.05	0.15
Tbill-364	-0.3	0.05*	0.03	0.01*	0.01*		0.13
B	-0.3	0.05*	0.03	0.01*	0.007*	0.04	0.16
Repo	-0.32	0.06*	0.01*	0.004*	-0.008*		0.12
B	-0.31	0.06*	0.01*	0.01*	-0.0004*	0.03	0.17

### For Uganda

Lending rate	$\alpha_1$	$\beta_1$	$\delta_1$	$\gamma_1$	$\sigma_1$	$\varphi_1$	R-squared
Interbank	-0.17	-0.18	0.04*	0.06	0.07		0.07
B	-0.2	0.12*	0.04*	0.07	0.08	0.007	0.10
Tbill-91	-0.21	-0.1*	-0.008	0.14	0.2		0.11
B	-0.24	-0.14*	-0.004*	0.15*	0.15*	0.13*	
Tbill-182	-0.2	-0.11*	0.07*	0.03*	0.2		0.10
B	-0.23	-0.13*	0.08*	0.05*	0.17	0.14	0.13
Tbill-364	-0.17	-0.11*	0.1*	-0.03*	0.26		0.10
B	-0.2	-0.13*	0.1*	-0.008*	0.22	0.13*	0.13
<b>Deposit rate</b>							
Interbank (A)	-0.43	-0.17	0.035	0.36	0.02*		0.18
B	-0.43	-0.16	0.034	0.35	0.02*	-0.004	0.18
Tbill-91	-0.4	-0.16	0.07	0.005*	0.03*		0.16
B	-0.4	-0.16	0.07	0.008*	0.02*	0.04*	0.16
Tbill-182	-0.4	-0.16	0.07	0.0003*	0.04*		0.16
B	-0.4	-0.16	0.07	0.003*	0.03*	0.21*	0.16
Tbill-364	-0.38	-0.16	0.06	-0.02*	0.05*		0.15
B	-0.39	-0.387	-0.16	0.06	*	0.16	8



## **Exchange Rate and External Sector Competitiveness in Rwanda**

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**Keywords:** Exchange rate misalignment, Competitiveness, Rwanda, Cointegration

**JEL Classification Numbers:** F31, C13

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## Abstract

*This paper estimates the impact of real exchange rate on external sector competitiveness in Rwanda. The analysis focuses on two main indicators namely exchange rate misalignment and marshall-lerner condition and the empirical analysis builds on quarterly data from 2000Q1 to 2015Q4 and derives a long-run Behavioral Equilibrium Exchange Rate (BEER). The econometric analysis starts by analyzing the stochastic properties of the data and found the variables stationary at first level of differencing. Accordingly, the paper proceeds by estimating the cointegration and error correction models. Regression results Show that most of the long-run behavior of the real exchange rate could be explained by net foreign assets, terms of trade, productivity, degree of trade openness and government expenditure. On the basis of these economic fundamentals, alternating episodes of overvaluation and undervaluation were identified and the antecedents characterizing the episodes were equally traced within the review period. Among others for instance, government expenditure on traded goods especially imports and deteriorating terms of trade were discovered to account for undervaluation while surges in capital flows and improved productivity in non-traded goods accounted for overvaluation. The study also points to the fact that though exchange rate impacts on trade balance, the marshall-lerner condition does not hold for Rwanda. The paper therefore recommends effective monitoring of exchange rate development to avoid higher levels of volatility which could lead to poor performance of Rwanda's tradable sector as well as putting in place better and sustainable strategies to increase production in Rwanda to avoid higher import prices induced by the exchange rate depreciation.*





## **1. INTRODUCTION**

The real exchange rate is one of the key economic indicators of the economy's international competitiveness, and therefore has a strong influence on a country's macroeconomic management particularly foreign trade developments. A real exchange rate that is broadly aligned with its equilibrium value is an important part of a country's external sector competitiveness because it improves trade balance and ensures macroeconomic stability given that for exchange rate to be in equilibrium economic fundamentals have to be at their sustainable levels.

However, persistently misaligned real exchange rates which is the deviation of exchange rate from its equilibrium value can cause misallocation of resources between tradable and non-tradable sectors and negatively impact labor market dynamics. Reduced external competitiveness due to over-valued exchange rate hampers exports, aggregate demand, growth and job creation. Besides the longer-term implications, real exchange rate misalignment can lead to inflationary pressures and even trigger speculative attacks. When setting their exchange rate policy, countries also need to balance their goals of reaching competitiveness and macroeconomic stability (Dornbusch, 1980)

Krugman(1979) and Frankel and Rose( 1996) argue that sustained real effective exchange rate (REER) overvaluations constitute an early warning indicator of possible currency crashes and they also have led to a drastic adjustment of relative prices and to a decline in the aggregate growth rate of the economy. On the other hand, RER movements determine production and consumption choices between domestic and international goods, policymakers sometimes perceive the REER as an additional tool to influence the economy.

Some countries have tried to maintain their currencies undervalued in order to boost the performance of the export sector and, hence, the aggregate economic activity. For instance, academics have suggested that capital controls and undervalued exchange rates have been key elements of an export-oriented development strategy for Japan and Germany after World War II and, more recently, China and other East Asian Economies (Dooley et al.2003).



Indeed according to (World Bank, 1984, Pfefferman, 1985), exchange and trade controls introduce large inefficiency costs and encourage the creation of strong lobbies that compete for the rents generated by protective measures.

These types of costs can even be significant in a situation of short-term structural misalignment if there are imperfections in local capital markets. Exchange rate misalignment also promotes speculation and usually generates massive capital flight out of the country. Although capital flight may be optimal from a purely private perspective, it can substantially reduce the social welfare of the country (Cuddington, 1986).

The existing literature suggests that maintaining the REER close to equilibrium level is necessary for sustained growth and countries that avoided overvaluation have been associated with sustained export-led growth and substantial export diversification. Others have argued that undervaluation which could be attributed to competitive devaluations may drive the exchange rate to a level that encourages exports and promote growth. On the other hand, overvaluations may reflect macroeconomic policy inconsistencies that are likely to discourage growth (Razin and Collins, 1999).

Edwards (1988) and Sachs (1985) claims that the different development experiences in East Asia, Latin America and Africa may be attributed to their different trade regimes and exchange practices. On the one hand, unstable and overvalued RERs hurt exports and support protectionist policies, while persistent misaligned RERs in Africa caused a severe drop in agricultural output (The World Bank, 1984). On the other hand, it has been argued that outward-orientation policies and exchange rate levels that encouraged export growth in East Asian countries generated a boost in their growth rates (Dollar, 1992). More recently, the appropriate level of the RER and its effects on economic activity has been present in crucial debates like the performance showed by the Chinese economy and the exchange rate policy of future accession of countries to the Euro Area.

Government of Rwanda has embarked on economic reforms since 1995. The foundation of the transformation of the economy is based on a process of economic liberalization and turning away from control regulation and state command to market policies. One of the key areas of reform were the



introduction of a more flexible exchange rate regime and fully liberalized current account.

Rwanda is one of the African countries that demonstrate ownership of its development programs and progress in good governance and institutional capacity. Consequently, the country continues to receive more international aid and other capital flows for financing the economy. However, resource booms, such as those associated with rapid aid surges could also pose a serious challenge for macroeconomic stability, especially with regard to the tendency of high aid flows to be associated with disequilibrium Real Exchange Rate (RER) appreciation because of increased and possibly unsustainable domestic absorption.

Despite vast literature on the effects of exchange rate variation on external sector competitiveness, little is known in the case of Rwanda. This study therefore attempts to assess the impact of exchange rate on external sector competitiveness in Rwanda by re-assessing exchange rate misalignment in Rwanda as well as estimating another indicator of exchange rate-external sector competitiveness namely Marshall-Lerner condition.

Secondly, the studies that dealt with the exchange rate movements and its effect on external sector competitiveness have yielded mixed results. This prompts the need to attempt to shed light on this issue by providing empirical estimates on key indicators that link exchange rate fluctuations and external sector competitiveness.

The objective of this paper is therefore, to estimate an equilibrium relationship between REER and the economic fundamentals based on the theoretical model in the spirit of Edwards (1989) identifying the impact of RER misalignment on external sector competitiveness in Rwanda and assess whether exchange rate movements affect trade balance in Rwanda.

The rest of the paper is organized as follows. Section 2 presents an overview of exchange rate policies in Rwanda and external sector performance. Section 3 provides literature review and theoretical issues with emphasis on studies that have applied the BEER approach. Section 4 presents methodology and



empirical results and discussion and Section 5 entails conclusion and proposed policy recommendations.

## **2. OVERVIEW OF EXCHANGE RATE POLICIES IN RWANDA**

The exchange rate policy in Rwanda is analyzed in two distinct periods; the first period reflecting a system of fixed exchange rate and the second period, as more flexible exchange rate system.

During the fixed exchange rate system, foreign currencies of the banking system were held by the central bank, the later was the sole institution authorized to carry out exchange transactions.

The exchange rate was initially pegged to the Belgian franc, then to the American dollar and finally to the SDR. Its value did not reflect economic reality due to lack of exchange rate flexibility (Kigabo and Nuwagira 2014). During this period, the exchange rate seemed to be overestimated; causing a rising of effective prices of Rwandan exports and a loss of competitiveness on the international market. However, many reforms of exchange rate system were undertaken since 1990 to correct the overvaluation of FRW and to improve external competitiveness.

The statutory order n° SP 1 of 3rd March 1995 organizing the foreign exchange market instituted a flexible system of exchange of RFW.

The objective of this flexible system aims at approaching as much as possible the exchange rate equilibrium level; to stabilize prices and support growth. Under this system, BNR intervenes on foreign market to smoothen the volatility of exchange rate using its reference rate as the average of interbank exchange rate and the BNR intervention rate.

### **2.1. EXTERNAL SECTOR PERFORMANCE**

In the period under review, Rwanda's external sector has been deteriorating with current account deficit as a percentage of GDP reaching 13% in 2015. The deterioration in the current account is due to worsening trade deficit,

negative services net as well as declining factor income driven by increasing interest payments on external borrowing.

The increasing trade deficit has been mainly due to export growth that has not kept up with import growth. Indeed, Rwanda's exports and imports have grown substantially but imports have grown faster than exports. High growth in imports has been in line with high economic growth recorded in the period under review as well as due to increase in people's disposable income which led to high imports of consumer goods

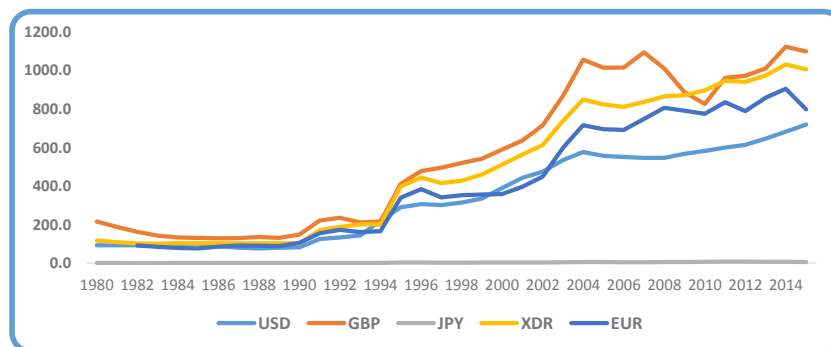
**Table1: External Sector Competitiveness**

	2010	2011	2012	2013	2014	2015
<b>Exports</b>	297.3	464.2	590.8	703.0	723.1	683.7
<b>Imports</b>	1084.0	1565.8	1859.0	1851.5	1990.2	1917.4
<b>Trade balance</b>	-786.7	-1101.6	-1268.3	-1148.4	-1267.1	-1233.8
<b>Services net</b>	-169.6	-104.3	-2.9	-14.7	-77.3	-194.3
<b>C/A balance</b>	-426.8	-465.3	-734.6	-557.5	-945.4	-1098.3
<b>Trade balance %</b>	-14%	-17%	-18%	-15%	-16%	-15%
<b>C/A balance % GDP</b>	-7%	-7%	-10%	-7%	-12%	-13%
<b>GDP (in USD mil)</b>	5720.0	6395.4	7234.5	7500.7	7909.0	8136.0

**Source:** BNR, Statistics Department

This increase in demand for imports has led to high demand for foreign exchange thereby putting pressure on the exchange rate. The table below shows the evolution of current account balance and its major components.

**Fig 1: Bilateral nominal exchange rate against selected currencies**



**Source:** BNR, Statistics Department

### 2.1.1. Capital flows and Import Financing (in USD millions)

The trade deficit has been financed by capital flows particularly foreign direct investment and both external public and private debt and occasional draw downs on central bank reserves.

**Table2. Capital flows**

	2010	2011	2012	2013	2014	2015
<b>FDI inflows</b>	250.50	119.11	254.96	257.64	458.9	471.24
<b>PI</b>	7.545	87.555	5.936	1.703	1.004	6.763
<b>Debt flows</b>	112.60	109.70	176.23	360.98	219.22	232.86

**Source:** BNR, Statistics Department

## 3. THEORETICAL AND EMPIRICAL LITERATURE REVIEW

In this section we briefly review the existing literature on the determination of RER in the long run and the calculation of RER misalignments based on fundamentals. The RER misalignment is conceptually defined as the deviation of the actual RER relative to some benchmark (or equilibrium) level. Its calculation therefore depends upon the measurement of the equilibrium level of RER, which is unobservable. An overvalued real exchange rate indicates that the value of current RER is above its equilibrium value, with undervalued RER indicating the opposite.

A number of studies have found that the level of the REER relative to an equilibrium REER, and its stability, has strong influence on exports and private investment (Caballero and Cobra, 1989, Ghura and Grennes, 1993), Yotopoulos and Sawada (2005) discover that systematic deviations of nominal exchange rate from their Purchasing power parity (PPP) levels may cause serious instabilities of the international macroeconomic system of a country.

Empirical studies on the determination of real exchange rate misalignment have been challenging mainly due to the fact that the equilibrium real exchange rate is unobservable and has to be estimated.

There are many approaches to determining the equilibrium exchange rate but three of them are considered for the purpose of this study. The first is based on purchasing power parity (PPP), which relates the nominal exchange rate to price differentials between countries.



Lucio Sarno and Mark P Taylor (2002) assert that the nominal exchange rate between two countries is equal to the ratio of two countries' price level. This suggests that the equilibrium real exchange rate remains constant with nominal exchange rate movement offsetting relative price change between the countries. Indeed several studies including Elbadawi & Soto (1997), Johansen and Julius (1992) and Williamson (1994) using different empirical models rejected PPP approach and suggested the use of approaches based on economic fundamentals. This because a misalignment measure based on purchasing power parity consists of the choice of a base period in which the economy is thought to have been in equilibrium and then the RER for this period is assumed to be in equilibrium for the rest of the sample period. The equilibrium RER is not a static indicator and moves overtime as the economy's fundamentals move.

The second approach concentrates on the exchange rate that supports sustainable internal and external macroeconomic balances over the medium to long term. This is often referred to as the fundamental equilibrium exchange rate (FEER) approach. Here the equilibrium exchange rate is essentially determined by the current account balance target, which depends on underlying sustainable equilibrium for international assets, as well as national income base on full employment. The current account targets should also be associated with desired levels of saving and investment.

Following FEER Approach, Terra and Valladares (2010) investigated episodes of real exchange rate appreciations and depreciations for a sample of 85 countries from 1960 to 1998 and used a Markov Switching Model to characterize real exchange rate misalignment series. They failed to find evidence of misalignment in some countries while in some other countries the evidence of misalignment was established in some states but lacked in others. For the countries with two misalignment regimes, the appreciated regime has higher persistence than the depreciated one.

Rajan et al. (2000) while investigating misalignment of the Baht and the crisis in Thailand highlighted productivity (proxied by GDP per capita) as a major fundamental influencing the equilibrium real exchange rate in any economy. Using quarterly data spanning the period 1988 to 1999, they applied the



standard Johansen cointegration test to the natural real exchange rate model developed by Stein (1994) and identified persistent and significant misalignments (overvaluation) of the Thai baht against the Japanese yen.

Elbadawi and Soto (1997) used single equation cointegration methodology and discovered that the RER for Mali was virtually in equilibrium on the average between 1987 and 1994. Devarajan (1997) used computable general equilibrium estimates and found that the RER for Burkina Faso was overvalued by about 9% in 1993.

