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Monetary Transmission Mechanisms in Rwanda

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Preface

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The objective is to increase research capacity and quality, to promote research and collaboration in research, to share gained insights into important policy issues and to acquire a balanced viewpoint of economics and financial policymaking which enables us to identify the economic problems accurately and to come up with optimal and effective guidelines for decision makers. Another important aim of the series is to facilitate communication with development cooperation agencies, external research institutes, individual researchers and policymakers in the East Africa region.

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Abstract

This paper assesses monetary transmission mechanisms in Rwanda. By first analyzing their key determinants the paper highlights the good progress accomplished in increasing the National Bank of Rwanda's (BNR) independence, flexibility in the current monetary policy framework and financial sector development. However, the banking sector continues to show persistent short-term liquidity, the size of the formal financial sector remains small and banks are more competitive in the deposit rather than in the loan market. Thus, the interest rate pass-through to the lending rate remains very weak and this limits the impact of monetary policy actions on the cost of banking loans. The exchange rate channel has started improving after the introduction of more flexibility in the exchange rate policy and a decline in foreign resources. There is clear evidence that the monetary aggregates channel is active in Rwanda. A shock to M3 as well as changes in the available amount of credit as a result of BNR's actions appears to have a very rapid, significant and persistent effect on output which peaks after around 5 quarters. This may be a reflection of the increasing monetization of the Rwandan economy that has taken place. The effect of a shock to M3 on prices is positive and significant but appears late, after more than two years. More efforts are needed to support further development of the financial markets and extending the formal financial sector to all sectors of the economy.

Keywords: Monetary policy, transmission mechanism, Rwanda.

JEL Classification Codes: E52.

1.1. Introduction

Monetary policy plays a fundamental role in price stability which is a precondition for sustainable growth in output and employment over the long-run. Although ineffective in the long-run, monetary policy is a powerful tool in influencing economic activity in the short-run. It has an impact on economic activities and inflation through several transmission mechanisms which describe how policy induced changes in the money stock or the short-term nominal interest rate impact aggregate demand. This explains why there has been an increasing interest in empirical studies on monetary transmission mechanism channels which are aimed at understanding how these channels work by describing their relative dominance, importance and spread in propagating effects (time-lag).

This is important for central banks because the efficacy of monetary policy depends on how monetary authorities make accurate assessments of the timing and the effects of their policies on economic activities and prices. In general, specific channels of monetary transmission operating through the monetary policy effect interest rates, exchange rates, equity and real estate prices, bank lending and firm balance sheets (Mishkin, 1995). The focus of our study is on the interest rate channel, the bank lending channel and the exchange rate channel which are working in developing countries.

International experience shows that the effectiveness of monetary transmission mechanisms varies across countries depending on the extent of financial intermediation, the structure of the financial system and structural economic conditions (see Checetti, 1999; Creel and Levasseur, 2005). The link between monetary policy instruments under the direct control of a central bank (like short-term interest rates and reserve money) and variables that affect the conditions in the non-financial sector (like lending rates, deposit rates, the exchange rate and asset prices) depend on the depth and structure of the financial system. This explains why monetary transmission mechanisms are fundamentally different in low-income countries and in advanced economies (Mishri et al., 2010) and why monetary transmission mechanisms are still weak in emerging and developing economies.

The interest rate channel is very active in advanced countries due to their well-functioning financial systems. Changes in the policy rate by the central bank significantly impact aggregate demand and price level (see, for example, Mojon and Peersman, 2001). This transmission channel is hampered in emerging and developing countries as their financial systems are not developed. Their bond markets are under-developed or they do not exist, their banking sectors are not competitive and their informal finance sectors are very large (see, for example, Buigut, 2009; Lungu, 2008; Moreno, 2008; Saxegaard, 2006).

Exchange rate offers an additional transmission mechanism for monetary policy in a small open economy where consumer price inflation is directly affected by changes in the exchange rate through the effect of import prices and aggregate demand. Thus, in an open economy inflation is influenced by how its determinants adjust to exchange rate movements (Adolfson, 2001) and this explains why this channel varies across countries. In low income countries where exchange rate flexibility tends to be restricted, the scope for an exchange rate channel is reduced (Adam Mugume, 2011; Cheng, 2006). In general, the exchange rate pass-through to domestic prices is higher in countries using

exchange rate to anchor inflation than in countries using inflation targeting as a framework for implementing monetary policy (Soffer, 2008).

Some studies have found that the bank lending channel of monetary policy transmission is dominant in low-income countries (Lungu, 2008; Uanguta and Ikhide, 2002) but others have found mixed evidence for this channel. The bank lending channel depends on the link between monetary policy actions and the availability and cost of bank credit and that between availability and cost of banking credit and aggregate demand (Ciccarelli et al., 2015). These links depend on the health of the banks' balance sheets, market conditions, competition in the banking industry and the size of the formal financial sector.

While there is consensus that the existence of a credit channel influences credit supply, the key issue is identifying whether credit change is due to a shift in credit supply or a change in credit demand. Different researchers have found that loan supply is more sensitive to monetary policy shocks than loan demand (Ciccareli et al., 2015; Havro and Vale, 2011) and that monetary policy affects aggregate loan supply through changes in maturities of new loans, particularly for large banks (Black and Rosen, 2009).

The credit channel is affected by financial market conditions specifically when there is a decrease in market liquidity. About bank balance sheet conditions, different researches conclude that well-capitalized banks with well-balanced maturity structures are less likely to ration credit. In addition, balance sheet conditions of both banks and firms play an important role in extension credit (Jimenez et al., 2010).

In sub-Saharan African countries, the bank lending channel is also hampered by the small size of and imperfections in the financial sector. Credit market frictions make bank deposits with the central bank, government bonds and foreign securities much closer substitutes among themselves than with credit to the private sector (Mishri et al., 2010; Sacerdoti, 2005).

There is no published research on monetary transmission mechanisms in Rwanda. Our study fills this gap by first focusing on selected aspects of monetary transmission mechanisms such as interest rate pass-through and exchange rate pass-through before assessing channels of monetary transmission in a unified empirical framework using the vector auto regressive (VAR) model.

Understanding monetary policy transmission mechanisms in Rwanda is essential for the National Bank of Rwanda (BNR) to design, manage and implement its monetary policy. Currently, BNR conducts its monetary policy under the monetary targeting regime with the broad monetary aggregate M3 as the intermediate target and reserve money as the operating target. M3 is composed of the currency in circulation out of the banking system, the demand and time deposits in Rwandan francs and deposits in foreign currencies. Reserve money (RM) is composed of the currency in circulation out of the central bank and banks' deposits with the central bank.

In this framework, the monetary transmission mechanisms are set out from the quantity of monetary base (B) as an operational target and move towards inflation through money supply (M3). The framework is based on two important assumptions: the stability of money demand to ensure the existence of a strong and reliable relationship between M3 and inflation and the stability of money multiplier to ensure the

controllability of M3 via reserve money. However, recent studies (Kigabo, 2014; Kigabo and Mutuyimana, 2016) show that money multiplier and velocity of money in Rwanda are not stable and that there is a structural change in the long run relationship between M3 and RM on the one side and between M3 and nominal GDP on the other. This limits the efficiency of the current monetary policy framework in Rwanda.

These structural changes are mainly due to changes introduced in the monetary policy framework such as the use of the key repo rate (KRR) to signal the monetary policy stance since 2008 and the use of the reserve money band since 2012 instead of targeting one value of reserve money. This has contributed to improving liquidity management and promoting more flexibility in money market rates. In addition, different financial innovations have also been introduced in the banking system in the last decade including the establishment of new financial institutions, extension of the banking sector's network and the introduction of new financial products such as automated teller machines and mobile and internet banking. Further, the capital market was created in 2008 and it has been becoming progressively active since 2014 after BNR and the Ministry of Finance and Economic Planning decided to issue treasury bonds on a quarterly basis.

