BNR Economic Review, Volume 20(2).

Interest rate pass-through in Rwanda

John Musekera *

Mathias Karangwa †

Thierry M. Kalisa ‡

Hoziane Amen §

October, 2023

Abstract

This paper aims to assess whether there has been an improvement in the interest rate pass-through in Rwanda following the adoption of a price-based monetary policy framework since January 2019, bearing in mind recent financial sector developments and improvements in monetary policy formulation and implementation. Empirical estimations based on the entire estimation sample[1] show that there is incomplete but statistically significant long-run pass-through from the interbank rate, the repo rate, and the 13-week and 26-week T-bills rates to the deposit rates of 1, 2, 6, and 12 months, respectively. The estimations of the pass-through from policy rates to the lending rates are generally counter-intuitive, suggesting that the former are driven by other structural issues in the loan market, especially the banks' high-cost structure and the loan market power. Our empirical estimations also show that the interest rate pass-through from various proxies of policy rates to the market rates has generally declined since January 2019 (Appendix B & table 5) compared to the sample before, and this can be attributed to the fact that the sample is still small yet the recent period has also been affected by shocks, notably COVID-19, the Russia-Ukraine war and domestic weather shocks. The main policy recommendation is that existing initiatives should be strengthened and new ones developed to help improve the Monetary Policy Transmission Mechanism.

Keywords: Interest rate channel, Transmission mechanism, Monetary policy.

JEL Classification: E52, L14.

*Economist, Research Department, National Bank of Rwanda.

†Director, Research Department, National Bank of Rwanda.

‡Chief Economist and Executive Director, MPRD, National Bank of Rwanda.

§Senior Economist, Chief Economist's Office, National Bank of Rwanda.

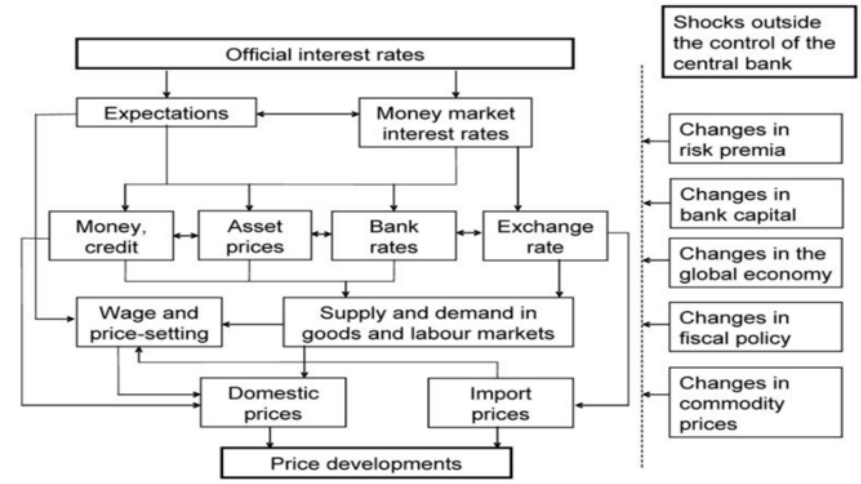
[1]Estimation samples for the pass-through to other interest rates from: the Repo rate (January 2008 - June 2022); CBR (January 2005 - June 2022); Interbank (January 2004 - June 2022); 4, 13 and 26 weeks T-bills rates (January 2004 - June 2022); 52-week T-bills (January 2005 - June 2022); Weighted T-bills rate (January 2008 - June 2022).

1 Introduction

Generally, the main objective of central banks while conducting monetary policy is to be able to affect aggregate demand in an economy and, hence, inflation. This is achieved when the Monetary Policy Transmission Mechanism (MPTM) is efficient. An efficient MPTM occurs when the actions of monetary authorities affect liquidity conditions, which in turn affects economic agents' aggregate consumption and investment decisions. Thus, the MPTM explains how monetary policy actions affect aggregate demand, economic activities, and the general price level. The speed and magnitude with which monetary policy actions affect the output and inflation often vary from country to country depending on factors such as financial sector development and the degree of formalization of the economy.

The effectiveness of monetary policy, therefore, has two stages. The first stage is the "interest rate pass-through", which is about how changes in the CBR affect other interest rates in the economy. The second stage is how the real economy (i.e. aggregate demand and inflation) are affected due to monetary policy actions. Due to the first stage, there are changes in liquidity conditions in the economy, leading to changes in consumption and investment decisions, ultimately affecting aggregate demand and inflation. These two stages constitute what is known in the literature as the interest rate channel of monetary policy, which explains how changes in an economy's interest rates affect both aggregate demand and inflation via their effect on the demand for credit and available income of borrowers and lenders.