Williamson (1994), for instance, estimates the fundamental equilibrium exchange rate of the G-7 countries given desirable current account balances based on the potential output estimates for those countries calculated by the IMF and the OECD. He found that in the last quarter of 1989, the actual U.S. dollar was 14 percent overvalued, while the Japanese yen was 27 percent undervalued.

The Fundamental equilibrium exchange rate approach is based on macroeconomic identities; because it does not involve a theory of exchange rate determination (Clark and MacDonald, 1998), the equilibrium exchange rate calculated should not be viewed as normative. The equilibrium concept is largely meant to imply the desirability of the underlying internal and external balances rather than exchange rates per se (Bayoumi et al., 1994). However, it is observed that this approach is less applicable as it is based on value judgments therefore, inappropriate for meaningful and dependable applications.

Finally, the behavioral equilibrium exchange rate (BEER) approach focuses on the dynamic behavior of the exchange rate, including short-run movements and deviations and taking broader macroeconomic conditions into account. The choice of fundamentals may vary depending on the theoretical model used. Starting with a model of risk-adjusted interest parity to construct an equilibrium real exchange rate equation, Clark and MacDonald (1998) include in their model as fundamentals terms of trade, the ratio of the domestic consumer price index to the producer price index and the stock of net foreign assets, as well as the relative supply of domestic to foreign government debt as a risk premium factor.





Aliyu (2011) applied the Johansen's cointegration approach and vector error correction model to investigate RER misalignment in Nigeria. He adopted the behavioural equilibrium exchange rate approach and included variables such as terms of trade, crude oil volatility, monetary policy performance and government fiscal stance in his model. His study showed that the naira was overvalued by about 5.9 per cent.

Iossifov and Loukoianova (2007) estimated BEER model for Ghana and results show that most of the REER's long-run behavior can be explained by real GDP growth, real interest rate differentials (both relative to trading-partner countries), and the real world prices of Ghana's main export commodities. The REER in late 2006 was found to be very close to its estimated equilibrium level and deviations from the equilibrium path are eliminated within two to three years. The review of the empirical literature on the exchange rate misalignment reveals that while much has been done on developing countries, the studies on Rwanda are still very few.

Iimi (2006) used the BEER methodology and found that the Botswana's pula seems to have been undervalued in the late 1980s and overvalued by 5 to 10 percent in recent years, though the misalignment in the 1990s seems to have been very marginal. Although the limitation of this study is that the model included a few fundamental variables for fear of loss of degree of freedom, it should still be recognized that these pieces of evidence were arrived at from a sample comprising of only 19 observations (1985 – 2004).

Agu (2002) adopted a single equation procedure to estimate the time path of the naira equilibrium exchange rate between 1970 and 1998 using fundamentals such as trade policy, terms of trade, government consumption expenditure, capital flows, and debt to GDP ratio. His estimates were compared with the observed real exchange rate that prevailed during the same period and it was discovered that real exchange rate misalignment in Nigeria was irregular but persistent. The naira was found to be overvalued by an average of about 1.4 per cent during the period. He confirmed that real exchange rate misalignment and its volatility affects both the trade balance and the capital account



Maesofernandez, Osbat and Schnatz (2001) using quarterly data from 1975 to 1998 and up to four different specifications of BEER/PEER methodology indicate that the euro effective exchange rate was unambiguously undervalued in 2000, although the extent largely depends on a particular specification chosen. The driving fundamental variables in their models were long term real interest rates differentials, productivity, net foreign assets, relative fiscal stance, real price of oil, and relative total consumption differentials.

Baffes, Elbadawi, and O'Connell (1999) examine misalignment for Côte d'Ivoire and Burkina Faso using single-equation time series. They found that for Côte d'Ivoire the actual real exchange rate was overvalued by 34 percent on average during the period 1987–93, though Burkina Faso does not seem to have experienced any major overvaluation. In the panel context, on the other hand, Dufrenot and Yehoue (2005), analyzing the relationship between real exchange rates and economic fundamentals in 64 developing countries, found that exchange rate dynamics are less likely to be explained by fundamentals such as productivity, terms of trade, and trade openness for middle-income countries than for low income countries.

Using a similar approach, Elbadawi (1994), relying on an identity for nominal domestic absorption, estimated the long-term equilibrium exchange rates for Chile, Ghana, and India for the period 1967-1988. The fundamentals include terms of trade, resource balances, degree of openness of the economy, share of government expenditure in GDP, and a measure of excess money supply.

This paper employs the third approach because it seems to be a more general method for calculating the real exchange rate and exchange rate misalignment consistent with the concept of economic equilibrium. More important, the analytical focus of the paper is equilibrium exchange rate behavior, including cyclical and transitory deviations, in connection with macroeconomic fundamentals. For Rwanda, the main factors that affect the equilibrium exchange rate may be the terms of trade, government consumption, capital flows, productivity and the degree of openness based on findings from studies done in countries that have similar features like Rwanda.

## **4. METHODOLOGY**

To estimate the indicators that link exchange rate and external sector competitiveness namely, exchange rate misalignment and marshall-lerner condition which are used in the context of this study, we specified different models for each indicator. For exchange rate misalignment, the model specified is based on behavioral equilibrium exchange rate while elasticity approach was used in the case of Marshall-Lerner condition. Despite different theoretical and empirical foundations, maximum likelihood method to cointegration estimation technique was used in both cases.

### **4.1. Empirical model**

#### **4.1.1. Behavioral Equilibrium exchange rate model**

To determine the extent of misalignment, we first need to establish the long-run relationship between the real effective exchange rate and its determinants. Econometrically, this paper applies a single equation approach and uses cointegration analysis to identify the long run relationships among variables. Meanwhile, the stochastic properties of data are assessed on the basis of unit root tests and long run relationship is estimated as well as error correction mechanism (ECM) to account for short run deviations from the long run equilibrium. The cointegration parameters are used to perform a permanent-transitory decomposition using the Hodrick and Prescott filter (1997). Similar methodology was applied by Clark and MacDonald (1998), Baffes, Elbadawi and O'connell (1999), recently Lim (2006) as well as Lossifov and Loukoianova (2007).

To obtain equilibrium exchange rate we first used Hodrick-Prescot filter to decompose the trend from the cycle to obtain permanent values of the fundamentals. We then calculate the long run equilibrium level of REER by multiplying the estimated coefficients obtained through BEER approach with permanent values of the fundamentals.

For the purpose of this paper, the movements in the exchange rate of Rwandan franc are explained by macroeconomic variables such as terms of trade (TOT), relative productivity of home tradables proxied by GDP percapita, government expenditure as a ratio of GDP (GOV), capital flows proxied by net

foreign assets (NFA) and the degree of economic openness (OPEN). The main question that arises is whether the actual real exchange rate is overvalued or undervalued in comparison with sustainable equilibrium levels. To address this question, this paper applies the behavioral equilibrium exchange rate (BEER) approach to determine the extent of misalignment to Rwanda exchange rate movements over the period 2000Q1-2015Q4. The study utilizes the traded weighted REER index while the rest of the data is constructed and collected from various secondary data sources such as the National Institute of Statistics of Rwanda; the Ministry of Finances and Economic Planning and the National Bank of Rwanda.

Thus the model is specified as below;

$$\log(RER)_i = \beta_0 + \beta_1 \log(TOT)_i + \beta_2 \log(prod)_i + \beta_3 \log(open)_i + \beta_4 \log(NFA)_i + \beta_5 \log(Gov)_i + \varepsilon_i \dots\dots\dots(1)$$

Where;

The dependent variable is the real effective exchange rate. It is the CPI-based multilateral real effective exchange rate. The REER is defined as the ratio of the domestic consumer price index to the foreign consumer price index and constructed as the trade-weighted average of the real exchange rate where the weights are generated by the IMF based on both bilateral trade shares and export similarities.

$$Reer_{it} = \sum (NEER_{it}) (p_{it}^* / p_{it}) \dots\dots\dots(2);$$

Where  $NEER_{it}$  is the nominal effective exchange rate for Rwanda with respect to the partner  $i$ ,  $p_{it}^*$  is the price in partner trading country,  $i$  representing the price of tradable and  $p_{it}$  is the CPI of home country as a proxy for price of non-tradable.

TOT is terms of trade which is defined as the ratio of export price index to import price index.

OPEN is the degree of openness of the economy and is computed as the ratio of the sum of export and import to the gross domestic product (GDP).

PROD relative productivity proxied by percapita gross domestic product.



NFA is net foreign assets used as a proxy measure for capital flows; it is computed by adding net foreign assets by monetary authority (central bank) and net foreign assets by commercial banks.

GOV is government expenditure as a ratio of GDP less capital expenditure.

$\varepsilon_t$  is disturbance term that contains all other influences

Expected signs for the coefficients according to the economic theory are as follows:

The terms of trade's influence on the *REER* cannot be signed a priori, as this depends on whether income or substitution effects dominate. The former leads to real currency appreciation (increase in *REER*) while the latter to real currency depreciation (decrease in *REER*).

An increase in the openness variable is assumed to be arising from a decline in tariff rates, leading to a fall in the domestic prices of importables. This will lead to high demand of foreign currency to take advantage of cheap imports, and less demand for domestic currency. Hence an increase in the degree of openness is expected to lead to the depreciation of the equilibrium real effective exchange rate. As a result, the coefficient of openness variable is expected to have a negative sign. Empirical researches show that there is a negative link between trade integration and real exchange rate volatility (Calderon and Kubota, 2009, Hau, 2002).

High government spending is likely to translate into high demand of non tradables, which would lead to a rise in the price of non tradables. According to the definition of *REER* as the ratio of the domestic consumer price index (CPI) to the foreign consumer price index, this will lead to a real appreciation. The effect partially depends on the extent of how RER is fully determined by the supply side of the economy. The increase of public expenditures causes an appreciation of RER and a permanent increase in government spending leads to an appreciation of the equilibrium RER in the long run (Edward, 1989; Frenkel and Mussa, 1985). We expect this variable to be positively signed.

Similarly high productivity will make the economy stronger leading to an appreciated equilibrium *RER* hence we expect it to carry a positive sign. Productivity in the traded goods sector relative to the non-traded sector. A rapid economic growth is accompanied by real exchange rate appreciation because of the differential productivity growth between tradable and non-tradable sectors (Imed and Christopher, 2001, Antonia and Bara, 2006, Samara, 2009)

Higher net foreign asset payments from abroad would lead to higher capital inflows with a pressure on the exchange rate. We expect this variable to be positively signed

#### 4.1.2. Marshall-Lerner condition (Elasticity Approach)

We employ elasticity approach known in literature as imperfect substitutes approach a kin to Bayoumi et al (2011), Chen et al (2012), Aziz and Chinoy (2012) to estimate marshall –Lerner condition for Rwanda using quarterly data spanning the period 2000Q1 to 2015Q4 to analyze the impact of exchange rate on trade balance . We employ maximum likelihood method to cointegration to estimate the both the export and import demand functions. The models are specified as –

$$\ln ex_t = \alpha_1 \ln reer_t + \alpha_2 \ln wgd p_t + \varepsilon_t \dots \dots \dots (4)$$

$$\ln imp_t = \alpha_1 \ln reer_t + \alpha_2 \ln rgd p_t + \varepsilon_t \dots \dots \dots (5)$$

Where  $\ln ex_t$  is exports,  $\ln reer_t$  is trade weighted CPI based real effective exchange is rate,  $\ln wgd p$  is foreign income as a proxy for external demand,  $\ln rgd p$  as proxy for national demand for imports and  $\varepsilon_t$  is the disturbance term. All variables are transformed into natural logarithms and Real exchange rate lagged by two quarters to allow for lags in the effect of relative price changes.

#### 4.1.3. Sources of Data

Most of the relevant data used to estimate both exchange rate misalignment and Marshall-Lerner condition were obtained from the world development indicators dataset, MINECOFIN and others from BNR statistics department.

#### 4.2. EMPIRICAL RESULTS

The BEER approach benefits from cointegration technique to establish a long run relationship between REER and its fundamental determinants. The variables used as proxies for fundamentals include: log of relative productivity of tradables (LNPROD); log of openness (LNOPEN); log of net foreign assets (LNNFA) as a proxy of capital inflows, log of terms of trade (LNTOT) and log of government expenditure (LNGOV)

Before implementing the cointegration technique, the stationarity of variables used in the model is checked by applying Augmented Dickey-Fuller (ADF) test. All variables are I (1) as shown in table 1 below.

**Table 3:** Results of tests for stationarity using Augmented Dickey-Fuller (ADF)

Variables	ADF test statistic (Absolute Values)	Critical Values			Order of integration
		1%	5%	10%	
lnreer	3.18	3.57	2.92	2.59	I(1)
lnTOT	2.04	2.62	1.95	1.61	I(1)
lnprod	5.14	4.16	3.51	3.18	I(1)
lngov	5.85	4.16	3.51	3.18	I(1)
lnopen	3.21	3.57	2.92	2.59	I(1)
lnnfa	6.77	4.17	3.51	3.18	I(1)

**Source:** Authors' estimations

#### 4.3. Cointegration

We applied Johansen's cointegration technique to test for the existence of long run relationship between real exchange rate and explanatory variables used in the model. Using Johansen's procedure, the tables below depict that both trace statistic and maximum eigenvalue indicate one cointegrating equation.

**Table 4a: unrestricted cointegration Rank test (Trace statistic)**

Series: LNREER LNTOT LNPROD1 LNGOV LNOPEN  
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.449095	77.99279	76.97277	0.0417
At most 1	0.268295	41.62499	54.07904	0.3913
At most 2	0.181529	22.56998	35.19275	0.5571
At most 3	0.114969	10.35063	20.26184	0.6054
At most 4	0.046438	2.900570	9.164546	0.5994

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

**Table 4b: Unrestricted cointegration Rank test (Maximum eigenvalue)**

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.449095	36.36780	34.80587	0.0323
At most 1	0.268295	19.05502	28.58808	0.4873
At most 2	0.181529	12.21934	22.29962	0.6333
At most 3	0.114969	7.450065	15.89210	0.6143
At most 4	0.046438	2.900570	9.164546	0.5994

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

The cointegrating relationship identified by both trace statistic and max-eigenvalue is used to describe the relationship between REER and its fundamentals. In this study, the first cointegrating vector, therefore, is utilized as the long-run relationship, which exists between real exchange rate and its fundamentals. The estimated equilibrium exchange rate equation is presented as follows

$$\text{LnREER} = 0.20 \text{LnTOT} + 1.61 \text{LnPROD} - 0.12 \text{LnOPEN} + 0.13 \text{LnNFA} + 0.36 \text{LnGOV} \dots \dots (3)$$

(1.84)      (1.50)      (2.69)      (2.91)      (3.90)

In this long run relationship, LNPROD, LNNFA, LNTOT and LNGOV have positive (appreciating) effects whereas LNOPEN have negative (depreciating) effect on real effective exchange rate. The positive sign of LNPROD is according to the so called Balassa- Samuelson theory which states that productivity rise





in tradables leads to increase in demand of non-tradables, thus real exchange rate appreciates. This is due to the fact that if productivity of traded goods relative to non-traded goods productivity is growing faster at home than abroad, the home currency should appreciate in real terms. As far as the impact of NFA on REER is concerned, the results show that increase in long-run capital inflows appreciate real exchange rate. NFA can affect equilibrium real exchange rate through both supply and demand channels. In the supply channel, Capital inflows increase the existing capital stock and bring spillover effects of technology transfer and indeed Rwanda has received enormous amounts of capital flows which in first round leads to an increase in output and fall in prices of non-traded goods thus depreciating the real exchange rate and in the second round, the increase in output of non-traded goods expands disposable income and thus leads to the appreciation of Rwandan currency.

The Positive sign of terms of trade indicate that income effect dominates insinuating that improvement in terms of trade raises demand for locally produced goods (non-traded) hence non-traded goods prices increase relative to traded goods, thus appreciating Rwanda's currency. As regards to government expenditure, the sign is positive implying that an increase in government expenditure translates into high demand for non-traded which leads to the rise in prices of non-traded goods thereby appreciating real effective exchange rate.

Finally, the sign of openness is negative, implying that an increase in openness depreciates REER because as Rwanda seeks to fully integrate within East African community there has been a decline in tariff rates together with the removal of non-tariff barriers, this has led to the fall in prices of importable goods from EAC leading to expenditure switching thereby depreciating our equilibrium real effective exchange rate.

#### **4.4. Short-run dynamics of Exchange Rate**

The appropriate mechanism for modeling the short-run real effective exchange rate for Rwanda is an error correction mechanism (ECM). The results from an error correction mechanism show that in the short term, only NFA carries the burden of adjustment of real effective exchange rate. The error

correction term (-0.36) is negative which indicates that if the REER is overvalued, it will adjust downward to re-establish the long-run equilibrium and vice-versa. The partial adjustment of short-run disequilibrium is corrected for in period close to three quarters.