Consequently, like other central banks in the East African Community (EAC) countries BNR is also planning to move from reserve money programs to more policy based monetary policy frameworks by 2018. It is planned that all EAC central banks will start using interest rate as their operating objective by 2018. It is crucial today for BNR to have a clear understanding of monetary transmission mechanisms so that it is able to anticipate the impact (and the time lag) of changes in the central bank's rate on aggregate demand, because BNR will not rely on just controlling M3 assuming that this will help achieve price stability.

2. Literature review on monetary policy transmission mechanisms

In general, analyses of monetary transmission mechanisms have been done using the VAR framework which explicitly recognize the simultaneity between monetary policy and macroeconomic developments. A VAR analysis is considered as a particularly useful tool to investigate monetary policy transmission in developing economies with short data series and structural changes complicating the use of structural models.

A few studies have used a simple single equation to analyze specific channels of transmission mechanisms such as exchange rate pass-through and interest rate pass-through as the first stage of the interest rate channel (Borio, 1997; De Bondt, 2002; Tieman, 2004).

It can be concluded from empirical literature that in developed countries the interest and exchange rate channels are the most important in the transmission of monetary policy actions to influence aggregate demand and affect the central bank's ultimate objectives such as price stability, but that these vary from one country to another. Coudert and Mojon (1995) analyzed transmission mechanisms in four countries of the European Union (Germany, France, Italy and the United Kingdom) using the VAR model and found that a change in interest rate had varied effects in the different countries.

Angeloni et al., (2002) analyzed 12 countries in the Euro zone (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain) using VAR models and show that interest and exchange rate channels are present in almost all the countries and the role of the credit channel varied from one country to another. Loayza and Schimidt's (2002) study on Australia, Canada and the United Kingdom came up with similar findings.

Hericourt and Matei (2005) did an empirical evaluation of transmission mechanisms of monetary policy in eight central and eastern European countries (Czech Republic, Hungary, Poland, Slovak Republic, Estonia, Lithuania, Latvia and Slovenia) and concluded that for countries which had maintained a fixed exchange rate regime, monetary aggregate channels were active while countries with a flexible exchange regime had heterogeneous behavior profiles.

Empirical studies on exchange rate pass-through to domestic prices conclude that in emerging economies the exchange rate pass-through is higher than it is in developed countries. In general, the pass-through is higher in countries using the exchange rate to anchor inflation than it is in countries using inflation targeting as the framework for implementing monetary policy (Soffer, 2008).

Moreno's (2008) study analyzed monetary policy transmission in emerging markets using short-term rates as operating instruments. It estimated a VAR model to assess the importance of domestic policy and foreign factors in influencing long term rates. The study concluded that with some exceptions, external long rates were better predictors of long term yields in these countries than short term interest rates.

Disyatat's (2010) study on the bank lending channel shows that greater reliance on market based funding enhanced the importance of this channel and that banks could act either as absorbers or amplifiers of shocks originating in the financial system depending on the strength of the banks' balance sheets.

Studies on African countries show different results. Cheng (2006) studied the impact of a shock in the monetary policy on production and prices in Kenya and found that a monetary shock had a very significant impact on production (GDP) and inflation and that a shock in the interest rate had short-term effects on the nominal exchange rate and prices but not on production.

Buigut (2009) concluded that changes in policy interest rates had small and not statistically significant effects on output and inflation in Kenya, Tanzania and Uganda and that the monetary transmission mechanisms were weak in these countries.

Mishra at al., (2010) did a study on monetary transmission mechanisms in low-income countries (LIC) and found that the bank lending channel should be the dominant channel in these countries, the effectiveness of the exchange rate channel depended on the exchange rate regime adopted by a country and that their interest rate channels were weak.

Adam Mugume's (2011) study shows that there was no support for credit and exchange rate channels in Uganda; however, changes in the amount of credit available resulting from changes in the monetary policy stance had an impact on inflation. Innovation to M2 had no significant effect on output growth and inflation. The interest rate channel remained weak in Uganda.

IMF's (2007) study examined transmission mechanisms in Egypt and shows that the exchange rate channel was active, bank lending and asset price channels were weak and the interest rate channel was under-developed but appeared to be strengthening since the introduction of the interest rate corridor in 2005. Applied to Mauritius, the VAR analysis concluded that a change in the policy interest rate had an impact on inflation and not on output and that monetary aggregates and exchange rate channels were active (Tsangarides, 2010).

Uanguta and Ikhide (2002) analyzed monetary transmission mechanism channels in Namibia and found that changes in the South African reserve bank's policy rate (Namibia has a currency pegged to the South African rand) had an impact on lending rates in Namibia as well as on private investments. However, Sacerdoti (2005) concluded that the transmission mechanisms through the bank lending channel were weak in many sub-Saharan African countries due to credit market frictions.

3. An Analysis of some key drivers of monetary transmission in Rwanda

There is consensus about key drivers of monetary policy transmission mechanisms which explain why channels of monetary transmission mechanisms are fundamentally different in low-income countries and in advanced economies. These include country institutional frameworks in which financial intermediation is conducted, independence of central banks, level of liquidity in the banking sector, development of the financial market, degree of international capital mobility and level of flexibility in the exchange rate regime (Mishri et al., 2010).

3.1. Institutional framework

Macroeconomic and political stability

A stable macroeconomic environment is conducive for business and can reduce banks' risk aversion and the price mark up. The macroeconomic environment in Rwanda has been healthy, stable and sound since 2000 with high real economic growth of 8 per cent on average, low and stable inflation (4.1 per cent in the last 5 years) and a stable exchange rate (depreciation of 3.9 per cent against the US dollar for the last 5 years).

In addition, political stability can affect the whole economic environment and banks' investments, assets and profitability. Hence, it definitely affects banks' pricing behavior. Rwanda is favorably ranked by the World Bank in terms of good governance, according to the Worldwide Governance Indicators (WGIs). In terms of corruption perceptions, Rwanda was ranked the second least corrupt country in Africa after Botswana in 2012 and in 2013. At the global level, Rwanda was ranked 50th and 40th in 2012 and 2013 respectively out of 177 countries. In 2015, Rwanda was ranked the 2nd easiest place to do business in Africa with the most efficient government in Africa (the World Bank, 2015) and the 7th most efficient globally.

Legal environment

The legal right index as measured by the World Bank has also been strengthening in Rwanda since 2010, reflecting on-going improvements in this area. Normally, this should reduce loan risks and subsequently the lending rate (Table 1).

Table 1: Evolution in strength of the legal rights index in Rwanda (0=weak to 12=strong).

Index	2010	2011	2012	2013	2014
Strength of legal rights index (0= weak to 12 strong)	7	7	7	9	11

Source: The World Bank reports.

3.2. Monetary policy framework in Rwanda

BNR is an independent central bank with the following missions: ensuring and maintaining price stability, enhancing and maintaining a stable and competitive financial system without any exclusion and supporting the government's general economic policies without prejudicing its other missions (BNR law 55/2007, article 5).

BNR conducts its monetary policy under the monetary targeting framework, with the broad monetary aggregate (M3) as the intermediate target and reserve money (RM) as the operating target. M3 is composed of currency in circulation out of the banking system, the demand and time deposits in Rwandan francs and deposits in foreign currencies. Reserve money is composed of currency in circulation out of the central bank and banks' deposits with the central bank.