These two stages constitute what is known in the literature as the interest rate channel of monetary policy, which explains how changes in an economy's interest rates affect both aggregate demand and inflation via their effect on the demand for credit and available income of borrowers and lenders. Other channels of MPTM include the asset price channel, exchange rate channel, and bank lending channel, whose discussion is beyond the scope of this study. The MPTM channels are broadly summarized in Figure 1. This study examines how effective the interest rate channel in Rwanda is by focusing on the interest rate pass-through.



Source: European Central Bank

Figure 1: Channels of Monetary Policy Transmission

Focusing on the interest rate pass-through, theoretical literature shows that the stickiness of interest rates is generally explained by four theories, namely: agency costs (Stiglitz & Weiss, 1981), adjustment costs (Cottarelli & Kourelis, 1994), switching costs (Klemperer, 1987), and risk sharing (Fried & Howitt, 1980). Additionally, most theoretical and empirical works have concluded that the interest rate pass-through is generally influenced by financial sector development, the degree of competition in the banking system, the level of operating costs incurred by banks and general macroeconomic stability (i.e., exchange rate and inflation stability).

The main objective of this paper is to assess the MPTM in Rwanda, focusing on the interest rate channel and providing policy recommendations. The current study builds on Kigabo (2021) and extends the sample until June 2022. While Kigabo (2021) captured some changes related to an interest rate-based monetary policy framework, such as improved daily liquidity management by the Financial Markets Operations Committee (FMOC) guided by enhanced liquidity forecasting, this study captures recent changes, such as the downward revision of the corridor within which the interbank rate fluctuates (from CBR $\pm 2\%$ to CBR $\pm 1\%$since July 2020) since July 2020), takes into account the lags in the transmission mechanism, the challenges emanating from recent shocks (COVID-19 and Russia-Ukraine war), and partially the effect

of a prolonged tightening cycle since February 2022.

The main mandate of the National Bank of Rwanda is to maintain price stability and, hence, contribute to overall sustainable macroeconomic stability. For a period of two decades, ending in December 2018, the NBR conducted its monetary policy under the money-targeting framework. However, the NBR adopted a price-based monetary policy regime in January 2019. Under this new regime, the NBR sets its Central Bank Rate (CBR) so as to affect the interbank rate and other short-term interest rates in the economy. It is believed that the MPTM improves when the interbank is close to the CBR as this will affect the liquidity position of banks and hence lead to the desired changes in other interest rates, especially deposit and lending rates (Kigabo, 2021). Specifically, this paper re-estimates the magnitude of the interest rate pass-through and compares the findings with recent empirical studies on Rwanda to see if there have been improvements.

After the introduction, covered in section one, the rest of the paper is organized as follows: section two gives an overview of monetary policy in Rwanda, section three covers the theoretical and empirical literature, section four explains the methodology used in this paper, section five focuses on the discussion of both descriptive and empirical results, while section six gives the conclusion and policy recommendations.

2 Literature Review

2.1 Theoretical literature

In this chapter, we review both empirical and theoretical literature regarding the factors that can make the interest rate pass-through either complete or incomplete, drawing on cross-country findings. Most empirical work on the interest rate pass-through focuses on estimating the degree and speed of adjustment of the retail rates following changes in the official rate. The general consensus from these studies is that the interest rate pass-through is incomplete, especially in developing countries (De Bondt, 2002) where a non-competitive banking sector may not fully pass through or may delay the transmission of the changes in the monetary policy rate to borrowers. While the interest rate pass-through tends to be low in the short run, it progressively increases in the long-run toward complete pass-through. The incomplete pass-through from the policy

rate to the lending rate may be due to the stickiness of the latter.