**Table 5. Results of Error Correction Model**

Variable	Coefficient	Std.error	-statistic	Prob.
<b>D(LN Tot)</b>	-0.065	0.097	-0.67	0.50
<b>D(LNProd)</b>	0.0015	0.004	0.33	0.74
<b>D(LNOpen)</b>	-0.018	0.031	0.571	0.57
<b>D(LNNfa)</b>	-0.157	0.073	-2.15	0.035
<b>D(LNGov)</b>	0.0014	0.027	0.053	0.958
<b>ECM</b>	-0.364	0.075	-4.846	0.0000

**Source:** Authors' estimations

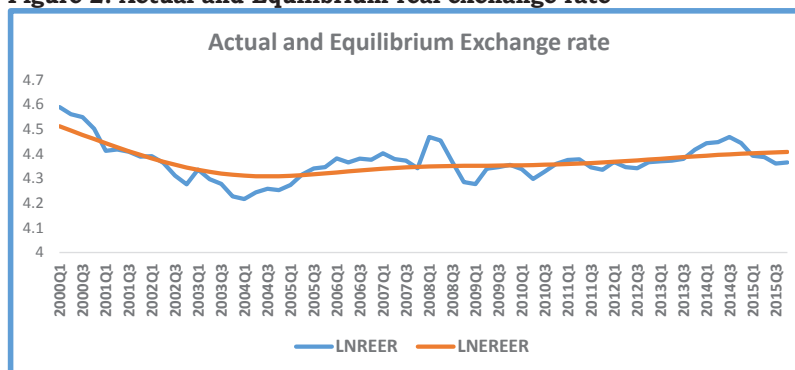
#### 4.5. Exchange Rate Misalignment

The Equilibrium real exchange rate was obtained by first decomposing the fundamentals of the equilibrium real exchange rate into their permanent and cyclical components. This is because the equilibrium real exchange rate requires the fundamentals to be at their sustainable values.

To do this we used the Hodrick-Prescott Filter and the permanent components were then substituted into the equilibrium real exchange rate model to obtain the equilibrium real effective exchange rate. Figure 2, Shows the level of exchange rate misalignment. When actual real effective exchange rate (LNREER) is above the equilibrium real effective exchange rate (LNEREER), is over-valued and vice versa.

Real exchange rate misalignment is then calculated as the difference between actual and equilibrium real effective exchange rate.

$$MIS = LREER - LEREER \dots \dots \dots (3)$$

**Figure 2: Actual and Equilibrium real exchange rate****Source:** Author's Estimations

The results of misalignment as depicted by the above graph reject the purchasing power parity (PPP) school of thought and support Edwards and Elbadawi's view of behavioral approach that equilibrium real effective exchange rate is not constant over time, as PPP approach contends. Equilibrium real effective exchange rate can change over time, as a result of fundamentals like productivity and capital flows. We further identified the episodes of overvaluation and undervaluation and the antecedents characterizing the episodes were equally traced within the review period. The table below shows that the level of misalignment in Rwanda is not high, varying between 0.48% and 3.2% in absolute terms.

**Table 6:** Episodes of Real Effective Exchange rate Misalignment in Rwanda

2000Q1-2001Q1	Overvaluation	1.39%
2002Q1-2005Q2	Undervaluation	-2.33%
2005Q2-2008Q3	Overvaluation	1.67%
2008Q3-2010Q4	Undervaluation	-0.86%
2013Q3-2015Q1	Overvaluation	0.48%
2015Q1-2015Q4	Undervaluation	- 3.2%

**Source:** Authors' Estimations

#### 4.5. Estimation of Marshall-lerner condition for Rwanda

After finding out that Rwanda's exchange rate does not deviate much from its steady state value implying that the exchange rate misalignment level is not high to induce a significant impact on external sector competitiveness, we further estimated marshall-lerner condition for Rwanda to understand how

trade balance might be affected if the exchange rate changes given that improved trade balance is central to the objective of achieving export-led growth given that exchange depreciation assuming plausible trade-exchange rate elasticities can boost exports and discourage imports thereby curtailing current account deficit and the strength of the effect will depend on the pass through from exchange rate to export and import prices.

Marshall -Lerner condition states that if the sum of price elasticities of demand for exports and imports in absolute terms is greater than unity, then exchange rate depreciation improves trade balance. According to Marshall – Lerner, depreciation reduces the prices of exports in terms of foreign currency and therefore cheapens exports, the measure also makes imports expensive in the country whose exchange rate has depreciated and the sum of it will have corrective effect on trade balance. If they are low, whether with respect to external demand or prices, then changes in the exchange rate are unlikely to have much of an impact on Rwanda’s growth or its current account. If trade elasticities are not stable, then little can be said with any degree of confidence on how the exports might react to such changes. The results obtained from the estimation of the above specified exports function is presented below.

**Table 8:** Results of Marshall-lerner condition

MLM					
Export equation			Import		
variable	coefficient	T-Value	variable	coefficient	T-value
<b>lnexp</b>	1		<b>lnimp</b>	1	
<b>lnreer</b>	2.84	3.51	<b>lnreer</b>	-1.99	3.8
<b>lnwgdp</b>	2.44	11.9	<b>lnrgdp</b>	2.08	5.7

**Source:** Authors’ estimation

From export and import demand functions estimation results, we calculate various elasticities with respect to exchange rate. The elasticities of exports and imports with respect to exchange rate depreciation are respectively 0.32 and 0.50. Though significant their magnitudes are still low and their sum is less than unity implying that the marshall-lerner condition does not hold for Rwanda for the period under review. This finding is quite plausible because improvement in Rwanda’s trade balance so much depends on external demand than exchange rate fluctuations and this is supported by the fact



that income elasticity which is the sum of export and import elasticities (0.86) with respect to world gross domestic product as a proxy for external demand and gross domestic product as a proxy for Rwanda's demand for foreign goods and services respectively is greater than the sum of price elasticities (0.82 < 0.86). The finding broadly confirms that exchange rate changes though significant do not have bigger impact on Rwanda's trade balance and Taken at face value, the response of Rwanda's external sector to external demand insinuates greater dependence of the Rwandan economy on external conditions. These estimates are within the range of other studies on trade elasticities (Goldstein and Khan, 1985, cheung, chin and Fuji, 2007). The elasticities are presented below-

$$\varepsilon_{exp} = \frac{\Delta \ln exp}{\Delta \ln reer} = 0.32, \varepsilon_{imp} = \frac{\Delta \ln imp}{\Delta \ln reer} = 0.50, \varepsilon_{yx} = \frac{\Delta \ln exp}{\Delta \ln wgdg} = 0.38, \varepsilon_{ym} = \frac{\Delta \ln imp}{\Delta \ln rgdp} = 0.48$$

$$\varepsilon_{exp} + \varepsilon_{imp} = 0.32 + 0.50 = 0.82, \varepsilon_{yx} + \varepsilon_{ym} = 0.86$$

## 5. Conclusion and Policy lessons

The main objective of this paper is to evaluate the impact of REER on external sector competitiveness. The analysis focuses on two main indicators of external sector competitiveness namely exchange rate misalignment and Marshall- Lerner condition.

The general finding points out to the existence of long-run relationship between real effective exchange rate and the proposed set of economic fundamentals. The normalized estimates confirm that productivity (balassa-samuelson effect), openness, terms of trade, government consumption and capital inflows are important long run determinants of the equilibrium exchange rate in Rwanda. However, the level of misalignment taken in absolute terms is not very high, fluctuating between 0.48% and 3.2%. This indicates that the REER path is not a high level to prompt a significant impact on Rwanda's external sector competitiveness.

We also found out that Rwandan exports and imports respond more to income than relative prices .For instance exports so much depend on external demand than exchange rate changes and imports respond more to national demand for imports proxied by Rwanda's GDP confirming that exchange rate



movements have a small effect on Rwanda's trade balance. In other words, the income elasticity of demand for exports and imports is greater than the price elasticity of demand for exports and imports in this respect therefore, marshall-lerner condition doesn't hold for Rwanda.

Despite the fact that marshall-lerner condition is not satisfied in the case of Rwanda due to low export elasticity, both exports and import elasticities are quite significant implying that exchange rate effect on trade balance is becoming important and indeed the sum of the two elasticities (0.82) is close to unity. For imports, the magnitude of responsiveness to exchange rate is slightly higher (0.50) suggesting that the depreciation of Rwandan franc slightly reduces imports given that most of the goods imported by Rwanda have inelastic demand and as such their importation is less affected by increase in prices for foreign goods. This finding calls for effective exchange rate monitoring to avoid higher levels of exchange rate depreciation that could make imports expensive. In view of this, the paper recommends a number of but not limited to the following recommendations.

The government and the private sector should explore opportunities for better and sustainable strategies to increase production in Rwanda to avoid higher import prices induced by the exchange rate depreciation both in the short-run and long-run. This is long-run solution and would imply for the government to gradually proceed to expenditure switching.

Though Rwanda's export sector is less sensitive to exchange rate movements, effective monitoring of exchange rate developments remains vital to avoid higher levels of volatility which could lead to poor performance of the country's tradable sector.



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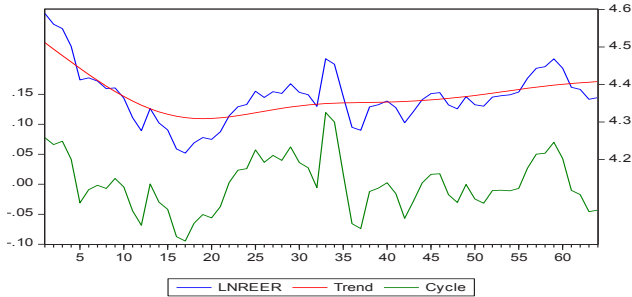
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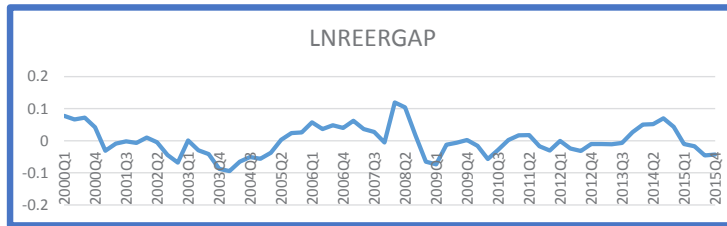
## APPENDICES

### Appendix: 1 Permanent and transitory components

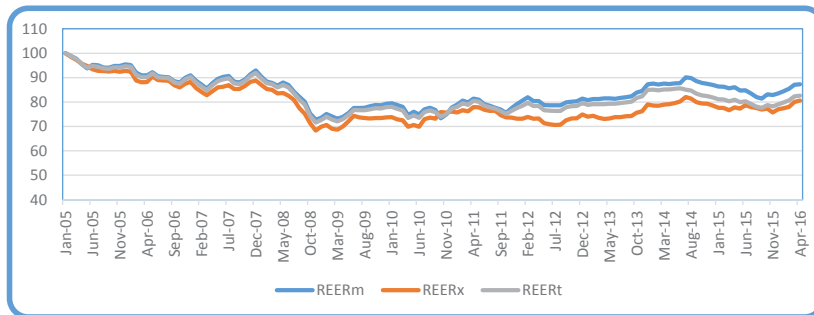
Hodrick-Prescott Filter (lambda=1600)



### Appendix 2.misalignment



### Appendix 3: Development of REER in Rwanda



### Appendix 4.Descriptive Statistics

Variable	Mean	Maximum	Minimum	Std. Dev.	Variance
lnreer	4.35	4.58	4.21	0.07	4.35
lnprod	10.72	11.01	10.43	0.17	10.72
lnopen	-2.85	-0.86	-3.27	0.56	-2.85
lntot	3.36	3.42	2.85	0.31	3.36
lngov	-2.07	-1.43	-2.81	0.44	-2.07
lnnfa	5.26	6.5	3.58	0.81	5.26



## **Effects of Fiscal Policy on Inflation and Money Market Interest Rates in Rwanda**

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**NYIRAKANANI Regine\***

**Key Words:** Fiscal Policy, Inflation, Money Market Interest Rates, recursive SVAR

**JEL Classification:** E62, E31, E43, C32

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### **Abstract**

*The purpose of this study is to examine the effects of fiscal policy on inflation and money market interest rates in Rwanda using structural autoregressive models on variables including nominal GDP, core Consumer Price Index, interbank rate, Government spending, and government tax receipts over the period from 2006Q1 to 2015Q4.*

*The results show that both the government spending and government tax revenues affect positively and significantly nominal GDP and inflation. The interbank rate is found less responsive to fiscal shocks. These findings show that the effect on interest rate is not significant in Rwanda due to shallow financial markets which could be impeding the transmission of monetary policy signals.*



## **1. Introduction**

The theory suggests that fiscal policy imposes no effect on aggregate demand and inflation as long as consumers are furnished with rational expectations. However, the assumption seems to be utopic especially in times of high deficits as evidenced by Perotti (2004). Indeed, Woodford (1996) had shown that changes in fundamentals of fiscal policy affect aggregate demand and the specification of fiscal policy matters even when the monetary policy rule is explicitly independent. Among others, Hilbers (2004) pointed out that there are both channels through which the actions of fiscal policy may affect monetary policy variables. Under such posture, the effectiveness of one policy is realized after imposing its effects on the other and therefore, this call for macroeconomic policy coordination.

Definitely, several studies concert that fiscal policy and monetary policy are perfect complements and their coordination is pre-requisite for achieving sustainable economic growth. Among many others, Mishkin (2006) and Mohammad *et al.* (2010) point out the interdependence of the two policies and agree that monetary policy cannot successfully achieve its objectives unless monetary and fiscal policies are well coordinated. Hence, being dependent to each other, pursuing one policy without considering the other may lead to inevitable sub-optimal outcomes such as huge budget deficits, high price levels, exchange rate pressures and an adverse impact on aggregate demand via their impact on monetary variables (Arby and Hanif, 2010).

Late in the 1990s, Calvo and Vegh (1999) have shown that monetary policy is subservient to the fiscal policy in developing economies which could affect inflation directly or indirectly. Mindful of these challenges, several institutional reforms including the reforms reinforcing the central bank independence have been executed in many developing countries which certainly resulted in increased disassociation between fiscal and monetary goals. But still, the importance of coordination of fiscal and monetary policy for macroeconomic management rests on the fact that the two policies are interdependent.

In Rwanda for instance, coordination between fiscal and monetary policies is enforced through joint committees such as the Treasury Management



Committee (TMC) and Debt Management Committee (DMC), as well as through the joint setting up of short and medium term Macroeconomic framework. Among other national arrangements and policies, the coordination of fiscal and monetary policies has yielded positive results that include but not limited to low level of inflation and a small budget deficit as percent of GDP. Mindful of good coordination and positive trends, this paper aims to identify key channels through which the actions of fiscal policy may affect monetary policy variables, namely inflation and money market interest rates.

In fact, though the effect of fiscal policy on inflation and response of financial market conditions has received enough attention globally, little is known for the case of Rwanda. To the best of our knowledge, the only existing study (by Karuhanga and Nyirakanani, 2015) has investigated the effect of shocks to fiscal deficit and its financing components on conduct and transmission of monetary policy. This study is different in that it examines the effect of government spending and tax revenues on inflation and money market interest rates.

The remainder of this paper is organized as follows. Section two presents a brief review of the theoretical and empirical literature on different channels through which fiscal policy can affect monetary policy. Section three lays out the trends in Rwanda's macroeconomic performance. Section four presents model specification, data source and variable definition. Section five discusses the empirical results, while section six concludes.

## **II. REVIEW OF THE LITERATURE**

### **II.1 Theoretical Literature**

There has been a consensus that fiscal and monetary policies are tools used by government authorities to direct changes in the economy in order to achieve macroeconomic stability. Theories confirm that in situations of uncoordinated policies, fiscal policy actions may cause economic distortions and may affect the effectiveness of the other macroeconomic policies. In this



section, we provide the recap of the theories behind the impact of fiscal policy on inflation and money market interest rates.

### **II.1.1 Fiscal effect on inflation**

In a poorly coordinated macroeconomic environment, fiscal authority takes the first move while monetary policy remains passive to fiscal actions. This directly affects monetary policy variables through substantial increases in indirect tax rates which impact on prices and hence on inflation (Andrea, 1991, Hilbers, 2014). These changes in fiscal policy influence the aggregate demand through both changes in the government spending and in household disposable income. On this regard, the change in demand conditions consecutively leads to a wage-price spiral and price setting behavior and hence influences inflation and inflationary expectations. In response, the monetary policy reacts to stabilize the overall demand at the level that maintains inflation consistent with the target range.