Targets of reserve money are achieved using open market operations conducted through the sale and purchase of government securities and other short-term instruments using repurchase agreements (REPO) with commercial banks. Others monetary instruments used by BNR are reserve requirements and rediscount facilities.

BNR introduced indirect monetary policy instruments in 1995 after abandoning the use of quantitative ceilings on bank credit, selective credit controls and administrated interest rates and exchange rate used before the economic and financial liberalization introduced in 1990. Open market operations (OMOs) were introduced in September 1997 when BNR launched money market operations (short term liquidity sale/purchase through the auction system) with the objective of influencing monetary aggregates using indirect mechanism tools. The bank intervened once a week for a maturity duration of seven days to mop up or provide liquidity into the market.

Following external inflows from donors that the government benefited from after 2004 and high government absorption capacity of capital inflows from aid1 which created a permanent short-term excess liquidity in the banking system, BNR introduced an overnight facility at a fixed interest rate of 5 per cent as the floor of the corridor to

[1] The proper use of inflows from aid by the Government of Rwanda to finance development has translated into a high increase in BNR's sales of dollars to commercial banks which has contributed to reducing banking liquidity in the domestic currency. Another big portion of these inflows was externally sterilized and has not contributed to generate liquidity in the banking sector.

smoothen the extra liquidity prevailing within the week and the high volatility in reserve money. In August 2008, BNR introduced repurchase agreement operations (REPO) to provide banks with a new reference for efficient management of liquidity by setting the central bank rate at 8 per cent per annum. This rate has been changed by the monetary policy committee (MPC) to signal the central bank's monetary policy stance. The discount rate, defined as penalty rate, has been introduced and is defined as equal to the central bank's rate plus a margin set in accordance with the economic fundamentals.

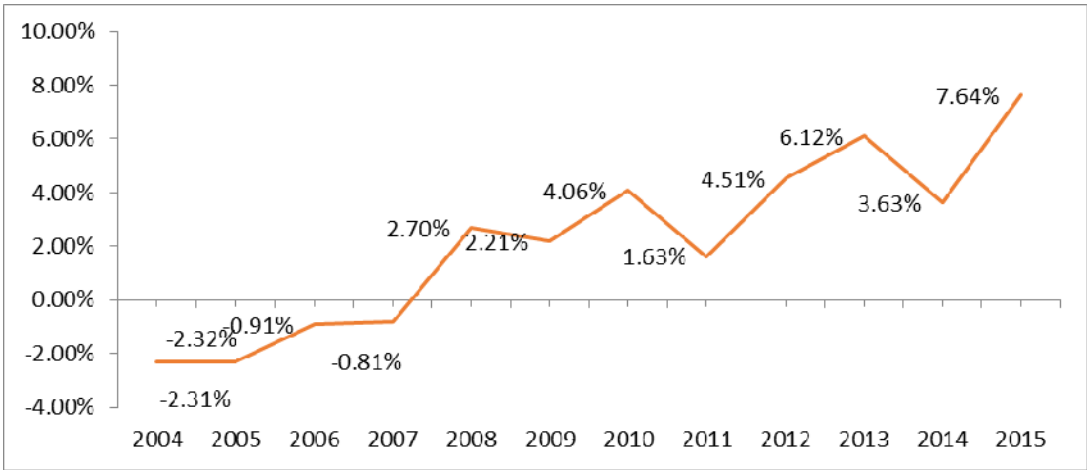
The reserve money program in Rwanda has been adjusted to introduce more flexibility in implementing the monetary policy. Prior to 2010, targets on reserve money were set using end period stocks which led to high fluctuations in money market rates as monetary policy actions were concentrated in programs' assessment periods, particularly end of quarters. To distribute policy actions over time, BNR adopted the average reserve money system in 2010. In a bid to improve monetary policy transmission mechanisms, increasing the effectiveness of its monetary policy and contributing to the development of the interbank market, BNR moved to a more flexible monetary targeting regime framework in October 2012 by introducing a reserve money band of plus or minus 2 per cent around a central reserve money target.

BNR also used its regular intervention in the foreign exchange market selling US dollars to commercial banks as a tool for managing banking liquidity. As a result, the Rwandan franc (Raff) was very stable between 2004 and 2012. However, after an aid cut in 2012 and a significant decline in export earnings due to poor global economic conditions, Rwf depreciated significantly by 7.6 per cent in 2015 and 9.8 per cent in 2016. This contributed to an increase in the exchange rate pass-through to domestic prices in Rwanda (Figure 1).

BNR adopted the reserve requirement system in 1990 as a measure to protect depositors before using it as a tool of liquidity management in 1995 and improving the banking regulatory framework to ensure the stability of the banking sector. The development of the money market created in 1997 and low inflation rates have allowed BNR to progressively reduce the reserve requirement ratio since May 1995 to 12 per cent in 1997, 10 per cent in 1998, 8 per cent in 2000 and 5 per cent since the first quarter of 2009.

BNR conducts its monetary policy with very limited fiscal dominance. Fiscal dominance refers to a situation where fiscal policies exert more power than the monetary policy over the macro-economy, in particular in the determination of inflation. One mechanism by which fiscal policy affects prices is if the government chooses to finance its expenditure by borrowing excessively from the central bank. By law, BNR is prohibited to grant direct advances or other loans to the State before it is approved by law.

Figure 1: The Rwf exchange rate's development



Source: BNR (2015).

The only facility that BNR provides to the treasury is overdraft to ensure the smooth functioning of the state treasury considering the gap that could occur between public revenue and public expenditure. The debit balance of the current account of the treasury cannot exceed 11 per cent of the state's current revenue collected during the previous financial year (BNR, 1997). To ensure BNR's independence in the choice and use of its monetary policy instruments, a treasure management committee was created and is composed of staff members from BNR and the Ministry of Finance and Economic Planning. The main mandate of the committee is discussing government plans of issuing its securities in the domestic market to ensure that the issuance is in line with liquidity forecasts provided by BNR.

3.3 The financial system's development in Rwanda

The Rwandan financial system has undergone significant reforms since 1995 with the adoption of market based mechanisms, coupled with financial sector liberalization and economic reforms. For instance, lending rates and deposit rates are determined freely by the market and credit is no longer rationed by the government. The capital account was fully liberalized in 2009 and the exchange rate regime shifted from a fixed to a progressively more flexible regime.

The financial sector in Rwanda is dominated by the banking sector composed of 17 commercial banks (up from five banks before 1994) and the banking sector has significantly extended its network across the country by opening bank branches and agents' banking.

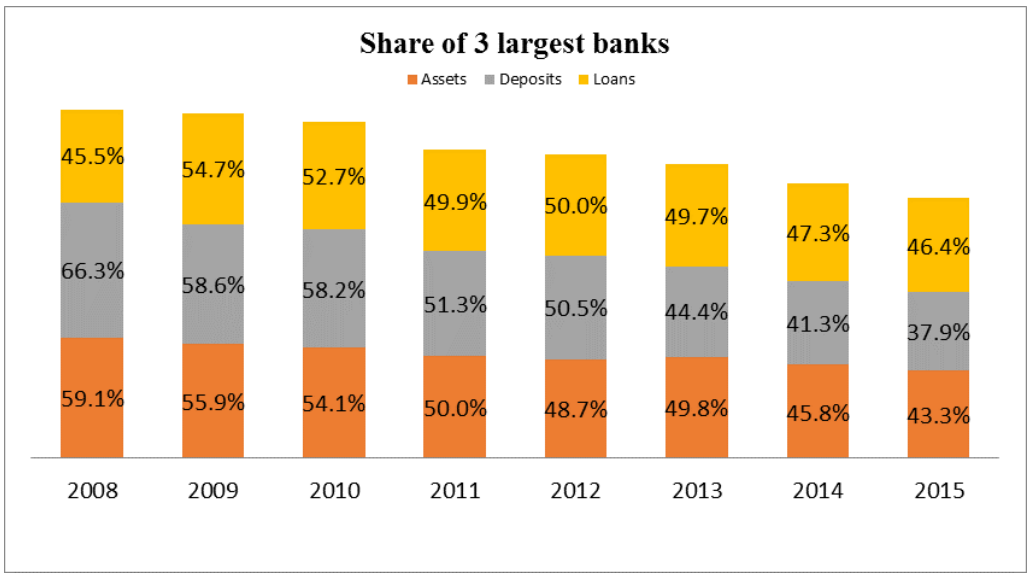
These reforms have generated positive results in many important respects including in particular, a rapid expansion of the banking system (financial deepening) and an even faster expansion of bank lending to the private sector. The ratio of broad money (M3) to GDP rose from 17.1 per cent in 2004 to 24.1 per cent in 2019. Over the same period, the ratio of private sector credit to GDP increased from 10.9 per cent to 19.2 per cent while deposits as a percentage of GDP increased from 13.8 per cent to 21.2 per cent (Table 2).

Table 2: Development in financial development indicators

	2004	2005	2006	2007	2008	2009	2010
M3/GDP	17.1	17.1	18.5	20.3	17.5	17.2	18.3
CPS/GDP	10.9	11.5	12.1	12.4	12.8	11.7	11.8
Depos/GDP	13.8	13.8	15.4	17.3	14.5	14.6	15.6
	2011	2012	2013	2014	2015	2016	
M3/GDP	20.0	19.8	20.9	22.4	24.9	24.1	
CPS/GDP	13.0	15.2	15.4	16.6	19.8	19.2	
Depos/GDP	17.4	17.4	18.5	20.2	22.5	21.9	

Source: Calculated based on monetary survey data and GDP published by NISR.

Figure 2: Development in banking concentration in Rwanda

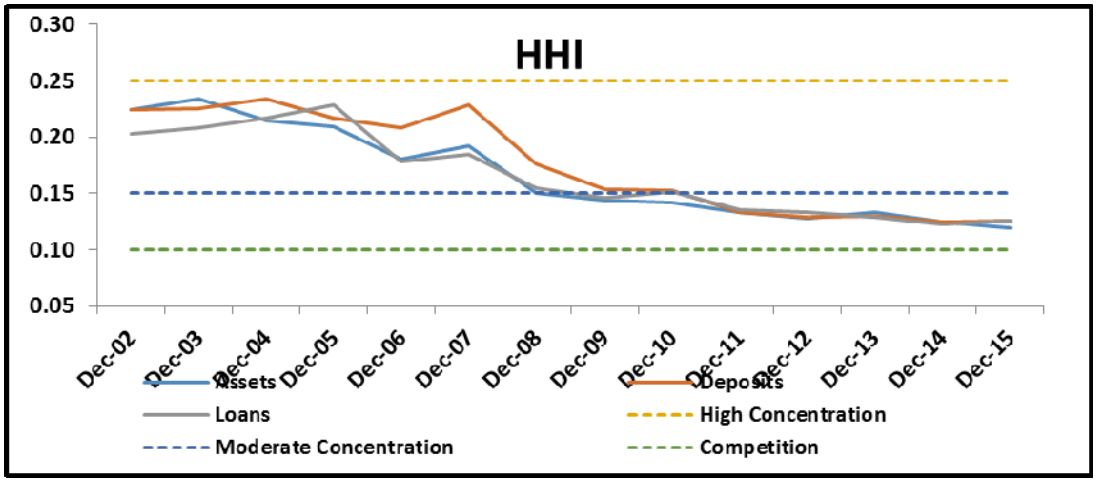


Source: BNR, Financial Stability Directorate (2015).

In addition, concentration in the banking sector has been decreasing over time showing an improvement in the banking sector's competitiveness. The share of the three biggest banks in loan and deposit markets has been declining over time from 54.7 per cent and 58.6 per cent in 2009 to 46.4 per cent and 37.9 per cent in 2015. The share of the three biggest banks in total assets of the banking sector also declined from 55.9 per cent to 43.3 per cent in the same period (Figure 2).

The Herfindahl index (HI), generally used to assess structural changes in an industry has been reducing over time from high concentration between 2002-10 to moderate concentration since 2011 in loan and deposit markets and also for banks' assets (Figure 3).

Figure 3: Herfindahl index's development in the Rwandan banking sector



Source: BNR, Financial Stability Directorate (2015).

In addition, the introduction of digital financial services in 2010 such as mobile payments, mobile banking and internet banking contributed to expanding financial services between 2012 and 2016. According to a FINSCOP survey 2015, the use of digital financial services boosted access to formal non-bank financial services to 42 per cent in 2015 from only 19 per cent in 2012, with 74 per cent of the adults in Rwanda (2.8 million) using mobile money in 2015.

Despite these positive developments in the banking industry, the sector has been characterized by persistent short-term liquidity as the financial market in Rwanda is not yet well developed and there is a need for liquidity as generated by the extension of banks' networks across the country. High excess liquidity in the banking industry in Rwanda has limited BNR's policy rate to opportunity cost of holding liquidity by banks instead of reflecting the margin costs of funding. In addition, the size of the formal financial sector in Rwanda remains small as shown by key indicators of financial sector development. Thus, effects of monetary actions on aggregate demand are limited.

4. Methodology

We first analyze the interest rate pass-through and exchange rate pass-through in Rwanda before discussing monetary transmission mechanisms using the VAR model.

Interest rate pass-through

An assessment of interest rate pass-through is generally based on a marginal pricing model which considers that a bank set an interest rate equal to the marginal cost of funding approximated by a market interest rate and a constant mark-up (see for example Borio, 1997; De Bondt, 2002; Tieman, 2004).

(1) $$i_t^m = \alpha + \beta i_t^p + \varepsilon_t$$

Where β is the pass-through parameter.

Under perfect competition and complete information =1. It is less than 1 if the markets are imperfect and in the presence of asymmetric information.

The degree of pass-through highly depends on the level of the demand for deposit and loan elasticities to the deposit and lending rates respectively in such a way that elasticity less than 1 results in an incomplete pass-through. Different factors contribute to the lower level of demand elasticities including imperfect substitutions between bank deposits and other investment facilities with the same maturity like money market funds and T-bills on the one hand and between bank lending and other types of external finances like equity or bond markets on the other, high concentration of the banking sector which can lead to a monopolistic market and the cost of changing banks (see, for example, Tieman, 2004).

Equation 1 gives a long-term relationship between these variables and does not take into consideration the fact that in developing countries market rates will not react instantly to changes in the policy rate. In practice, there is a gradual adjustment of market rates to the new policy rates which is modeled by considering Equation 1 as the

long run relationship around which short term dynamics abound. This corresponds to error correction models (see, for example, Engle and Granger, 1987) linked to the cointegration concept:

(2) $$\Delta i^{m}{}_{t} = \gamma_1 + \gamma_2 \Delta i^{m}{}_{t-1} + \gamma_3 (i^{m}{}_{t-1} - \beta i^{p}{}_{t-1} - \alpha) + \nu_t$$

In such an ECM, the coefficient γ_3 indicates the speed of adjustment of short run dynamics to the long run equilibrium relationship. A high level of this coefficient indicates a faster market response to the policy rate.

Exchange rate pass-through

We assess the exchange rate pass-through using the structural VAR approach by defining the exchange rate pass-through as the impulse response of domestic prices to an exogenous exchange rate shock. The estimated basic SVAR is given as:

(3) $$\alpha_0 X_t = n_t + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \cdots + \alpha_p X_{t-p} + u_t$$

With X composed of the exchange rate and the price index in Rwanda.