The fiscal theory of the price level (Woodford, 1994 and Leeper, 1991) also posits the importance of fiscal policy in stabilization of the economy. The theory suggests the role of government's inter-temporal budget constraint in determination of the price level. Both policies vary between active and passive behavior (Davig and Leeper, 2009). The passive policies ensure the satisfaction of the government's intertemporal budget constraint while the active monetary pursues its inflation target independent of the government's financial position. In uncoordinated environment where fiscal discipline is not viable, the reaction of monetary policy through aggressive increase in interest rate cannot impact fluctuations in aggregate demand and inflation. Dixit and Lambertini (2003) had earlier disclosed that fiscal authorities with discretionary powers tend to constrain monetary policy commitment by running their own policy based on rules.

Although it is currently less likely for governments to finance their deficits with direct monetization, large dependence on domestic budget financing through financial markets may cause crowding out effect on private sector investment. Eventually, the economy is negatively affected leaving monetary



policy with the task to keep inflationary pressure under control. Therefore, with central bank's reluctance to intervene on the market would undermine a country's objective of having private sector based economic growth due to crowding out effect.

### **II.1.2 Fiscal effect on interest rate**

The channel views the number of ways through which the operations of the government would indirectly affect the behavior of market conditions such as interest rate, interest rate spread and exchange rate. A consensus among several policy discussions with regard to impact of fiscal policy on interest rate channel state that higher fiscal deficits through expansionary fiscal policy may lead to higher medium-term and long-term interest rates (Greenspan, 2002). In fact, many scholars support the idea that monetary authorities regard fiscal policy as an important determinant of long-term interest rates (Mohanty and Scatigna, 2003). Indeed, another broad compromise exhibits the channel as a way through which public debt impacts on long-run interest rates. This postulates that higher indebtedness increases the risk of default on sovereign debt, which translates into higher interest rate spreads on government bonds (Ferrucci, 2003).

In his analysis, Andrea (1991) highlights three aspects under which fiscal policy may affect monetary policy through interest rates channel. Firstly, fiscal policy via its impact on aggregate domestic demand affects interest rates by changing the demand for funds in the economy. Second is the effect of the overtime unsustainability of fiscal settings on the expectations of the future monetary policy to monetize the growing fiscal deficit. The reduced credibility of the government commitment raises the inflation expectations and hence increases the cost for monetary policy to maintain price stability. The effect of fiscal policy is manifested through capital markets financing.

## **II.2 Empirical Review**

The effect of fiscal policy on monetary variables is a controversial issue and has been a debatable topic since the past decades. Both cross-sectional and case study regressions on effects of government fiscal policies have been





conducted. These studies show that the effects of fiscal policy on monetary variables differ across countries even when identical approaches are used. Consequently, this sub-section reviews both country and cross-sectional cases seeking to review how significant the fundamentals of fiscal policy may be influencing the monetary variables.

Indeed, Anyanwu (1993), Sheffrin (2003), Alesina and Tabelini (1990) among others provide that fiscal policy is repeatedly subjective towards attaining higher growth and employment even at the cost of the high inflation. The fiscal policy makers intervene through policy activist, discretionary and countercyclical policy in an effort to achieve the objective of macroeconomic stability and growth.

Blinder (1982) offers that uncoordinated behavior arises when monetary policy decides to tighten in response to loosening in fiscal policy or monetary policy carries out loosening accompanied by tightening in fiscal policy. He further notes that poor coordination between authorities arises from three folds notably differences in objectives of what is best for society; adherence to different theories about the effects of policy actions on the economy; as well as on divergence in forecasts about the likely state of the economy in absence of policy intervention.

Using three variables namely government expenditure, tax revenues, and the level of output for USA, Blanchard and Perotti (1999) analyzed the effect of fiscal policy shocks on output and consumption. They found a positive impact of an expenditure shock on output and consumption. In contrast, an increase in tax revenues is found to negatively affect the two variables. Höppner (2001) adopted the same work by Blanchard and Perotti for Germany and obtained the same findings.

In their analysis for Colombia, Lozano and Rodríguez (2011) conclude that a positive shock on expenditure has a positive and statistically significant effect on output, private consumption, employment, price level and short-term interest rates. An increase in tax revenue was found less efficient because of its impact on private investment. The results contradict with findings reported



by Ravnik and Žilić (2011) for Croatia where a positive expenditure shock has an immediate and negative effect on money market interest rates.

For Sub-Saharan African countries, Baldini and Ribeiro (2008) found mixed results with some countries dominated by fiscal regime, others by monetary policy while the remaining did not show any clear result. The study also reveals that changes in nominal debt could be the basis of price variability through aggregate demand effects. Their results are consistent with the fiscal theory of price level suggesting that the effects of fiscal actions could be direct source of price distortions.

The analysis for Egypt and Tunisia by Slimane and Tahar (2013) found a negative and persistent effect of revenue shock on money market interest rate in Egypt while increase in expenditure had positive and immediate effect on inflation and interest rate. For Tunisia, revenue shock impacts positively inflation and interest rate while expenditure shock increases inflation with an immediate effect and reverse for interest rate.

For the case of Italy, Giordano *et al.* (2007) concluded that a positive shock on expenditure has an expansionary impact on the economic activity but with a small and short-lived effect on inflation. The response of tax revenues to expenditure shock is positive. For Czech Republic, the findings by Frantz (2012) also confirm the expansionary effect of an expenditure shock on inflation and are in line with findings by Agha and Khan (2006).

### **III. FISCAL AND MONETARY POLICY DEVELOPMENTS IN RWANDA**

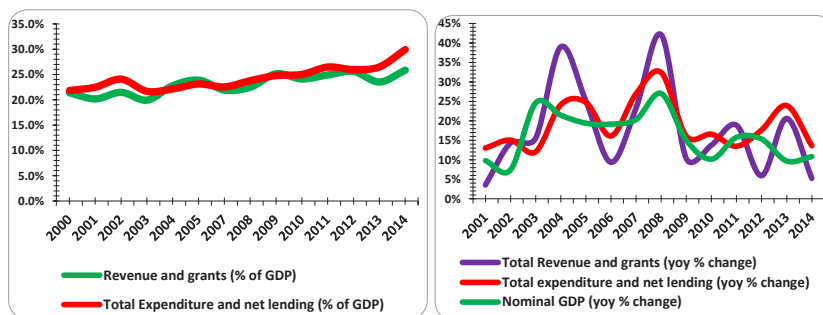
#### **III.1 Fiscal Policy in Rwanda**

Given the broad commitment of the government to achieve rapid growth and sustainable macro-economic stability, the management of fiscal position has been set under fiscal consolidation strategy (FCS). The program aims to improving public revenue mobilization and prioritizing public expenditure, with a view of reducing dependence on foreign aid.

Over the period from 1990 to 1994, public finances reached the bottom line as result of the civil war and the 1994 genocide against Tsutsi. To ensure the restoration of the country's financial health, the government of Rwanda established Rwanda Revenue Authority (RRA) in 1998 aiming to revitalize the tax capacity and tax administration equitable enough to raise revenues for the country's development ambitions. Definitely, the Rwanda's fiscal position has been improving following the RRA's efforts through tax administration reforms and efficient collection mechanisms.

Following remarkable reforms, the total government resources registered an incessant increase to the level above the pre 1994 records. On average, the overall receipts as percentage of GDP reached 21.2% between 2000 and 2004, 23.5% in 2005-2009 and 24.5% over 2010-2014. Similarly, the growth in total outlays as percent of GDP grew progressively from 22.4% in 2000-2004 to 23.8% in 2005-2009 and 27.9% in 2010-2014. The left figure below shows that the government for the most of the period was conducting loosening fiscal policy while the right figure clearly shows the co-movement in growth of fiscal position in relation to growth of the economy which is consistent with procyclical behavior of fiscal policy.

**Figure 3.1 Evolution of overall receipts, overall spending and nominal GDP**



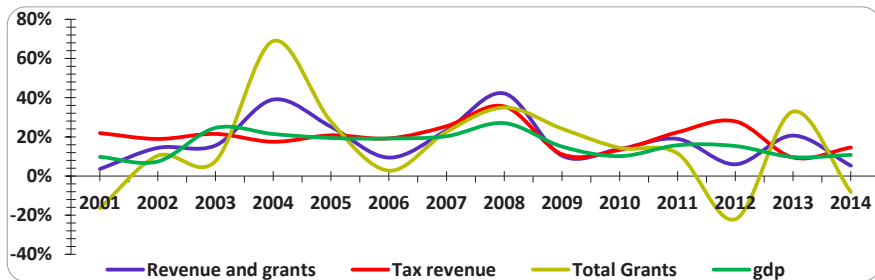
**Source:** Ministry Finance and Economic Planning and authors' computations

This made domestic revenues to increase from 47.0% of the overall receipts and grants in 2000 to 57.6% in 2008 and 74.3% in 2015. In addition, Rwanda benefited from external support under different policy support frameworks in form of direct financial aid, in kind support, and debt relief. In fact, the overall

external grants have been important in overall revenue basket as evidenced by its co-movement with the overall revenue.

Tax revenue also increased, representing around 15.9% of GDP in 2015 up from 12.5% in 2008 and 9.6% in 2000. The stronger performance in revenue collection was mainly driven by gains in both direct and indirect tax revenues. The decline in growth of government revenues in 2009 resulted from the global financial crisis while in 2013, it was due to a slowdown in economic performance following 2012 aid suspension.

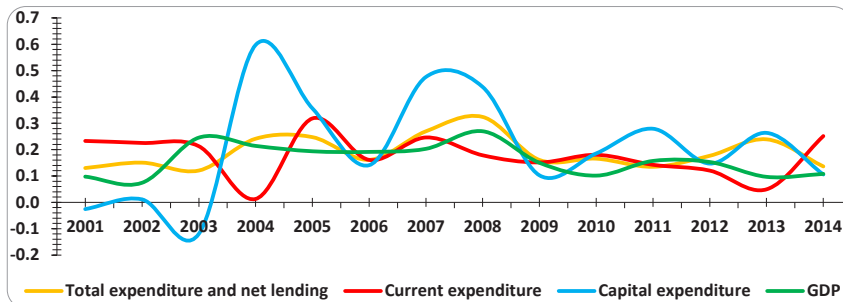
**Figure 3.2 Growth rates of nominal GDP, Tax revenue and its components (y-o-y % change)**



**Source:** Ministry of Finance and Economic Planning

The Government spending increased from 21.8% of GDP in 2000 to 30.0% of GDP in 2015 of which capital spending increased to 13.3% of GDP and recurrent outlays to 14.8% from 8.7% and 13.0% respectively.

**Figure 3.3 Nominal GDP, total spending growth and its components (yoy % change)**

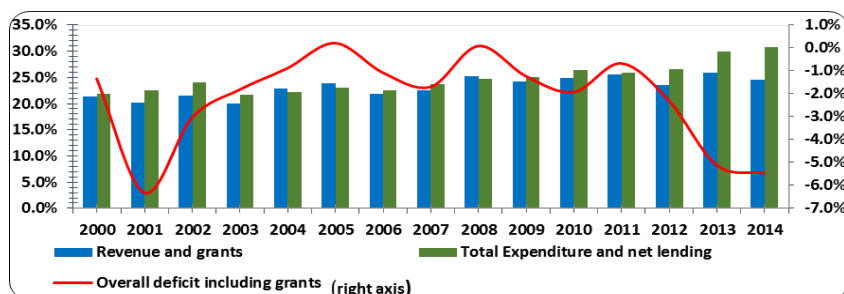


**Source:** Ministry of Finance and Economic Planning (MINECOFIN)



Despite the effort to control government expenditures and mobilize maximum tax collection, the government budget consistently closed with deficits that sometimes were higher than expected. Such cases include periods of unexpected aid cuts and delays that led to deterioration of the existing fiscal deficit. For instance during the period 2012-2015, the average overall deficit including grants stood at around 4.3% of GDP up from 1.3% of GDP during the period 2009-2011.

**Figures 3.4 Development in key fiscal indicators, % of GDP**



**Source:** Ministry of Finance and Economic Planning (MINECOFIN)

To cover the overall government outlays available resources were complemented by the government borrowing from both domestic and external markets.

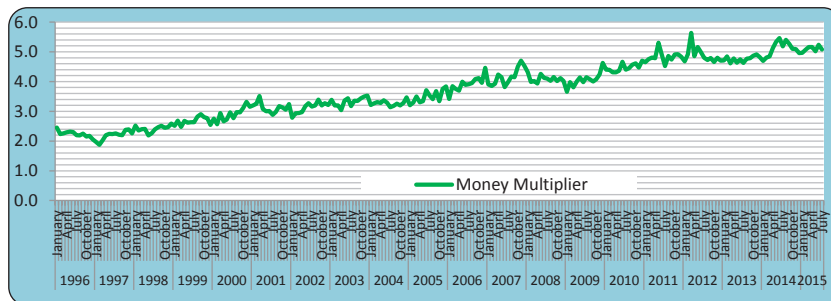
### III.3 An Overview of Monetary Policy in Rwanda

The conduct of monetary policy by the National Bank of Rwanda has undergone profound changes. The period 1964-1980 was characterized by direct monetary controls by BNR, regulating the demand and supply of money, controlling exchange rates and directing credit to key sectors considered as prioritized by the government. The main missions were to maintain monetary stability, implement credit and exchange rate policies conducive to harmonize economic development, issue national currency and play the role of the Government treasury. But in 1981, the role of BNR was reviewed to the formulation of the monetary policy, the credit and exchange rate policy to support the implementation of the Government economic policy and ensure the internal and external stability of the national currency.

In 1990s, direct monetary policy was perceived to be inefficient, especially in terms of optimal allocation of resources. Following this drawback and its adverse effects on the economy, BNR embarked on financial liberalization since 1990 but became a fully-fledged liberalized financial system in 1995. Since then, BNR adopted monetary targeting regime with broad money as nominal anchor, reserve money as operating target and price stability as ultimate objective. The direct measures were progressively replaced by mechanisms that relied more on market forces to regulate the liquidity in the banking sector (indirect instruments) such as open market operations (such as Repos, reverse repos, key repo rate, treasury bills, lending and deposit facilities), the discount window and the required reserve ratio. The BNR policy rate (Key Repo Rate) was first introduced in 2008.

The monetary policy targeting framework is however challenging following the indication of instability of money demand and money multiplier (in short term), and lag in the relationship between broad money and prices. Figure 3.6 shows that the money multiplier has generally not been stable and so difficult to predict.

**Figure 3.6 Developments in Money multiplier**

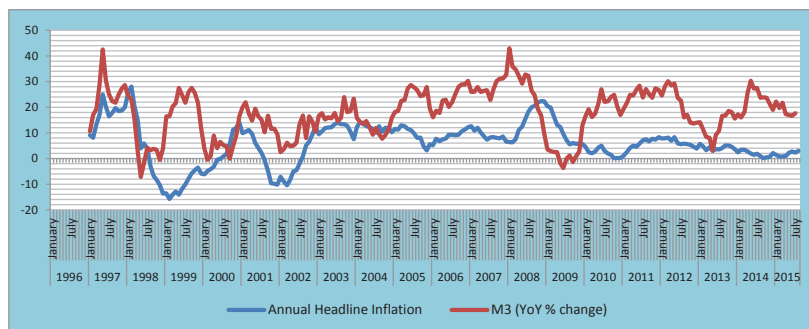


**Source:** BNR, Monetary policy and Research Department

The existence of a resilient and stable relationship between money supply and inflation is prerequisite for the success of monetary aggregate targeting. This entails that for this framework to be effective there is need for a strong positive link between inflation and broad money for the bank to be able to credibly control inflation through changing monetary aggregates. By contrast, figure 3.7 below shows a weak relationship between broad money and prices which may be challenging for the bank to control inflation using monetary

aggregates. Therefore, this growing instability of the money multiplier as well as the weakening relationship between broad money and inflation reflect the BNR's plan to adopt an inflation-targeting framework by 2018.

**Figure 3.7 Link between Money Supply and Inflation (YoY % changes)**

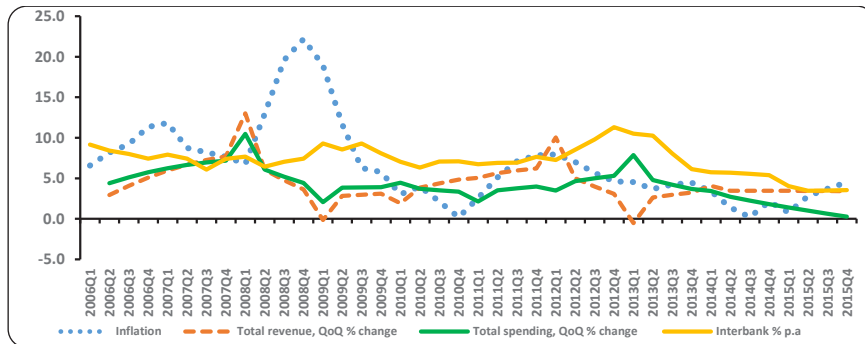


**Source:** BNR, Statistics Department and computations by authors.

### III.4 Inflation dynamics

Over the last two decades, the trend in inflation was moderate following sustained economic performance, efficient and well-coordinated monetary and fiscal policies as well as stable FRW exchange rate. Inflation hiked in 2007/2008 as result of commodity prices crisis. It was decelerating thereafter as regional inflationary pressures were overcompensated by declines in prices of domestically produced goods and falling international commodity prices. With 2012 economic recovery, demand driven inflationary pressures were tamed by increasing nominal interest rate on the back of monetary policy reaction and government borrowing after the aid cut. Fiscal spending adjustments contributed to falling aggregate demand and lower inflation in the following years necessitating further accommodative monetary policy stance to support the economy. Indeed, inflation averaged 1.8% in 2014 and 2.5% in 2015 due to good domestic harvest and falling international commodity prices which add to weakening aggregate demand. The figure below represents a co-movement between inflation and fiscal stances as well as the interbank rate.

**Figure 3.8 Fiscal stances and Inflation Dynamics (QOQ % change)**



**Source:** BNR, Monetary Policy and Research Department

## IV METHODOLOGY

The study follows a methodology that has been used by several studies that include Blanchard and Perotti (1999), Haug *et al.* (2013) as well as Kamps and Caldara (2008) among others. The approach uses a recursive model which draws out the dynamic effects of fiscal variations on the macroeconomic variables. The approach imposes contemporaneous structural restrictions based on the assumption underlying the structure of the economy.

### IV.1 Model Specification

The baseline VAR model specification can be written in a reduced form as follows:

$$X_t = A(L)X_{t-1} + u_t \dots \dots \dots (1)$$

Where;

$X_t = (g_t, \tau_t, y_t, \pi_t, i_t)$  denotes the k-dimensional vector of endogenous macroeconomic variables necessary to explain the effect of fiscal shocks on inflation and money market interest rates;  $g_t$  is the log of the total government spending;  $y_t$  is the log of nominal GDP;  $\tau_t$  is the log of government tax revenue;  $\pi_t$  is the log of core consumer price index;  $i_t$  is the interbank rate.





In addition,  $A$  matrix stands for contemporaneous relationship between endogenous variables collected in vector  $X_t$ .  $A(L)$  is a  $(n \times n)$  the matrix representing a lag polynomial.  $u_t = (u_t^g, u_t^r, u_t^y, u_t^p, u_t^i)$  is the vector of the reduced form innovations with  $E(u_t) = 0$ ,  $E(u_t u_t') = \Sigma_u$  and  $E(u_t u_s) = 0$  for  $s \neq t$  - residuals which in general have non-zero cross correlations.

To investigate the fiscal effect on inflation and money market interest rates, we estimated a SVAR model with the abovementioned five variables. This is done to avoid simultaneous estimation of large number of parameters. The reason centers on the preference to follow the footsteps of both theoretical views and on other similar empirical studies that estimated the very similar sets of variables.

Given that the reduced form residuals have little economic significance, other than having linear combination of the underlying structural variable shocks. Therefore, our interest to examine the effect of shocks in government spending and government revenue on a set of macroeconomic variables cannot be attained. For the matter of giving the model an economic interpretation, it is important to transform the reduced form model into a structural model that is able to investigate the responses on the shock. Without loss of generality, we multiply equation one by  $(n \times n)$  matrix  $A_0$  to obtain the structural form that can be written as:

$$AX_t = A^*(L)X_{t-t} + Be_t \dots\dots\dots (2)$$

Where  $A^* = A_0 A$  and  $Be_t = A_0 B_t$  which describes the relationship between the reduced form residuals  $u_t$  and the structural disturbances  $e_t$ . In the literature, this structural representation form is called the  $AB$  model. The square  $(n \times n)$  matrix  $B$  permits some shocks to affect directly more than one endogenous variable in the model. While  $e_t$  is  $n \times 1$  vector of structural innovations with  $e_t \sim N(0, BE(e_t e_t') B')$ . Both models (1) and (2) are observationally equivalent, thus without identifying restrictions on the parameters in  $A$  and  $B$ , no reliable conclusions regarding the structural parameters of the true model can be drawn from the data (Gottschalk, 2001).

In so doing, we generate two different restrictions on matrix  $A$ . The first is the normalization restriction that aims to assign the value of one (1) to variables  $X_t$ , with  $i$  in each of the  $i^{th}$  equation. The second is the exclusion restriction that aims to assign zero (0) to some variables in the equation particularly with contemporaneous relations. After obtaining the sufficient condition for the local identification, we impose restrictions suggested by the theoretical model and construct the matrix  $A$  to ascertain the relationship between the disturbances of the reduced form and structural models.

In other words, the structural innovations  $e_t$  are assumed orthonormal, implying that its covariance matrix is an identity matrix  $E[e_t e_t'] = 1$ . Certainly, this assumption of orthonormal shocks imposes the identifying restrictions on matrices  $A$  and  $B$  as follows:

$$A \Sigma A' = B B' \dots\dots\dots (3)$$

This implies that the matrix  $B$  is restricted to a  $k$ -dimensional identity matrix whereas matrix  $A$  is restricted to low triangular matrix with a unit diagonal. Hence, the relation between the structural disturbances  $e_t$  and the reduced-form disturbances  $u_t$  adopts the form below:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 & 0 \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^\tau \\ u_t^y \\ u_t^\pi \\ u_t^i \end{bmatrix} = \begin{bmatrix} \beta_{gg} & 0 & 0 & 0 & 0 \\ 0 & \beta_{\tau\tau} & 0 & 0 & 0 \\ 0 & 0 & \beta_{yy} & 0 & 0 \\ 0 & 0 & 0 & \beta_{\pi\pi} & 0 \\ 0 & 0 & 0 & 0 & \beta_{ii} \end{bmatrix} \begin{bmatrix} e_t^g \\ e_t^\tau \\ e_t^y \\ e_t^\pi \\ e_t^i \end{bmatrix} \dots\dots\dots (4)$$

The ordering of variables follows Perotti (2004) among others. Government spending ( $g_t$ ) comes first implying that it does not react contemporaneously to shocks from other variables in the system. Tax revenue ( $\tau_t$ ) is placed second to capture the contemporaneous effect of discretionary tax revenues variations on output and inflation. Output ( $y_t$ ) follows on assumption that it reacts contemporaneously to both government spending and tax revenue shocks. Inflation ( $\pi_t$ ) is ordered fourth, implying that it is affected contemporaneously by government spending, government revenue and output shocks. The interest rate ( $i_t$ ) like other monetary variables is lastly ordered meaning that it contemporaneously responds to all shocks in the system.



The ordering of interest rate is justified by two reasons. First, the interest rate is a function of the output gap and inflation; and second it is non-sensitive to the government spending and revenues.

## **IV.2 Data**

This study uses Rwandan quarterly data covering the period from 2006Q1 to 2015Q4. The data were compiled from the National Bank of Rwanda (BNR) and from the Ministry of Finance and Economic Planning (MINECOFIN). The key variables for the equations developed in this study include nominal GDP ( $y_t$ ) and core inflation ( $\pi_t$ ) as proxies of real activities; Interbank rate ( $i_t$ ) as proxy of monetary variable measuring the fiscal effect on financial market conditions; while the total government spending ( $g_t$ ) and total government tax receipts ( $\tau_t$ ) are proxies of fiscal policy. Core inflation has been preferred for it has more persistent behavior and less volatile and therefore serves as the best measure that policymakers may focus on for decision making. Headline inflation misses these properties as it includes volatile components and can be misleading for policymakers in case of supply shock and external shock.

A part from interbank rates all variables were transformed to natural logarithm to possess similar units.

## **V EMPIRICAL RESULTS**

### **V.1 Unit Root Test**

The study used Augmented Dickey-Fuller test to determine the order of integration of variables. With an automatic lag length selection using Schwarz information criterion (SIC), the results of ADF unit root test (as in table 5.1 below) show that all variables are integrated of order one  $\sim I(1)$ .

**Table 5.1 ADF test results**

Variables	ADF test Statistic	Critical Values			Order of Integration	Equation tested (with)
		1%	5%	10%		
$g_t$	2.18	2.64	1.95	1.61	I(1)	None
$\tau_t$	3.20	3.62	2.94	2.61	I(1)	Intercept
$y_t$	7.91	4.23	3.54	3.20	I(1)	Trend and intercept
$\pi_t$	3.86	3.62	2.94	2.61	I(1)	With intercept
$y_t$	4.90	2.63	1.95	1.61	I(1)	None

Stability test was conducted and the results showed that no roots lies outside the circle. Therefore, the study proceeded with the use of recursive SVAR model to investigate the response of inflation and interest rates on shocks to government expenditure and revenues in Rwanda.

## **V.2 Empirical Results for the SVAR Model**

### **V.2.1 Impact of Government spending shock on Inflation and Interest rate**

The impulse response functions (IRFs) illustrate the responses of GDP, core Consumer Price Index and interbank rate to fiscal spending shocks. The results are consistent with the Keynesian and business cycle theories which predict expansionary effects of government spending on each of the above variables.

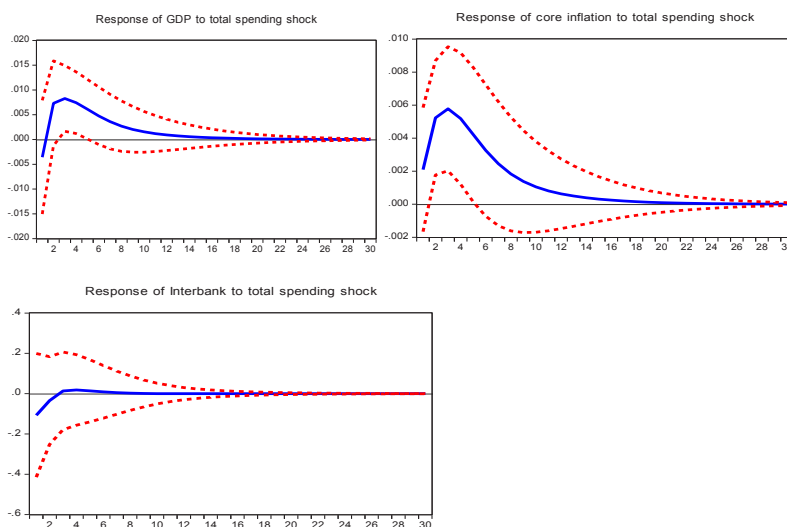
The figure 5.1 below shows that a 1% standard innovation in total government spending prompts a minor GDP growth to reach a trough of 0.008 percent in the second quarter and remains significant up to fifth quarter. From then on, the effect continues to converge to the initial level and fully dies at the fifteenth quarter; i.e after 5 years. The effect is in line with the growth enhancing activities of the government budget strategy.

The response of core CPI is positive and statistically significant from the very first quarter up to the 5th quarter. The highest response stands at 0.006 percent at the 3<sup>rd</sup> quarter and dies out after 23 quarters.

In line with the real practice, the increase in government spending increases the level of liquidity on the market and therefore lowers the cost of borrowing

which translates at the end into increased households' consumption and businesses' investment in equipment and structures pushing up prices.

**Figure 5.1 Impulse Responses of GDP, Core Consumer Price Index and interbank rate**



On the other side, the findings reveal that the response of interest rate to government spending is not statistically significant. At this stage, it is worth to conclude that GDP and inflation significantly respond to government spending while interest rate is not responsive.

For robustness check, we also followed the ordering of variables used in Blanchard and Perotti (2002). Tax is placed before government spending, followed by GDP, inflation and interest rate.

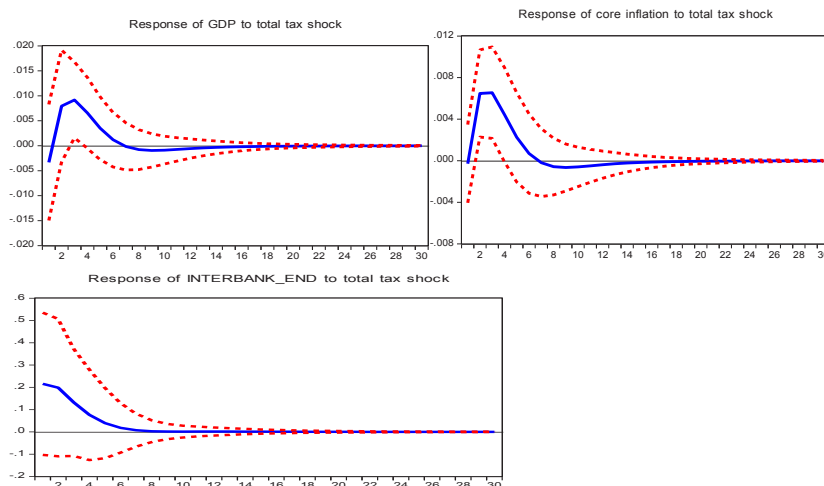
### **5.2.2 Effect of Tax Revenue shock on Inflation and Interest rate**

Impulse responses to a shock of government tax revenue show that government spending, GDP and core inflation react positively while interbank rate is not responsive.

The IRFs show an immediate short lived and significant effect of tax revenue shock on government spending. The effect on GDP is significant in the third

quarter with peak observed at 0.009 percent. This positive response of GDP to positive shock in tax revenue is consistent with findings from other studies such as Haug *et al.*(2013) for Poland.

**Figure 5.2 Response of GDP, core inflation and interbank rate**



The response of inflation is immediate and significant from the first quarter and lasts up to fourth quarter with the peak of 0.006 percent at the third quarter and beyond, the effect diminishes until it becomes negative tending towards its preshock equilibrium. Contrary to the spending shock, the impact of tax shocks on real activities and inflation are very short lived. As for the case of government spending shock, the response of interbank rate to tax revenue shock is not statistically significant.

### 5.2.3 Cumulative responses and GDP multiplier of Government spending

Using yearly cumulated response of different variables to government spending shock, it is worth to point out that the highest response of tax revenues to a one percent structural innovation in government spending is 0.04% obtained after 15 quarters. The highest cumulative response of GDP to one percent structural innovation in total spending shock is 0.05% and is reached after 19 quarters. For inflation, the pick in cumulative response is 0.04% and is obtained at 15<sup>th</sup> quarter while the deepest decline in interbank is at the very first quarter and stands at -0.11%.

**Table 5.3 Responses to a Government expenditure shock**

Quarter	4	8	12	16	20	24	Peak
$g_t$	0.04	0.05	0.05	0.05	0.06	0.06	0.06 (19)
$\tau_t$	0.02	0.03	0.03	0.04	0.04	0.04	0.04(15)
$y_t$	0.02	0.04	0.04	0.04	0.05	0.05	0.05(19)
$\pi_t$	0.02	0.03	0.03	0.04	0.04	0.04	0.04(15)
$i_t$	-0.11	-0.08	-0.08	-0.08	-0.08	-0.08	-0.11 (1)
GDP spending multiplier	0.55	0.77	0.81	0.82	0.82	0.82	0.82(15)

**Source:** Authors computation**Note:** The number in parenthesis are periods or numbers of quarters

Using Eichenbaum and Fisher (2004) approach to compute GDP multiplier of government spending which is the ratio of yearly cumulative response of GDP over the yearly cumulative response of total spending, we noted that the highest GDP multiplier in case of Rwanda is 0.82 obtained after 15 quarters, between 3 and 4 years.

#### 5.2.4 Cumulative responses and GDP multiplier of Government tax revenues

Following the same approach, we computed the cumulative responses of various indicators and, we also calculated the GDP multiplier of government tax revenues as yearly cumulative change in GDP divided by the yearly cumulative change in government tax revenues. The results are indicated in the following table 5.3.