VAR model

The specified VAR model describing the Rwandan economy is:

(4) $$H(L)Y_t = K(L)X_t + \varepsilon_t$$

With $VAR(\varepsilon_t) = \Lambda$

The corresponding reduced form is:

(5) $$Y_t = A(L)Y_{t-1} + B(L)Z_t + \mu_t$$

Where Y_t is a vector of endogenous variables and Z_t is a vector of exogenous variables. Y_t consists of constant GDP (y), price 2001, consumer price (p) index CPI, nominal effective exchange rate (e), monetary aggregates (or total credit) and short-term interest rates such as repo rates and T-bill rates. A(L) corresponds to matrices of coefficients to be estimated, with lag lengths determined by standard information criteria. The vector Z_t consists of exogenous variables used to control for changes in the global economy. We use international oil prices because the Rwandan economy does not have an impact on their determination. All data is expressed in natural logs, with the exception of interest rate. The estimation is conducted on quarterly data from 2000 Q1 to 2016 Q1.

We adopt the following order of endogenous variables:

(6) $$Y'_t = [y_t, p_t, m_t, i_t, e_t]$$

To characterize relationships between output, prices and policy related variables, we used the Augmented Dickey-Fuller (ADF). As in most VAR models of monetary transmission mechanisms, we did not perform an explicit analysis of the economy's long-run behavior because monetary transmission mechanisms are a short-run

phenomenon. Using the estimated VAR model, we can analyze short-term dynamics based on variance decomposition and impulse response over the short to medium term. By estimating the VAR in levels, we implicitly allow cointegration relationships in the data.

All data is from BNR except data on GDP which is from the National Institute of Statistics of Rwanda (NISR) and data on oil prices is from IMF's international statistics.

Based on the estimated VAR model we examined the effect of a one standard deviation shock to interest rates, monetary aggregates and the exchange rate on both output and prices. We also estimated the reduced form by computing the Cholesky factorization of the reduced form VAR covariance matrix. In this framework, it is assumed that in the order of variables in the VAR model (given by Equation 6) a variable has no immediate effects on the preceding variable.

The relation between the reduced form errors (μ) and structural disturbance (ε) can be presented as:

$$(7) \qquad \begin{bmatrix} \varepsilon_t^{\,y} \\ \varepsilon_t^{\,p} \\ \varepsilon_t^{\,m} \\ \varepsilon_t^{\,i} \\ \varepsilon_t^{\,e} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ e_{21} & 1 & 0 & 0 & 0 \\ e_{31} & e_{32} & 1 & 0 & 0 \\ e_{41} & e_{42} & e_{43} & 1 & 0 \\ e_{51} & e_{52} & e_{53} & e_{54} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{\,y} \\ \mu_t^{\,p} \\ \mu_t^{\,m} \\ \mu_t^{\,i} \\ \mu_t^{\,e} \end{bmatrix}$$

The number of lags to be included in the model is determined using information criteria such as the Akaike information criterion and the Schwartz criterion. To check the robustness of our results, we also used the generalized impulses (Pesaran and Shin, 1998) which is less restrictive than Cholesky's and is invariant to the ordering of variables in the VAR model:

$$(8) \qquad y_t = \left[y_t, p_t, r_t, e_t, m_t / cps_t \right]$$

5. Empirical evidence

As mentioned earlier, we first analyzed some aspects of monetary transmission mechanisms (MTMs) such as interest rate pass-through and exchange rate pass-through before using a VAR model.

Interest rate pass-through in Rwanda

Based on an assessment of specific features of the Rwandan financial system (low degree of monetization, under-developed financial markets) it was expected to have incomplete interest rate pass-through. We estimated the pass-through from money market rates (repo rates, the interbank rate and the T-bill rates with different maturities: 91, 182 and 364 days) to deposit and lending rates. First, we performed unit root tests on all the data series, using the standard augmented Dickey-Fuller test at the 5 per cent uncertainty level and found that all the used variables were integrated of order 1. The

results of the Engle-Granger cointegration test on a pair of series confirmed that deposit rates in Rwanda can be explained by policy rates to the same extent, with long run elasticity varying between 0.25 and 0.33 for all money markets.

The coefficient C(3) in ECM which measures the speed of the pass-through to deposit rates from money market rates was as expected negative and significant. It varied between -0.45 for repo rates to -0.8 for T-bills of 182 days. This is an indication on how fast deposit rates in Rwanda react to changes in money market rates. For the lending rate, the pass-through was not significant. Cointegration was found only between the lending rate and the repo rate and between the lending rate and interbank rate but all coefficients (short term and long term) were not significant.

These results might be due to more competition in the market for deposits as compared to loans. The share of the three largest banks in deposits significantly declined by 20.7 per cent from 58.6 per cent in 2009 to 37.9 per cent in 2015 while the share of loans declined only by 8.3 per cent in the same period from 54.7 per cent to 46.4 per cent (Table 3).

Table 3: Estimation of deposit rates on money market rates.

Long-term	Coefficient	R^2	DW	Short-term	Coefficient	R^2	DW
Repo rate	C(1) = 7.24 C(2) = 0.33*	0.37	1.2		C(1) = 0.01 C(2) = - 0.3 * C(3) = - 0.45*	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* C(3) = - 0.65*	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** C(3) = - 0.67*	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 C(3) = - 0.8*	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* C(3) = - 0.7	0.48	2.1

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

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

Source: Author's estimations.

Exchange rate pass-through in Rwanda

We assessed the exchange rate pass-through using the structural VAR approach as defined by Equation 3. As shown in Table 4, the degree of pass-through was computed as the elasticity of prices to the exchange rate's initial shock and was found to be 0.30 in the period running from the first quarter of 2006 to the last quarter of 2014. It increased to 0.43 when we extended the sample to include 2015 and the first quarter of 2016, when Rwf experienced the highest depreciation in its history. The result points to the existence of the exchange rate channel in Rwanda though the pass-through remains incomplete.

Table 4: Exchange rate pass-through in Rwanda

	2006Q1 -2014Q4			2006Q1 -2016Q1		
Period in quarters	Exchange rate initial shock	D(LCPI) Estimates	Degree of pass-through	Exchange rate initial shock	D(LCPI) Estimates	Degree of pass-through
A	B	C	D	E	F	G
1	2.350692		D= C/B	2.451123		G= F/E
2		0.322237	0.137081761		0.383004	0.156256540
3		0.429397	0.182668338		0.614316	0.250626346
4		0.518272	0.220476353		0.783062	0.319470708
5		0.713977	0.303730561		1.000188	0.408052962
6		0.717240	0.305118663		1.045897	0.426701149

Period	D(LCPI)	D(LNEER)
1	0.000000	2.350692
	(0.00000)	(0.28935)
2	0.322237	2.162124
	(0.33227)	(0.55218)
3	0.429397	1.639962
	(0.57527)	(0.66436)
4	0.518272	1.699195
	(0.72199)	(0.61832)
5	0.713977	1.690035
	(0.77023)	(0.64554)
6	0.717240	1.619743
	(0.75044)	(0.67246)
7	0.661235	1.516896
	(0.73135)	(0.64149)
8	0.636187	1.619904
	(0.70201)	(0.58273)
9	0.635242	1.704487
	(0.66847)	(0.57264)
10	0.606136	1.698092
	(0.64277)	(0.58823)

Period	D(LCPI)	D(LNEER)
1	0.000000	2.451123
	(0.00000)	(0.28116)
2	0.383004	2.597868
	(0.30000)	(0.56218)
3	0.614316	2.179956
	(0.51459)	(0.71699)
4	0.783062	1.976343
	(0.66123)	(0.70014)
5	1.000188	1.857784
	(0.72995)	(0.66121)
6	1.045897	1.805769
	(0.73294)	(0.65293)
7	1.021953	1.744996
	(0.72127)	(0.63498)
8	0.981053	1.820001
	(0.70119)	(0.60019)
9	0.948757	1.902917
	(0.67763)	(0.59200)
10	0.905869	1.931718
	(0.65606)	(0.60311)

VAR model analysis

Before estimating the VAR model, we tested for unit root in all series using ADF tests. The results of the ADF tests suggest that all series were integrated of order 1 in levels, that is, they were I(1) (Table 1, Appendix A). As in most VAR models of monetary transmission mechanisms, we did not perform an explicit analysis of the economy's long-run behavior because monetary transmission mechanisms are a short-run phenomenon. Using the estimated VAR, we can analyze short-term dynamics based on

variance decomposition and impulse response over the short to medium term (Favero, 2001). Descriptive statistics of the data is reported in Table 5.