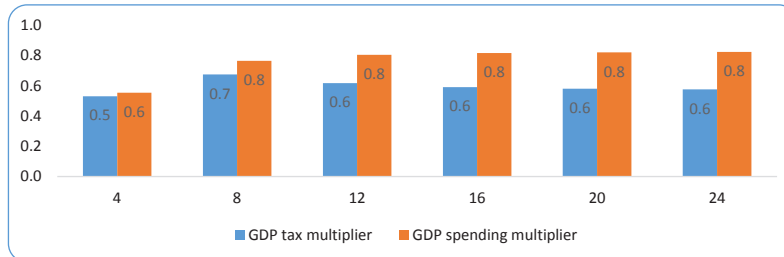
**Table 5.4 Responses to a Government tax revenue shock**

Quarters	4	8	12	16	20	24	Peak
$g_t$	0.04	0.04	0.03	0.03	0.03	0.03	0.04(3)
$\tau_t$	0.01	0.00	0.00	0.00	0.00	0.00	0.01(1)
$y_t$	0.02	0.02	0.02	0.02	0.02	0.02	0.02(4)
$\pi_t$	0.02	0.02	0.02	0.02	0.02	0.02	0.02(4)
$i_t$	0.62	0.69	0.70	0.70	0.71	0.71	0.71(20)
GDP tax multiplier	0.53	0.68	0.62	0.59	0.58	0.58	0.68(6)

**Source:** Authors computation**Note:** The number in parenthesis are periods or numbers of quarters

As portrayed in this table, the highest cumulative response of GDP to tax revenue is 0.02% obtained after one year. Similarly, the response of inflation obtained after one year is 0.02%. The highest GDP multiplier of tax revenue is lower (0.68) than the one for government spending (0.82). However, in the case of tax revenue, the effect is quicker (6 quarters) than the one for Government spending (15 quarters).

**Figure 5.3 Comparison between Government spending and tax multipliers on GDP**



With these results, we conclude that Government spending has a higher and longer lived effect on GDP than the government tax revenues. They are also more inflationary than the tax.

## VI CONCLUSION AND POLICY RECOMMENDATIONS

The study analyses the impact of fiscal policy on inflation and interest rate in Rwanda covering the period from 2006Q1 to 2015Q4. To investigate this effect, two separate SVAR models are estimated. Each model represented a transmission channel through which actions of fiscal policy can impact the monetary variables. The reason for separation centers on the preference to follow the footsteps of other similar empirical studies that estimated the very similar sets of variables. The variables we estimated include GDP, core inflation, interbank rate, government spending and tax receipts.

The findings of the study are in line with the results obtained by several previous studies but with much smaller magnitude for the case of Rwanda, advocating for well-coordinated macroeconomic policies. The results show that the government spending affects positively and significantly nominal GDP and inflation but does not significantly affect interbank rate.





Government spending has a higher and longer-lived effect on GDP and is more inflationary. In both cases, the effect on interbank rate is not significant, due to shallow financial markets which could be impeding the transmission of monetary policy signals.

Based on the above findings, there is a need for monetary authorities to enhance the developments of the financial markets to respond to changes in macroeconomic fundamentals for efficient monetary policy transmission channel.

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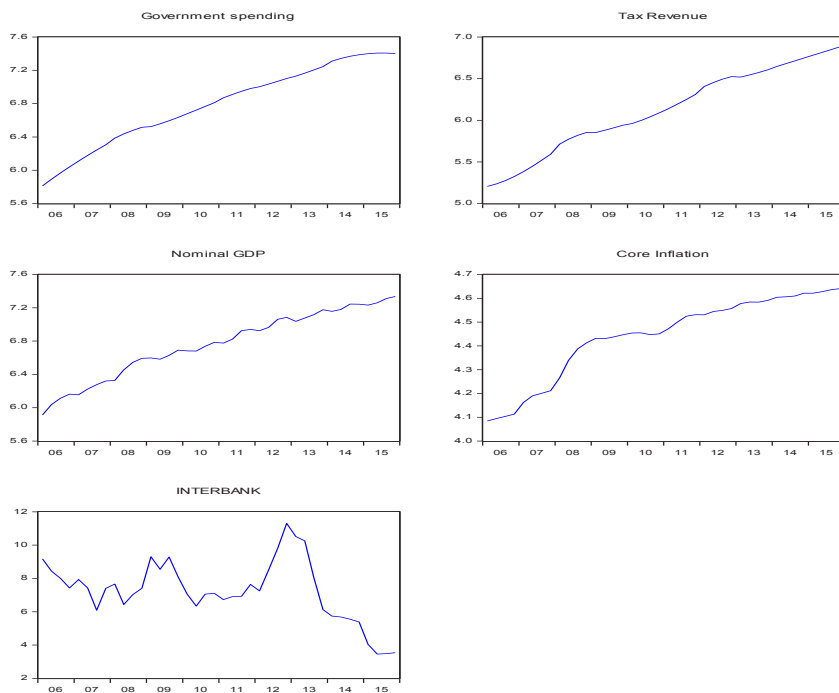


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## **APPENDICES**

### **A1. Trends in variables**

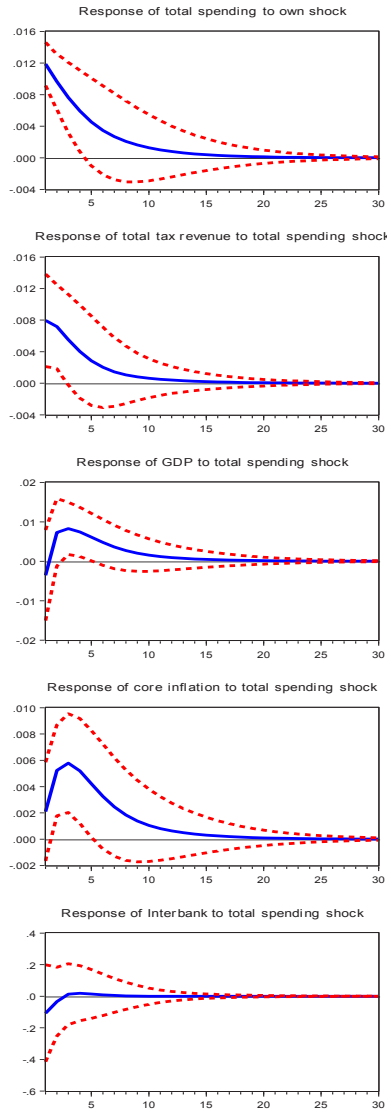
#### **Fiscal Variables and Monetary Variables (in logarithm except interbank rate)**



## A2. The effects of fiscal actions on Inflation and Interest rates

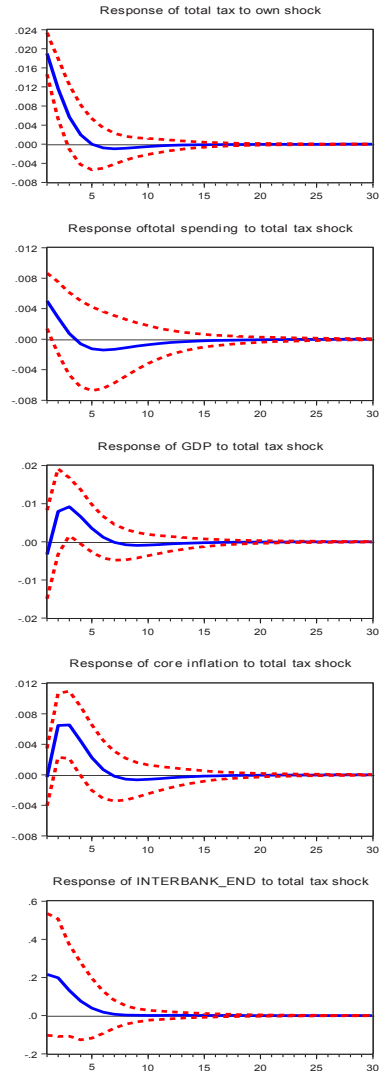
### Total government spending shock

Response to Structural One S.D. Innovations  $\pm 2$  S.E.



### Total tax revenue shock

Response to Structural One S.D. Innovations  $\pm 2$  S.E.





## **Determinants of Aggregate Demand in the Rwandan Economy: A Macroeconometric Approach**

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### **Abstract**

*The National Bank of Rwanda and other EAC central banks committed to move to an interest rate based monetary policy by December 2018. The interest rate based regime has a lot of forward looking aspects and therefore calls for more understanding of the economy and scaling up of modeling and forecasting capacities (Gill Hammond et al., 2012; Roger, Scott, 2010). In this view, the FPAS macro model, the core model of inflation as well as a set of near term forecasting and nowcasting tools were developed for the Rwandan economy. This paper explains the current structure of the core model of inflation and demonstrates how it is useful for forecasting and simulation analysis. Despite being called the core model of inflation, the model can be used to derive forecasts for aggregate demand and its components (section 4.1) and thus serve as a useful tool to track demand side inflationary sources. Being a macro-model, it also provides a consistent framework to analyze the impact of exogenous shocks on the Rwandan economy and thus helps to have structured discussions. The in-sample forecasts show that the model tracks well the path of key demand side macroeconomic variables (components of domestic and external demand) and thus, the in sample forecasts for real aggregate expenditure are quite close to the actual data.*





## **I. INTRODUCTION**

### **1.1 GENERAL BACKGROUND**

After realizing the weaknesses embedded in the monetary targeting framework, the Governors of the East African Community (EAC) central banks agreed to implement a price based monetary policy framework, using the interest rate as the operating target by 2018 as stated in the report of the Governors' 18th ordinary meeting of the monetary affairs committee. This decision was based on empirical evidence that the link between monetary aggregates and the real economy (i.e. inflation and output) across the East African economies was increasingly breaking down on the account of the instability and unpredictability of the money multiplier, money velocity and thus of the money demand function (Adam C., & Kessy, P., 2011; Kigabo, R., & Irankunda, J., 2012).

The governors of the EAC central banks also acknowledged that one of the requirements for successful adoption of the inflation targeting framework is to scale-up modelling and forecasting capacities to facilitate the putting in place of both short-term and medium-term forecasting tools. In line with the above, BNR has since 2011 put in place a suite of near term forecasting tools such as VAR, ARMA, BVAR, and state space models. These models have been quite useful in producing near-term forecasts but are less reliable in terms of producing medium-term forecasts that can guide monetary policy decisions over a relatively longer time horizon.

Thus, BNR found it necessary to embark on two projects aimed at producing medium-term forecasting models. The first project involved cooperation between BNR and IMF to build the "Forecasting and Policy Analysis Systems (FPAS)" for Rwanda. This project resulted into a small Keynesian type macro-economic model with four core equations: Aggregate demand (IS) equation, Aggregate Supply (Phillips curve) equation, the uncovered interest rate parity equation and the monetary policy rule (Karangwa et. al., 2015).

The second project aimed at building the core model of inflation for the Rwandan economy. Despite being called "the core model of inflation", the model is generally used forecast aggregate demand and its components and thus help to track demand-side sources of inflation.



The core model of inflation was built with the help of MEFMI and the South African Reserve Bank (SARB). The core model of inflation for Rwanda is adapted from the one used at the SARB but tailored to the specific realities of the Rwandan economy. Much effort has been devoted to make sure that the set of equations describing the demand-side part of the Rwandan economy can enable the preparation of internally consistent forecasts (i.e. the structural interdependencies) and of externally consistent forecasts (i.e. reflecting the actual course of the macro processes in the Rwandan economy). In addition, the model's structure should allow information from outside the model (i.e. expert judgment) to be incorporated and to help in both near-term and medium-term forecasting.

The core model of inflation is relatively big (it includes variables on employment, balance of payments, terms of trade and price deflators) and can therefore be more insightful in terms of understanding various inter-sectoral linkages. This paper aims at explaining in detail the structure of the core model of inflation for Rwanda, and demonstrating its applicability and relevance to the Rwandan economy. However, the size of the core model of inflation is kept at medium scale since experience shows that several countries prefer to use both small and medium size macroeconometric models following the fact that large ones are often too complex and not necessarily useful (Muhammad et. al., 2011).

The rest of the paper is organized as follows: section one gives the introduction with particular emphasis on the background, objective and theoretical basis for the core model of inflation; section two explains the structure of the model while section three briefly explains the estimation method used; section four compares baseline forecasts for aggregate demand and its components with actual and then presents the impact of selected shocks; section five covers the conclusion.

## **1.2 OBJECTIVES OF THE STUDY**

The main objective of this paper is to develop and explain a demand-side macroeconometric model of inflation forecasting for the Rwandan economy, capable of explaining the various demand-side inflationary factors.



Specifically, the study aims at estimating various demand-side equations of the economy and fit them together into a macroeconometric model. Thereafter, the study uses the constructed macroeconometric model to derive forecasts of key demand-side macroeconomic variables for the remaining three quarters of 2016 and to conduct relevant simulations to analyze the response of core inflation to some selected shocks and to approximate the reaction of monetary policy to a supply shock (i.e. a shock to headline inflation).

### **1.3 THEORETICAL FOUNDATIONS OF THE MODEL**

The structure of the core model incorporates both a long-run equilibrium based on economic theory and historical relationships, and short-run dynamics that allow the economy to gravitate towards its long-run equilibrium. The core model thus falls in the category described by Pagan (2003) as a medium-sized Type II hybrid model, i.e. where the long-run equilibrium component is explicitly modelled. In line with the expenditure account, both domestic and external demand determine the economic growth path. Domestic demand consists of total final consumption and gross capital formation while external demand is simply the difference between exports and imports.

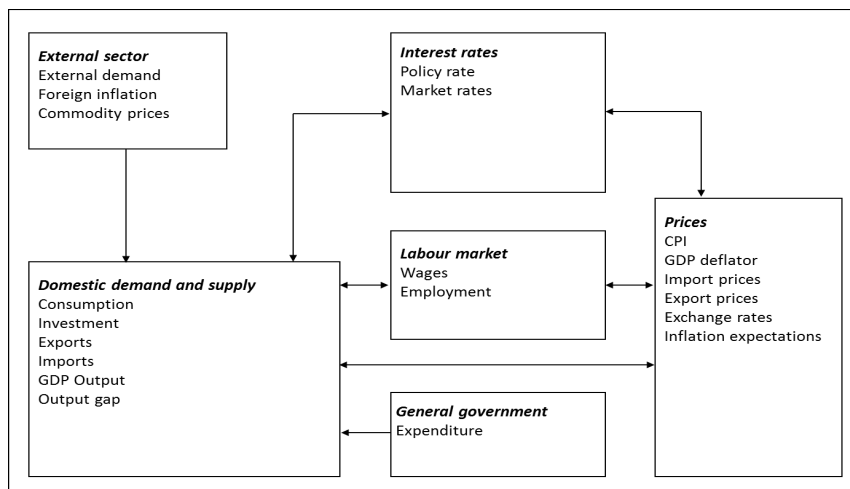
In the long run, supply-side factors determine the economic growth rate. Usually, the long-run economic growth is modelled by use of either a production function or by use of a simple statistical filter. In this paper, we use the HP filter to derive potential GDP and M3 due to data limitations.

Theoretically, the model replicates the famous “circular flow of income” that is common in several macroeconomics textbooks (Greg Mankiw, 1997). Households participate in the economic process by selling their labor and receiving income in the form of remuneration as well as interest and dividend payments and transfers from government. They pay taxes on their income received and use their disposable income to buy goods and services and to accumulate wealth. Business enterprises produce goods and services, which they sell in the domestic and global market. They use production factors, i.e. capital and labor, in the production process. They also pay taxes and make investment decisions. Government spends revenue on consumer goods and

services, and also undertakes investment. It receives taxes and makes transfer payments.

In practice, government income and expenditure, published in the annual Budget and Medium Term Budget Policy Statement are taken as given. The central bank controls the level of the official nominal short-term interest rate in order to meet the inflation target. Financial intermediaries constitute an element of the transmission channel of monetary policy through their interest rates on loans and deposits. The external sector contributes to the transmission mechanism through countries that provide goods and services to Rwanda and are, in turn, buyers of manufactured goods, commodities and services produced domestically.

**Figure 1:** A simplified diagram of interdependencies between variables



**Source:** South African Reserve Bank (Working Paper WP/07/02, June 2007)

## 2. THE STRUCTURE OF THE MODEL

The core model of inflation is a demand-side representation of the Rwandan economy. The model comprises of 17 stochastic equations (see appendix) and a number of identities and other auxiliary equations. The model is designed to capture developments from several economic blocks: expenditure side GDP, exchange rates and price deflators, terms of trade, inflation, money & credit, BOP accounts and interest rates.

The expenditure side GDP is represented as:

$$Y_t = C_t + I_t + G_t + (X_t - M_t) \dots \dots \dots (1)$$

Where  $Y$  is expenditure-side real GDP;  $C$  is private consumption expenditure;  $I$  is investment expenditure;  $G$  is government expenditure;  $X$  refers to exports and  $M$  stands for imports. Measured in real terms and in line with equation 3, the sum of private consumption expenditure ( $conshh6_t$ ), total investment expenditure ( $cap6_t$ ) and government consumption ( $consgg6_t$ ) yields total domestic demand ( $dodem6_t$ ). External demand is computed as the difference between real exports ( $expt6_t$ ) and real imports ( $impt6_t$ ). In turn, the sum of external demand and domestic demand must equal to GDP as shown in equation 2.

$$gdp6_t = dodem6_t + expt6_t - impt6_t \dots \dots \dots (2)$$

$$dodem6_t = conshh6_t + cap6_t + consgg6_t \dots \dots \dots (3)$$

With the exception of government expenditure & government investment, all domestic variables are modelled as endogenous. We also include international commodity prices, particularly for oil and the weighted index for Rwanda's key exports (tea, coffee and tin). The computation of the weights for each of these exports takes into account their respective shares in total exports. These external variables are assumed to be exogenous, just like in many other macroeconomic models.

## 2.1 BEHAVIORAL EQUATIONS

In line with equation 1, we estimate behavioral equations for private consumption, private investment, exports and imports (from national accounts), average salaries, private sector employment, core inflation, bilateral exchange rate, M3, the lending rate, the interbank rate, imports and exports (from BOP) and the key repo rate. From the national accounts, we bifurcate GDP, exports and imports into nominal and real variables. Thus, we also include equations for the deflators of GDP, imports and exports. The main reference materials for this paper are the South African Reserve Bank (2007) and Muhammad et. al., (2011).

### 2.1.1 The consumption function

To estimate the consumption function, we consider a hybrid model combining Milton Friedman's permanent income hypothesis, Hall's random walk model and the Keynesian absolute income theory. We assume that real personal disposable income ( $pdinc6_t$ ) and real lending rate ( $lrater_t$ ) are the main drivers of real private consumption expenditure ( $conshh6_t$ ). The stochastic error term in the consumption function equation is represented by  $\varepsilon_t^{conshh6}$  and it is assumed to be independently and identically distributed.

$$conshh6_t = f(pdinc6_t, lrater_t, conshh6_{t-1}, \varepsilon_t^{conshh6}) \dots \dots \dots (4)$$

In view of equation 4 and consistent with economic theory, current period real consumption positively depends on current personal disposable income but negatively depends on the current real lending rate. We also include the lag of real consumption ( $conshh6_{t-1}$ ) to capture the smoothing effect and the assumption is that lagged consumption positively influences current period consumption. Real personal disposable income is defined as nominal disposable income ( $Pdinc5_t$ ) deflated with domestic headline CPI ( $cpi\_tot_t$ ). Note that all variables, but the real lending rate, are measured in logs.

$$pdinc6_t = \frac{pdinc5_t}{cpi\_tot_t} \dots \dots \dots (5)$$

The nominal personal disposable income is defined as the wedge between the total personal salaries ( $saltotn5_t$ ) and direct personal taxes ( $dptax5_t$ ), both measured in nominal terms.

$$pdinc5_t = saltotn5_t - dptax5_t \dots \dots \dots (6)$$

Usually, the direct tax bill is always computed as the product of the personal taxable income ( $taxhh5_t$ ) and the direct personal tax rate ( $dptaxr$ ). The personal taxable income is simply the total salary ( $saltotn5_t$ ) earned by an individual (formal sector) worker.

$$dptax5_t = taxhh5_t * dptaxr \dots \dots \dots (7)$$

However, past data trends show that direct personal taxes ( $dptax_5$ ) are on average 30% of total tax revenue whereas  $saltotn_5$  is on average 22% of nominal GDP ( $gdp_5$ ) in the 2006Q1-2016Q1 period. Thus, these assumptions are used to simplify the computation of personal disposable income ( $pdinc_5$ ) as they make it possible to overcome the problem of timely data availability for direct personal taxes and salaries.

### 2.1.2 The investment function

The second important component of aggregate demand is real investment given its usefulness in terms of fueling capital accumulation and sustained economic growth as documented in various growth models. We model real investment ( $cap_6$ ) as a function of real economic activity ( $gdp_6$ ), the interbank rate ( $int\_intbank_t$ ) and the lag of real private investment ( $cap_{6,t-1}$ ). Investment is assumed to be positively related to real GDP but inversely related to the real interbank rate and real company taxes. The stochastic error term in the investment function equation is represented by  $\varepsilon_t^{inpriv6}$  and it is assumed to be independently and identically distributed. While gross operating surpluses (i.e. company profits) are always important, we assume that their effect is roughly captured by the previous level of investment ( $cap_{6,t-1}$ ). All variables, except the interbank rate, are measured in logs.

$$cap_6 = f(gdp_6, int\_intbank_t, cap_{6,t-1}, \varepsilon_t^{cap6}) \dots \dots \dots (8)$$

Note that, total investment ( $cap_6$ ) is usually derived by summing up real government investment ( $capgov_6$ ) and real private sector investment ( $cappriv_6$ ).

$$cap_6 = capgov_6 + cappriv_6 \dots \dots \dots (9)$$

However, data on real government investment and private investment are not available for Rwanda, thus we opt to model total investment as in equation 8.

### 2.1.3 Total real exports of goods and services

The exports of goods and services are assumed to depend on: their own lag ( $expt_6$ ), the real effective exchange rate ( $exreald_t$ ), domestic agricultural GDP ( $agr_6$ ) and foreign demand, proxied by world economic activity/GDP ( $wgdp_t$ ).

All variables are measured in logs. World GDP, domestic agricultural GDP, the lag of exports and real effective exchange rate depreciation are all expected to positively affect exports.  $\varepsilon_t^{\text{exp}t6}$  is the error term assumed to be independently and identically distributed.

$$\text{exp}t6_t = f(\text{exp}t6_{t-1}, \text{exreal}d_t, \text{wgdp}_t, \text{agr}6_t, \varepsilon_t^{\text{exp}t6}) \dots (10)$$

#### **2.1.4 Total real imports of goods and services**

Total imports of goods and services are assumed to be positively affected by their own lag ( $\text{im}pt6_{t-1}$ ) and a measure of domestic demand ( $\text{dodem}6_t$ ) but negatively affected by real effective exchange rate depreciation ( $\text{exreal}d_t$ ). All variables are measured in logs and therefore coefficients represent elasticities. The real effective exchange rate depreciation makes imports expensive relative to domestically produced goods and services. Domestic demand is defined in equation 3 above.

$$\text{im}pt6_t = f(\text{im}pt6_{t-1}, \text{dodem}6_t, \text{exreal}d_t, \varepsilon_t^{\text{im}pt6}) \dots (11)$$

#### **2.1.5 Private sector employment and salaries**

Due to data limitations, formal private sector employment and corresponding salaries are approximated by considering the dataset from Rwanda Social Security Board (RSSB) which contains information on social security contributions, number of employees and salaries for both the private and public sectors, with the latter assumed to be exogenous. With this information, private sector employment ( $\text{emppriv}5_t$ ), which is simply the number of employees working in the private sector, is assumed to be affected by its own lag ( $\text{emppriv}5_{t-1}$ ), the lag of real average private sector salaries

$\left( \frac{\text{avspriv}5_{t-1}}{\text{cpig\_tot}_{t-1}} \right)$  and the lag of real economic activity, proxied by real GDP ( $\text{gdp}6_{t-1}$ ).

With all variables expressed in log form, the equation is specified as:

$$\text{emppriv}5_t = f\left(\text{emppriv}5_{t-1}, \frac{\text{avspriv}5_{t-1}}{\text{cpig\_tot}_{t-1}}, \text{gdp}6_{t-1}, \varepsilon_t^{\text{emppriv}5}\right) \dots (12)$$



Just like in other stochastic equations, the error term,  $\varepsilon_t^{\text{emppriv5}}$  is included in equation 12 and is assumed to be independently and identically distributed.

The other important equation in the employment block is for the determination of average private sector salaries ( $\text{avspriv5}_t$ ), which are assumed to depend on their own lag ( $\text{avspriv5}_{t-1}$ ), the smoothed CPI ( $\text{cpitdsm}_t$ ), which is a four quarter's moving CPI average and a measure of labor productivity  $\left(\frac{\text{gdp6}_t}{\text{emppriv5}_t}\right)$ , all expressed in logs. The equation is specified as:

$$\text{avspriv5}_t = f \left[ \left( \frac{\text{gdp6}_t}{\text{emppriv5}_t} \right), \text{avspriv5}_{t-1}, \text{cpitdsm}_t, \varepsilon_t^{\text{avspriv5}} \right] \dots \dots \dots (13)$$

Where  $\varepsilon_t^{\text{avspriv5}}$  is the error term assumed to independently and identically distributed.

Other identities include the definition of total private salaries ( $\text{salprivn5}_t$ ) as a product of average private sector salaries ( $\text{avspriv5}_t$ ) and private sector employment ( $\text{emppriv5}_t$ ):

$$\text{salprivn5}_t = \text{avspriv5}_t * \text{emppriv5}_t \dots \dots \dots (14)$$

Likewise, total public salaries ( $\text{salpubn5}_t$ ) is defined as a product of average public sector salaries ( $\text{avspub5}_t$ ) and average public sector employment ( $\text{emmpub5}_t$ ):

$$\text{salpubn5}_t = \text{avspub5}_t * \text{emmpub5}_t \dots \dots \dots (15)$$

Then, total salaries ( $\text{saltotn5}_t$ ) are defined as the sum of total private sector salaries and public sector salaries:

$$\text{saltotn5}_t = \text{salprivn5}_t + \text{salpubn5}_t \dots \dots \dots (16)$$

The formal sector total employment ( $\text{emptot5}_t$ ) is then computed as the sum of formal private sector employment ( $\text{emppriv5}_t$ ) and public employment ( $\text{emmpub5}_t$ ):

$$\text{emptot5}_t = \text{emmpub5}_t + \text{emppriv5}_t \dots \dots \dots (17)$$

While average economy-wide salary ( $avstot5_t$ ) is computed as the ratio of total salaries ( $saltotn5$ ) and total employment ( $emptot5_t$ ):

$$avstot5_t = saltotn5 / emptot5_t \dots\dots\dots (18)$$

### 2.1.6 Inflation

Rwanda's headline CPI has three components: core CPI, fresh products CPI and energy CPI with a weight of 74.9%, 17.4% and 7.8% respectively. Headline CPI is computed as a weighted sum of its components:

$$cpig\_tot_t = ((cpigw\_core * cpig\_core_t) + (cpigw\_en * cpig\_en_t) + (cpigw\_fp * cpig\_fp_t)) / 100 \dots\dots\dots (19)$$

Where  $cpig\_tot_t$  is headline CPI,  $cpigw\_core$ ,  $cpigw\_en$  and  $cpigw\_fp$  are weights for core CPI, Energy CPI and fresh products CPI, respectively and  $cpig\_core_t$ ,  $cpig\_en_t$ ,  $cpig\_fp_t$  are their corresponding price indices.

We model core CPI and assume the other components to be exogenous. Core CPI ( $cpig\_core_t$ ) is assumed to be positively affected by its own lag ( $cpig\_core_{t-1}$ ), imported inflation, proxied by the imports deflator ( $imptd_t$ ), unit labor costs ( $ulcstd_t$ ), the output gap ( $ygap$ ) and M3 gap ( $m3gap$ ), all measured in logs. The error term ( $\varepsilon_t^{cpig\_core}$ ) is assumed to independently and identically distributed.

$$cpig\_core_t = f[cpig\_core_{t-1}, imptd_t, ulcstd_t, ygap_t, m3gap_t, \varepsilon_t^{cpig\_core}] \dots\dots\dots (20)$$

Potential Real GDP and M3 are computed using the Hodrick-Prescott (HP) filter. Real GDP gap ( $gdpgapr_t$ ) is computed as the difference between the log of actual non-agricultural GDP, i.e.  $\log(gdpex6_t)$  and the log of potential non-agricultural GDP, i.e.  $\log(gdpot6_t)$ :

$$gdpgapr_t = (\log(gdpex6_t) - \log(gdpot6_t)) * 100 \dots\dots\dots (21)$$

Similarly, the M3 gap ( $m3gapr_t$ ) is computed as the difference between the log of actual M3, i.e.  $\log(m3_t)$  and the log of potential GDP, i.e.  $\log(m3pot_t)$ :

$$m3gapr_t = (\log(m3_t) - \log(m3pot_t)) * 100 \dots\dots\dots (22)$$

Unit labor cost is measured as the ratio between total salaries and non-agricultural real GDP:

$$ulcstd_t = \left[ \frac{saltotn5_t}{gdpex6_t} \right] \dots \dots \dots (23)$$

### 2.1.7 Price deflators

As mentioned earlier, we split GDP, exports and imports into real and nominal values. These real and nominal values are linked by their respective deflators\*. We then model the process for these deflators. First, the imports deflator ( $imptd_t$ ) is influenced by its own lag ( $imptd_{t-1}$ ), the nominal effective exchange rate of the FRW ( $exnomd_t$ ) and the index for foreign prices ( $forprd_t$ ), derived from the PPP equation:

$$imptd_t = f(imptd_{t-1}, exnomd_t, forprd_t, \varepsilon_t^{imptd}) \dots \dots \dots (24)$$

Secondly, the exports deflator is influenced by its own lag ( $exptd_{t-1}$ ), the bilateral exchange rate ( $exdolld_t$ ), and the international commodity price index ( $commdoll_t$ ), which is computed as a weighted average of international tea, tin and coffee prices, with estimated respective shares in total exports used as weights:

$$exptd_t = f(exptd_{t-1}, exdolld_t, commdoll_t, \varepsilon_t^{exptd}) \dots \dots \dots (25)$$

Third, the GDP deflator is assumed to depend on its own lag ( $gdpd_{t-1}$ ) and on headline CPI ( $cpig\_tot_t$ ):

$$gdpd_t = f(gdpd_{t-1}, cpig\_tot_t, \varepsilon_t^{gdpd}) \dots \dots \dots (26)$$

### 2.1.8 Exchange rates

In the exchange rates block, we define the nominal effective exchange rate and the process for the bilateral (FRW/USD) exchange rate. The nominal effective exchange rate is a trade weighted index, derived from the PPP as the product of the real effective exchange rate ( $exreald_t$ ) and the relative price,

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\* The deflator is defined as the ratio of nominal to real value

computed as the ratio of domestic CPI ( $cpig\_tot_t$ ) to trade weighted foreign CPI ( $forprd_t$ ):

$$exnomd_t = exreald_t * \left( \frac{cpig\_tot_t}{forprd_t} \right) \dots\dots\dots (27)$$

Developments in the bilateral (FRW/USD) exchange rate are determined by its own lag and by the nominal effective exchange rate:

$$exdolld_t = (exdolld_{t-1}, exnomd_t, \varepsilon_t^{exdolld}) \dots\dots\dots (28)$$

### 2.1.9 Money Supply and interest

Money demand is hypothesized to be positively linked with its lag ( $m3_{t-1}$ ) and nominal GDP ( $gdp5_t$ ) but inversely related with the interbank rate ( $int\_intbank_t$ ). The error term, has the same assumption as in the other stochastic equations.

$$m3_t = f(m3_{t-1}, gdp5_t, int\_intbank_t, \varepsilon_t^{m3}) \dots\dots\dots (29)$$

Note that the real lending rate enters into the equation for real private consumption while the interbank rate enters into the equations for core inflation and M3, thus we need some kind of processes for them if not assumed exogenous. The interbank rate ( $int\_intbank_t$ ) is assumed to positively depend on its lag ( $int\_intbank_{t-1}$ ) and on the policy rate ( $int\_krepo_t$ ). Similarly, the lending rate ( $int\_lend_t$ ) is assumed to be positively affected by its lag ( $int\_lend_{t-1}$ ) and the policy rate. With  $\varepsilon_t^{int\_lend}$  and  $\varepsilon_t^{int\_intbank}$  defined as the respective error terms, the interbank rate and lending rate equations are specified as:

$$int\_lend_t = f(int\_lend_{t-1}, int\_krepo_t, \varepsilon_t^{int\_lend}) \dots\dots\dots (30)$$

$$int\_intbank_t = f(int\_intbank_{t-1}, int\_krepo_t, \varepsilon_t^{int\_intbank}) \dots\dots\dots (31)$$

We also specify the equation for the policy rate (Taylor rule), so as to ensure complete definition of the interest channel of monetary policy transmission but also to ensure the model has a closure rule that ensures the smoothing out of short-run business cycles. A simple Taylor-type rule assumes that the central bank sets the policy rate (KRR) in view of two main objectives: ensuring

that inflation does not deviate much from the target (undershooting or overshooting) and supporting growth such that real GDP is close enough to its potential (i.e. a zero output gap).