Table 5: Descriptive statistics

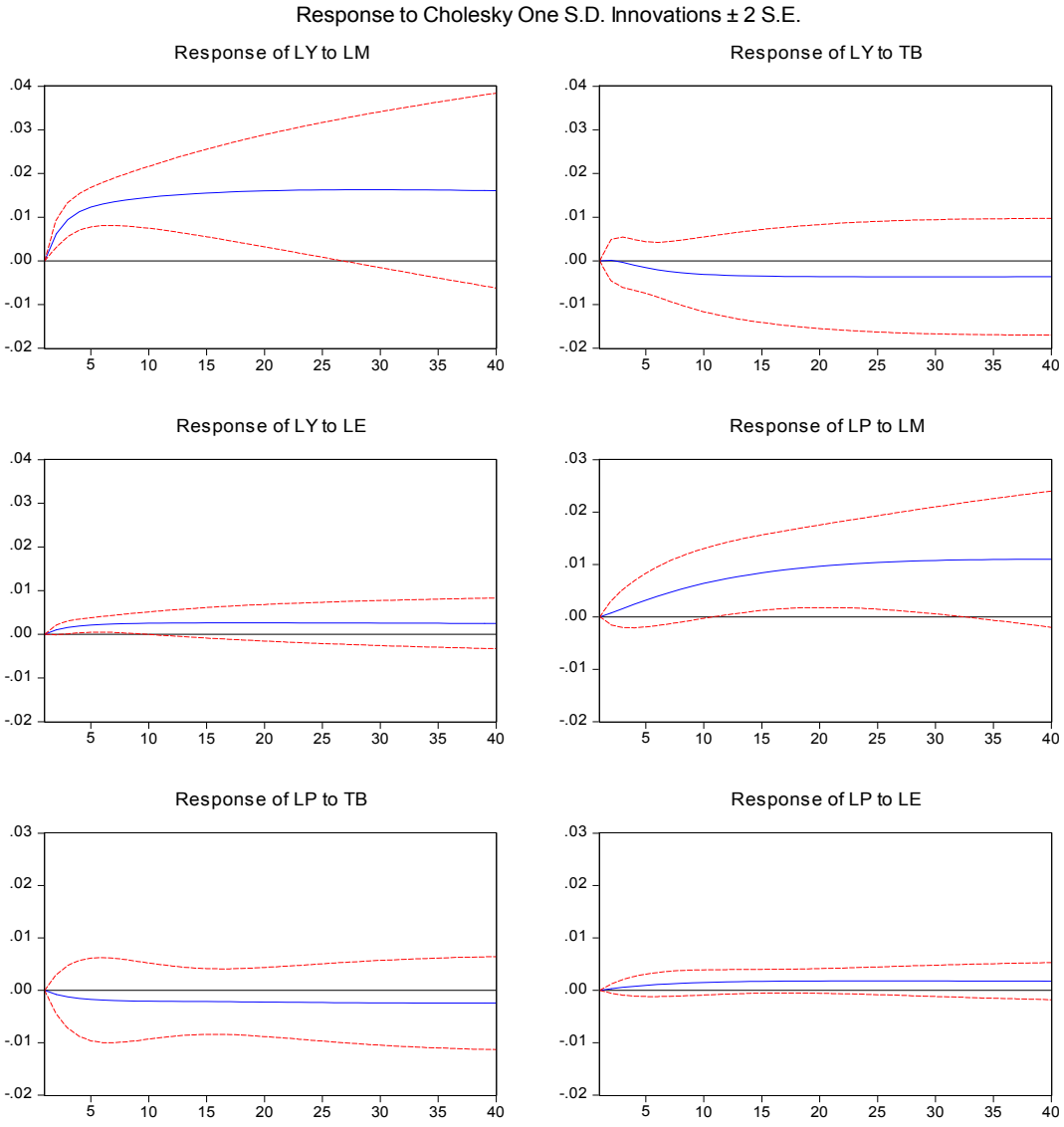
	LY	LP	LM	TB	LE
Mean	6.599806	4.199976	5.929448	8.618462	6.333081
Median	6.609349	4.223910	6.041444	8.700000	6.341593
Maximum	7.175490	4.657763	7.306397	12.80000	6.631475
Minimum	5.973810	3.637586	4.633758	4.000000	5.897429
Std. Dev.	0.359192	0.351422	0.828475	2.208994	0.152020
Observations	65	65	65	65	65

Lag length criteria indicate the use of 1 lag (Table 1, Appendix B) when the VAR is stable (Table 2 in Appendix B). The residual diagnostic tests in Tables 3 and 4 in Appendix B suggest well-behaved residuals. In summary, the analysis for modeling the data suggests that the VARs were empirically well behaved and with good residual diagnostics.

Figure 4 gives the impulse response functions indicating the impact of policy-related variables on output and prices, with the dotted lines representing 95 per cent confidence intervals. The results indicate that a 1 standard deviation shock to T-bill rates is associated with a drop in output and inflation. While the shape of the response function is consistent with the findings of different studies, the effect in Rwanda is not statistically significant. In addition, the results also indicate that the exchange channel is not active.

A shock to M3 appears to have a very rapid, significant and persistent effect on output which peaks after around 5 quarters. This is consistent with the real effects of monetary aggregates found in different studies in emerging and developing economies. In Rwanda it may be a reflection of the increasing monetization of the economy that took place over the period under review. This result indicates that changes in M3 resulting from changes in the monetary policy stance have an impact on output and inflation.

Figure 4. Impulse Response to One SD Innovations (± 2 S.E.)



In recent years Rwf has depreciated significantly leading to an increase in the exchange rate pass-through to domestic prices. In addition, significant changes were introduced in the reserve money program in Rwanda in 2010 and digital financial services were introduced in 2010 which also contributed to expanding financial services between 2012 and 2016. We estimated the impulse response function in the sub-sample starting with the first quarter of 2010 to analyze if those changes had an impact on monetary transmission mechanisms in Rwanda. Figure 5 shows that shock on monetary aggregates had an impact on both GDP and prices. In addition, prices and output reacted to changes in the nominal effective exchange rate, indicating that the exchange rate channel has been strengthening in recent years. Figure 6 shows impulse response to one SD innovations using credit to the private sector.

Figure 5. Impulse Response to One SD Innovations (± 2 S.E.)

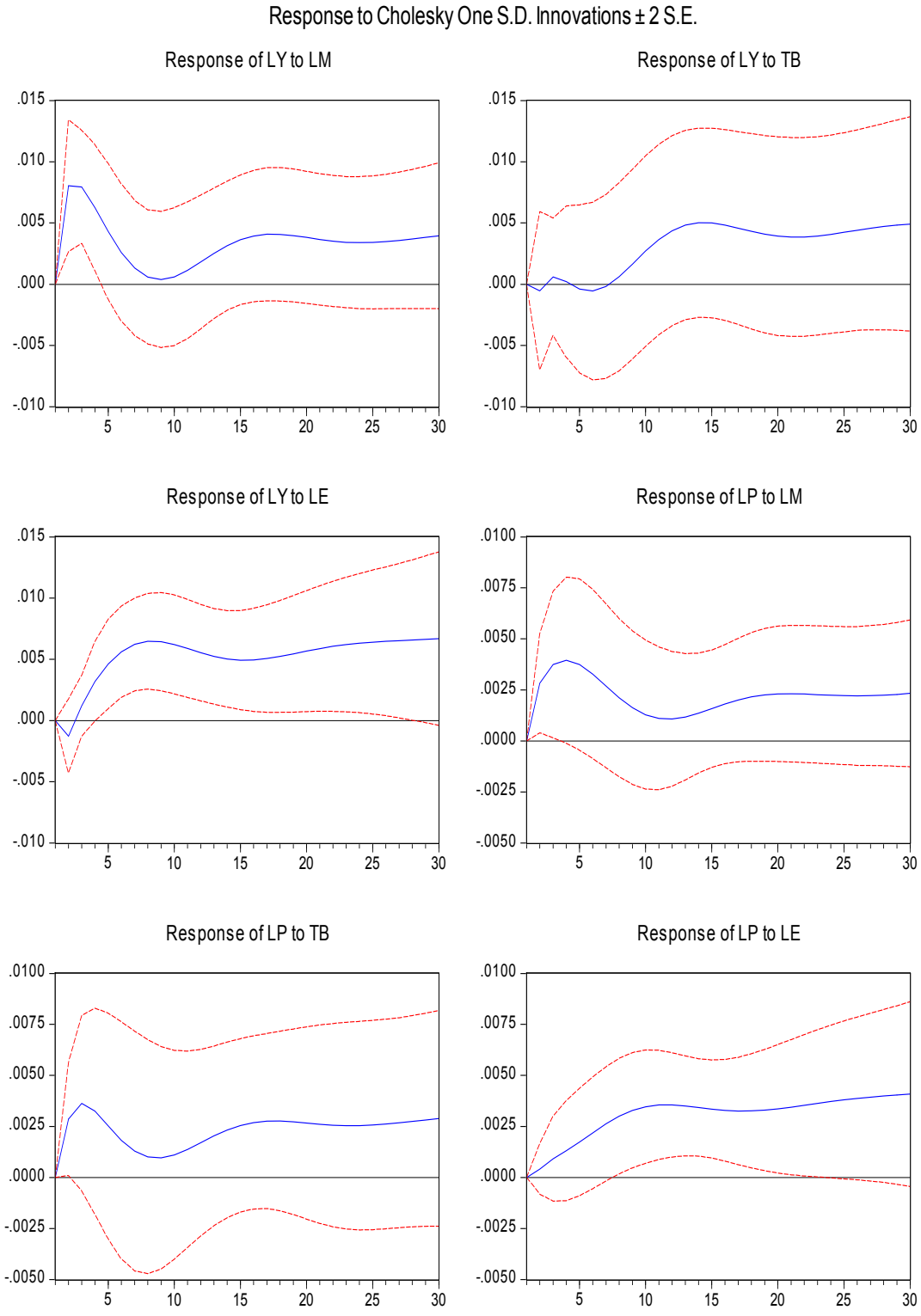
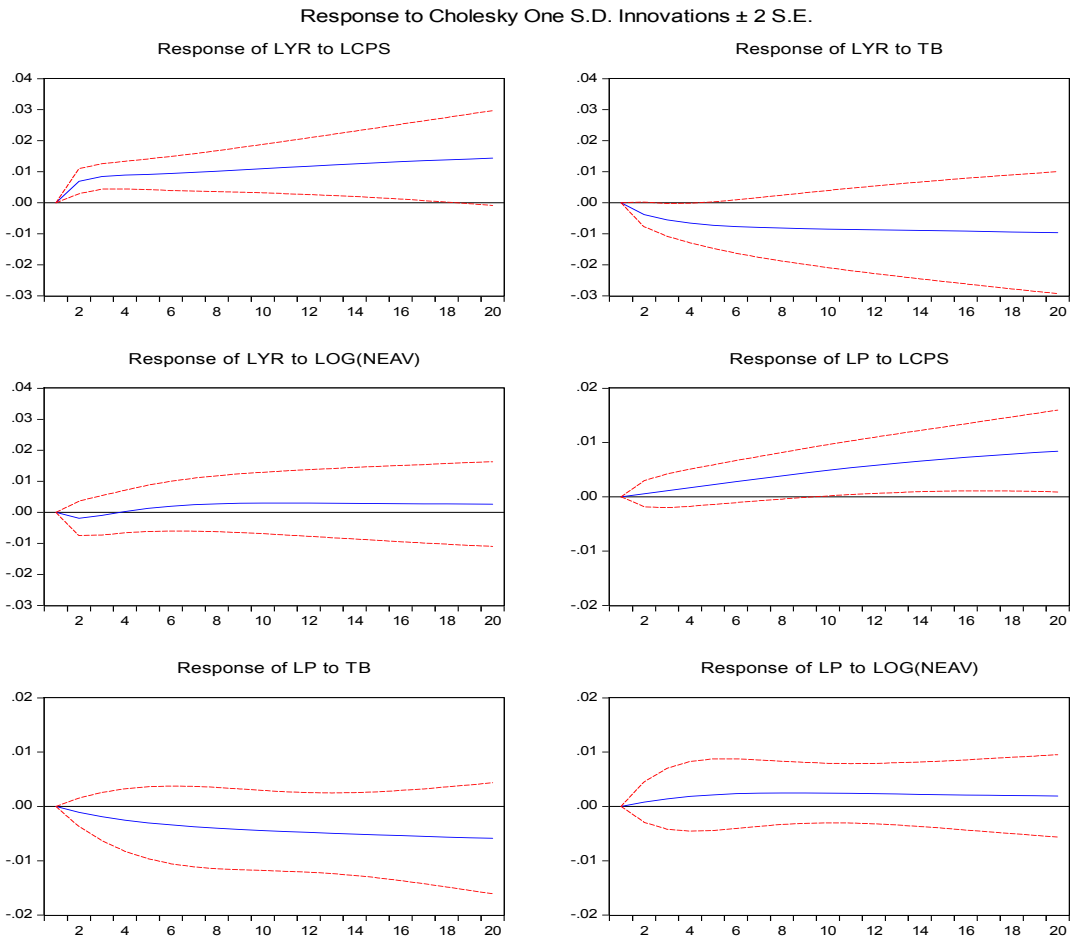


Figure 6. Impulse Response to one SD Innovations (± 2 S.E.) using credit to the private sector



6. Conclusion and policy recommendations

The objective of this paper was to assess monetary transmission mechanisms in Rwanda. We first analyzed their key determinants in Rwanda including BNR's monetary policy framework and conditions under which financial intermediation is conducted, the independence of the central bank and level of development of the financial system.

BNR is an independent central bank not allowed to grant direct advances or other loans to the state. To ensure BNR's independence a treasure management committee was created which had the mandate to ensure that the issuance of government securities was in line with liquidity forecasts provided by BNR. In terms of monetary policy, the current reserve money program in Rwanda was adjusted to introduce more flexibility in the implementation of the monetary policy. The main changes included the adoption of the average reserve money system in 2010 and the introduction of a reserve money band in 2012.