Thus, we assume here that the KRR is positively affected by its lag, the output gap and the deviation of inflation from target. The latter is set at 5% in line with the EAC countries' inflation objective.

$$\text{int\_krepo}_t = (\text{int\_krepo}_{t-1}, \text{ygap}_t, \text{inf\_dev}_t, \varepsilon^{\text{int\_krepo}}_t) \dots (32)$$

### 2.1.10 Balance of payments

In the current account of the balance of payments (BOP), we define processes for both imports and exports. Exports ( $\text{exports}_t$ ) are assumed to depend on their lag ( $\text{exports}_{t-1}$ ) and on the four quarters moving average of exports ( $@\text{movav}(\text{expt5}_t, 4)$ ) from the national accounts. By analogy, imports ( $\text{imports}_t$ ) in the BOP are assumed to depend on their lag ( $\text{imports}_{t-1}$ ) as well as on the four quarters moving average of imports ( $@\text{movav}(\text{impt5}_t, 4)$ ) from the national accounts. All variables are measured in log form.

$$\text{exports}_t = f(\text{exports}_{t-1}, @\text{movav}(\text{expt5}_t, 4), \varepsilon^{\text{exports}}_t) \dots (33)$$

$$\text{imports}_t = f(\text{imports}_{t-1}, @\text{movav}(\text{impt5}_t, 4), \varepsilon^{\text{imports}}_t) \dots (34)$$

## 3.0 ESTIMATION METHOD

The behavioral equations of the model are estimated using the single-step Engle Granger cointegration method, supplemented where necessary by expert judgments/calibrations. The estimation sample is set at 2006Q1 to 2016Q1. The estimated equations are then used to form the model objects which can be solved and used for forecasting and for conducting simulations. As an example of the single-step Engle Granger cointegration technique, consider the equation for real private consumption (other estimated stochastic equations are given in the appendix). The most parsimonious (calibrated) model is stated as:

$$\begin{aligned} \log(\text{conshh6}_t) = & -0.69 * (\log(\text{conshh6}_t) - 0.49 * \log(\text{pdinc5}_{t-1} / \text{cpig\_tot}_t + .01 * (\text{int\_lend}_t) \\ & + 4.4 + 0.44 * \log(\text{pdinc6}_t) - 0.008 * \text{d}(\text{int\_lend}_{t-3}) + \varepsilon^{\text{conshh6}}_t) \dots (35) \end{aligned}$$



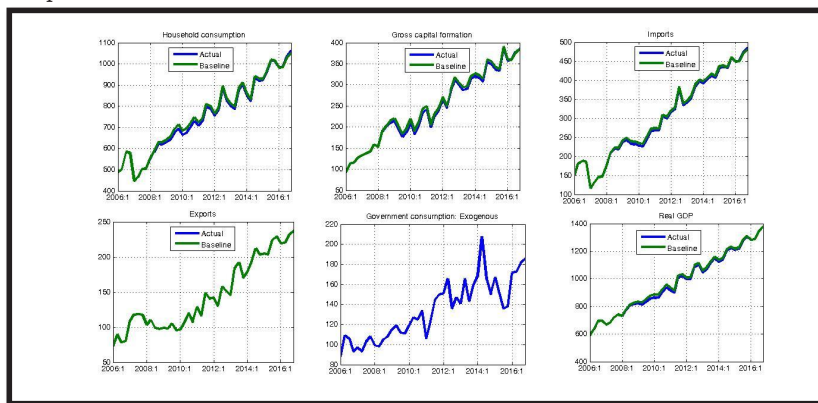
#### **4.0 USING THE MODEL FOR FORECASTING AND SIMULATION ANALYSIS**

The forecasting exercise helps to compare the in-sample forecasts to actual data whereas the simulation exercise enables the assessment of how well some key monetary policy transmission channels are functioning. We assess the reaction of core inflation to a shock on the output gap and M3 gap, respectively. We also assess how monetary policy reacts (i.e. the key repo rate) to an inflation shock.

##### **4.1 Model performance: Forecasts versus actual data**

As a first step to ensure the robust performance of the model and in line with equation 1, we compare the in sample forecasts to actual data for each component of aggregate demand. We then compare the baseline forecast for real GDP, which is equal to the sum of the individual components, with the actual data. Results show that the model tracks well the historical path of real GDP and its components.

**Figure 2:** Forecasts versus actual data for aggregate demand (AD) and its components



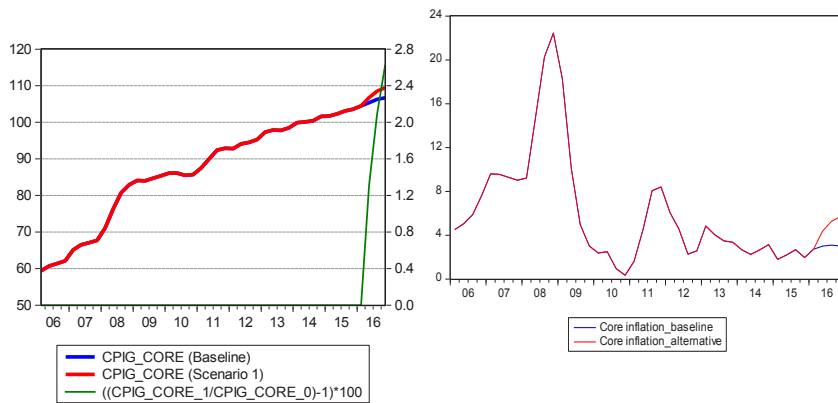
**Source:** Own computations and actual data from NISR

#### 4.2 A demand shock: shock on the output gap

Assume fiscal policy suddenly becomes expansionary such that more government spending raises aggregate demand by 10%. In the context of the core inflation equation and the monetary policy rule equation, a demand shock results into inflationary pressures and may result into monetary policy tightening to curb emerging inflationary pressures.

Since the output gap is measured as percentage deviation of actual real GDP from its potential level, we apply an additive shock on it and check how core inflation reacts. After applying a 10% output gap shock in the 2016Q2-2016Q4, it is clear that core CPI is higher in the alternative scenario than in the baseline scenario for the period during which the shock is applied. Consequently, core inflation projections increase from 3.0%, 3.1% and 3.0% to 4.36%, 5.26% and 5.71% in 2016Q2, 2016Q3 and 2016Q4 respectively.

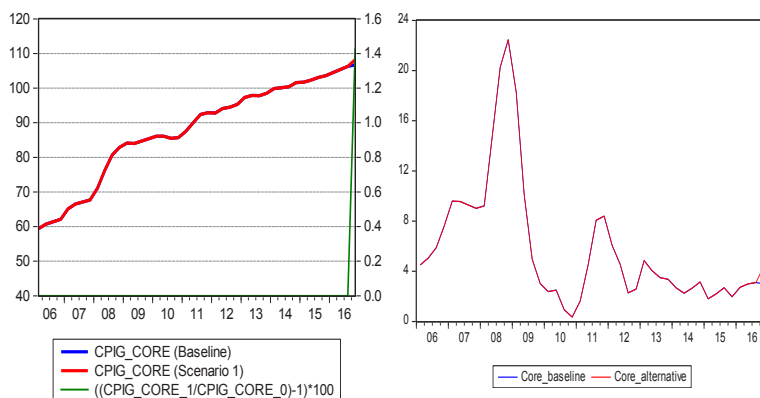
**Figure 3:** Response of core inflation to a 10% additive shock on the output gap



### 4.3 A shock on the M3 gap

The M3 gap is also one of the key determinants of core inflation. Just like the output gap, it is measured in percent. Thus, we apply an additive shock. Intuitively, an increase in the M3 gap implies that actual money supply has exceeded its potential level, resulting into inflationary pressures. The effect of a 10% shock on the M3 gap is quite small as core inflation projections only increase in 2016Q4 from 3.0% (baseline) to 4.5% (alternative scenario). The delayed response of inflation to M3 gap shock is due to the fact that monetary policy often affects the real economy after a time lag.

**Figure 4:** Response of core inflation to a 10% additive shock on the M3 gap

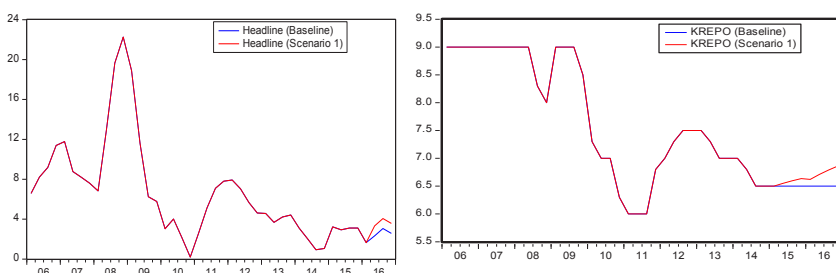




#### 4.4 A shock on headline inflation

Inflation is also measured in percent and thus we apply a 1% additive shock to it and check how the key repo rate reacts. What is expected is that when inflation increases, monetary policy becomes tighter depending on whether actual inflation has exceeded or is closer to the inflation target. In response to this shock, the key repo rate increases from 6.50% to 6.71%, 6.79% and 6.86% in 2016Q2, 2016Q3 and 2016Q4 respectively.

**Figure 5:** Response of the key repo rate to a 1% additive shock on headline inflation



#### 5.0 CONCLUSIONS

This paper is a first attempt to explain how the core model of inflation can be used for analysis, forecasting and deriving alternative simulations. The model is adapted from the one used at the Reserve bank of South Africa but is tailored to the realities of the Rwandan economy. This paper also explains the key stochastic equations in the current version of the core model of inflation based on quarterly data for Rwanda.

Given the closeness of in-sample forecasts for aggregate demand and its components, the model can serve as a useful forecasting tool. Simulation analysis reveals that owing to a 10% demand shock, core inflation projections increase from 3.0%, 3.1% and 3.0% in the baseline to 4.36%, 5.26% and 5.71% in the alternative scenario in 2016Q2, 2016Q3 and 2016Q4 respectively. However, the effect of a 10% shock to M3 gap is quite delayed as core inflation projections only increase in 2016Q4 from 3.0% (baseline) to 4.5% (alternative scenario). Results also show that the response of monetary policy to a 1% supply shock is quite significant as the key repo rate increases



from 6.50% in the baseline in 2016Q2-2016Q4 to 6.71%, 6.79% and 6.86% in 2016Q2, 2016Q3 and 2016Q4 respectively. Nonetheless, the reaction of monetary policy may depend on the source of the shock. For example, monetary policy may not tighten if there is a temporary food supply shock.

It is worth mentioning that most of the equations in the current version of the core model of inflation are calibrated, implying that more work is needed to understand and accurately model the various sectors of the economy. Satellite models are needed to help come up with near term forecasts for various blocks in the model and this work can be effectively handled by sector experts.



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### APPENDIX A: MODEL EQUATIONS ESTIMATED IN EIEWS

1.  $dlog(conshh6) = -0.692106341385 * (log(conshh6(-1)) - 0.492606200656 * log(pdinc5(-1) / cpitd(-1)) + .01 * (int\_lend(-2))) + 4.4 + 0.442641301293 * dlog(pdinc5 / cpitd) - 0.00807233024383 * d(int\_lend(-3)) + resconshh6$
2.  $dlog(cap6) = -0.264564888577 * (log(cap6(-1)) - 1 * log(gdp6(-2)) + .01 * (int\_intbank(-2))) - 0.380999051587 + 1.15178597706 * dlog(gdp6(-1)) - 0.01 * d(int\_intbank(-1)) + rescap6$
3.  $dlog(expt6) = -.5 * (log(expt6(-1)) - 1 * log(wgdp(-2)) - 1.0 * log(exreal(-2)) - 2.61485725092 * log(agr6(-2))) - 9.5 + 0.942393766483 * dlog(exreal(-2)) + 2 * dlog(wgdp(-1)) + resexpt6$
4.  $dlog(impt6) = -0.226685734888 * (log(impt6(-1)) - 1 * log(ddem6(-2)) + 1 * log(exreal(-1))) + 0.703275721191 - .5 * dlog(exreal(-1)) + 1.23980660581 * dlog(ddem6) + resimpt6$
5.  $dlog(avspriv5) = -0.595972842207 * (log(avspriv5(-1)) - 1.22192693551 * log(cpitsm(-1)) - 0.101534284887 * log(gdp6(-1) / emppriv5(-1))) - 6.8 + 0.205849155207 * dlog(gdp6(-1) / emppriv5(-1)) + 1.01382067609 * dlog(cpitsm) + resavspriv5$
6.  $dlog(emppriv5) = -0.103932816224 * (log(emppriv5(-1)) - 1.91968032209 * log(avspriv5(-1) / cpitd(-1)) - 1 * log(gdp6(-1))) + 2.7 + 0.0628491405535 * dlog(gdp6) - 0.0795226166874 * dum08q3 - 0.100430820444 * dum12q4 + resemppriv5$
7.  $dlog(cpig\_core) = -0.317694655736 * (log(cpig\_core(-1)) - 0.506161746041 * log(imptd(-1)) - 0.18070041533 * log(ulcstd(-1)) - 0.00371735813725 * ygap(-1) - 0.00447200881874 * m3gap(-2)) + 1.52 + 0.0859204176017 * dlog(imptd) + 0.0234564478018 * dlog(ulcstd(-2)) + 0.00130752151051 * d(ygap) + 0.00145734343895 * d(m3gap(-3)) + rescpigcore$
8.  $dlog(exptd) = -0.247456297602 * (log(exptd(-1)) - 0.299259086706 * log(commdoll(-1) * exdoll(-1))) - 0.8 + 0.0749687641546 * dlog(commdoll(-1) * exdoll(-1)) - 0.15592333218 * dum11q4 + resexptd$
9.  $dlog(imptd) = -0.692797947315 * (log(imptd(-1)) - 0.659412687882 * log(forprd(-1) * exnomd(-1))) - 4.05 + 0.192270529797 * dlog(forprd * exdoll) + 0.15 * dlog(oildol(-1) * exnomd(-1)) + resimptd$
10.  $dlog(gdpd) = -0.597855040806 * (log(gdpd(-1)) - 0.976841368116 * log(cpig\_tot(-1))) - 2.62 + 0.948887201511 * dlog(cpig\_tot) + resgdpd$
11.  $dlog(exdoll) = -.5 * (log(exdoll(-1)) - 1 * log(exnomd(-1))) + 0.9 + 1 * dlog(exnomd) + resexdoll$
12.  $dlog(m3) = -0.200009727058 * (log(m3(-1)) - 1.11615451676 * log(gdp5(-2)) + 0.0384678020514 * int\_intbank(-4)) - 0.12894162864 + 0.324938531443 * dlog(gdp5) - 0.0122265406497 * d(int\_intbank(-1)) + resm3$
13.  $int\_krepo = (0.9 * int\_krepo(-1) + 0.1 * (3 + inf\_dev + 0.5 * (inf\_dev(+4) - 5) + 0.5 * ygap)) + reskrepo$
14.  $d(int\_lend) = -0.6 * (int\_lend(-1) - 1 * int\_krepo(-1)) + 5.05011904762 + 0.5 * d(int\_krepo(-1)) + reslend$
15.  $d(int\_intbank) = -0.149147182424 * (int\_intbank(-1) - 1 * int\_krepo(-1)) + 0.0370149723932 + 1.19467376078 * d(int\_krepo) + resintbank$



$$16. \text{dlog(exports)} = -.5 * (\text{log(exports(-1))} - 1.20290383662 * \text{log(@movav(expt5 (-1) , 4))} - 0.6 + 1.31954170212 * \text{dlog(@movav(expt5 , 4))} + \text{resexports}$$

$$17. \text{dlog(imports)} = -.5 * (\text{log(imports(-1))} - 1.14998494989 * \text{log(@movav(impt5(-1) , 4))} - 0.3 + 1.57345597179 * \text{dlog(@movav(impt5 , 4))} + \text{resimports}$$











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