In addition, important developments were noted in the financial sector such as the entry of regional banks in the Rwandan banking sector, extension of the banking network

across the country and the introduction of new financial products like mobile payments and mobile and internet banking which significantly contributed to expanding financial services between 2012 and 2016. As a result, the concentration in the banking sector has been decreasing over time; this is also indicated by the increase in the shares of the three largest banks in loans, deposits and total shares as well as the Herfindahl index developed for the Rwandan banking sector.

However, despite these good developments, the banking sector continues to show persistent short-term liquidity mainly due to the not yet well-developed financial market, particularly the interbank market and the market for government securities. In addition, these developments have not contributed much to increasing the size of the formal financial sector in Rwanda. This explains why the interest rate pass-through to lending rate is very low. However, the results indicate a significant pass-through to deposit rates with corresponding coefficients ranging between -0.45 for repo rates and -0.8 for treasury bills of 182 days.

Weak pass-through to the lending rate is also due to limited substitution between bank lending and equity and other debt securities as the capital market in Rwanda is very nascent. Total investments in T-bills and bonds in Rwanda represented 5.5 per cent of GDP in 2015 up from 3.4 per cent in 2013. These results clearly indicate that the interest rate channel in Rwanda is not working properly and that the impact of monetary policy actions on the cost of banking loans is also very low. If the bank lending channel exists, it works through the impact of monetary policy actions on the availability (amount) of bank loans.

The exchange rate channel was weak till recently. Following increased external inflows, BNR regularly intervened in the FX market selling US dollars to commercial banks. This contributed to the stability of the Rwandan franc between 2004 and 2012. However, after the aid cut in 2012, there was a significant decline in export earnings due to poor global economic conditions and the introduction of more flexibility in the exchange rate framework and Rwf depreciated significantly by 7.6 per cent in 2015 and 9.8 per cent in 2016. This development contributed to the strengthening of the exchange rate channel.

Results from an estimation of impulse response functions confirm that the interest rate channel in Rwanda is weak with a one standard deviation shock to the T-bill rates (used as an indicator of monetary policy actions) associated with a drop in output and inflation. While the shape of the response function is consistent with the findings of different studies, this effect is not statistically significant in Rwanda. In addition, the results also indicate that the exchange rate channel is weak, but it has been improving in recent years.

There is clear evidence that the monetary aggregates channel is active in Rwanda. A shock to M3 (or changes in the available amount of credit), as a result of BNR's actions, appears to have a very rapid, significant and persistent effect on output which peaks after around 5 quarters. This may be may be a reflection of the increasing monetization of the Rwandan economy that has taken place over the period under review. The effect of a shock to M3 on prices is positive and significant but appears late, after more than two years. In recent years, Rwanda has experienced rapid money growth while inflation has remained relatively low. We estimated the impulse response function in the sub-sample starting in Q1 2010 to analyze if different changes

introduced in the financial sector in Rwanda and developments in the foreign exchange market had an impact on monetary transmission mechanisms. Our results show that not only did a shock in monetary aggregates have an impact on both GDP and prices but prices and output also reacted to changes in the nominal effective exchange rate.

As a policy recommendation, to ensure a smooth transition to the use of interest rate as the operating objective by 2018, BNR and other stakeholders will need to support the current trends in the development of financial markets to increase the: (i) substitution between bank deposits and T-bills by increasing the participation of households and non-bank institutional investors in treasury bills of different maturities; (ii) substitution between bank lending and other types of external finance like equity or bond markets by developing capital markets (both primary and secondary markets); (iii) increase competition in the banking sector not only by reducing concentration but also by diversifying financial products in the sector; (iv) extend the formal financial sector by helping banks to extend loans to key economic sectors which remain less financed by the banking sector such as the agriculture sector; and (v) allow more flexibility in the exchange rate policy.

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1. Appendix A

Table 1: Unit root tests

	Level		First differences	
Variables	Lag	ADF	ADF	Conclusion
Y	1	-2.74	-2.88***	I(1)
P	1	-2.64	-4.89*	I(1)
$M3^2$	0	-1.80	-10.3*	I(1)
T-bill rates	0	-2.90	-7.45*	I(1)
Repo rates	0	-0.96	-7.90	I(1)
Deposit rate	0	-0.32	-7.90	I(1)
Lending rates	2	-0.06	-8.01	I(1)
E	1	-2.06	-3.08**	I(1)
Cps	0	-2.97	-9.03*	I(1)

*: significant a 1%; **: significant at 5% and ***: significant at 10%.

Appendix B

Table 1: VAR Lag Order Selection Criteria
Endogenous variables: lry lp lm tb
Exogenous variables: C OIL

Lag	LogL	LR	FPE	AIC	SC	HQ
0	126.1943	NA	1.52e-09	-6.115488	-5.684544	-5.962162
1	290.5240	268.1170	1.01e-12	-13.44863	-11.94033*	-12.91199
2	327.9223	51.17653*	5.78e-13*	-14.10117*	-11.51551	-13.18121*
3	350.7444	25.22443	8.15e-13	-13.98655	-10.32352	-12.68327

Table 2: Roots of Characteristic Polynomial
Endogenous variables: lry lp lm tb lne
Exogenous variables: C OIL

Root	Modulus
0.983234	0.983234
0.869303	0.869303
0.634919 - 0.037241i	0.636010
0.634919 + 0.037241i	0.636010
-0.070706	0.070706

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table 3: VAR Residual Heteroskedasticity Tests:

Joint test:		
Chi-sq	df	Prob.
182.2901	180	0.4383

Tab 4: VAR Residual Normality Tests
Orthogonalization: Residual Correlation (Doornik-Hansen)
Null Hypothesis: residuals are multivariate normal

Component	Jarque-Bera	df	Prob.
1	1.072675	2	0.5849
2	0.669157	2	0.7156
3	1.268359	2	0.5304
4	10.72069	2	0.0047
5	1.410507	2	0.4940
Joint	15.14139	10	0.1270

Table 5: Variance decomposition

GDP Period	S.E.	LOG(RY)	LOG(CPI)	LOG(M3)	TB52	LOG(NE1)
1	0.025521	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.037670	56.26283	14.25988	28.66367	0.325971	0.487646
3	0.045957	46.31827	15.27432	37.58089	0.220103	0.606404
4	0.052994	41.63202	14.25481	43.17826	0.175998	0.758909
5	0.059276	39.11747	12.65157	47.13083	0.154607	0.945525
6	0.065079	37.62918	11.00417	50.08731	0.134685	1.144655
7	0.070554	36.67955	9.522879	52.34811	0.115112	1.334345
8	0.075783	36.02907	8.279474	54.09010	0.101204	1.500148
9	0.080814	35.55147	7.281413	55.43369	0.097845	1.635580
10	0.085669	35.17742	6.507242	56.46786	0.107476	1.740007
Price Period	S.E.	LOG(RY)	LOG(CPI)	LOG(M3)	TB52	LOG(NE1)
1	0.014483	2.958831	97.04117	0.000000	0.000000	0.000000
2	0.020708	1.887186	95.67815	1.947113	0.487404	0.000150
3	0.024662	1.926598	93.27041	3.438881	1.357493	0.006621
4	0.027508	2.314643	90.30165	5.147461	2.174418	0.061825
5	0.029679	2.961453	86.93502	7.111209	2.801310	0.191011
6	0.031427	3.824868	83.25380	9.323492	3.209899	0.387940
7	0.032914	4.865908	79.34036	11.74268	3.422146	0.628906
8	0.034248	6.040020	75.28845	14.30575	3.479304	0.886479
9	0.035496	7.299182	71.19762	16.93962	3.426166	1.137409
10	0.036704	8.596513	67.16300	19.57175	3.303108	1.365628