The stickiness in lending rates has generally been explained by four theories: agency costs (Stiglitz & Weiss, 1981), adjustment costs (Cottarelli & Kourelis, 1994), switching costs (Klemperer, 1987), and risk sharing (Fried & Howitt, 1980). Cottarelli and Kourelis (1994) argue that the structure of the financial system influences the stickiness of interest rates. More specifically, the presence of barriers to entry in the banking sector hinders competition among banks and negatively affects the adjustment of interest rates to a change in the policy rate. Similarly, Mojon (2000) argued that competition among banks significantly improves the interest rate pass-through. Borio and Fritz (1995) also suggest that under a perfectly competitive loan market, the interest rate pass-through would be complete, contrary to monopolistic and oligopolistic markets where the degree of interest rate pass-through would be much smaller. Collectively, all these papers agree that the degree of competition affects the level and speed of adjustment of interest rates to a change in the policy rate.

According to (Saborowski & Weber, 2013), financial development plays a significant influence on interest rate transmission, with the development of the money market for short-term instruments like certificates of deposits (CDs) and Treasury bills playing a huge role in the flexibility of lending rates (Cottarelli & Kourelis, 1994). On the contrary, banks' operating costs impede the interest rate mechanism, as suggested by Mojon (2000). He argues that the higher the staff costs, the smaller the degree of pass-through in setting credit rates. Likewise, (Sorensen, 2006) find a negative relationship between bank funding costs and the pass-through. Sorensen (2006) discuss the negative relationship observed between excess liquidity/excess capital and the pass-through. They argue that excess liquidity or capital can serve as a buffer against market variations, leading to a slow and small level of interest rate adjustments. Contrary to credit risk, they found that the more loans the banks give, the faster the adjustment. This implies that in a competitive environment, banks take more risk in giving out loans, making banks more vulnerable to changes in interest rates.

Medina, Carrión-Menéndez, and Frantischek (2011) attribute cross-country differences in interest rate pass-through on the exchange rate regime, with high pass-through expected for the case of flexible exchange rate regimes. Similar to Saborowski and Weber (2013), they argue that countries with a tight exchange rate regime can have a 40% long-run pass-through, lower than 60% for the countries with a flexible exchange rate regime. Another important determinant of the pass-through is the conduct of monetary policy. Borio

and Fritz (1995) capture this factor by analyzing the role of infrequently changed rates on official standing facilities, arguing that this serves as a signal about future interest rates or a policy change. They argue that the signal associated with a change in policy rates is very relevant to the speed and level of the pass-through. Mojon (2000) agrees that the conduct of monetary policy matters in determining the interest rate pass-through. The latter is measured using money market rates (MMR) volatility and inflation, and the MMR volatility is expected to have a negative impact on the pass-through, whereas the effect of inflation can have a positive impact.

2.2 Empirical literature

Empirical work around the interest rate pass-through has been growing over time, but the majority focuses on advanced economies. The results of these different studies have found that the level and speed of the adjustment of interest rates varies across countries and also depends on the type of interest rates used. Some studies go an extra step to analyze the presence of asymmetric adjustment.

Several studies on the adjustment of interest rates have been conducted for the Euro area. Kwapil and Scharler (2009) worked on the Euro area and the USA, using both the Engle-Granger cointegrating relationship and ARDL, using monthly data for the period of 1995 to 2003. They used the three-month money market rate as the policy rate and examined how this is transmitted to the various deposit and lending rates and to their respective weighted averages. They found that for the Euro area, the pass-through is incomplete but higher in the long-run than in the short run and that it is higher for lending rates than the deposit rates.

Hülsewig, Mayer, and Wollmershäuser (2009), studied the Euro area using quarterly data from 1999 to 2002, using the new Keynesian DSGE model. They used the nominal short-term Euro interbank offered rate (EURIBOR) as the policy rate and examined how this affects changes in the retail bank lending rates. Their main conclusion is that the pass-through is incomplete in the short run. Sudo and Teranishi (2008) conducted a study on 12 Euro countries, using an Error Correction Model (ECM) for a more recent period of 2003 to 2008 monthly frequency. They examined the degree of transmission of the ECB policy rate to the bank loan interest rates and found that the level of stickiness differs across countries but ranges from 0.2 to 0.8 in the short-run, leaving to conclude that the pass-through is incomplete.

For the USA, Neumark and Sharpe (1992) use Ordinary Least Squares (OLS), a partial adjustment model and a switching model of partial adjustment on monthly panel data from 1983 to 1987. The study covers 255 banks, and the results indicate that there is the presence of asymmetric adjustment, whereby banks adjust deposit rates downward quicker when above the equilibrium than upward when below the equilibrium. Similarly, Hannan and Berger (1991) using multinomial logit estimation on a sample from 1983 to 1986 found the presence of asymmetric adjustment. Deposit rates adjust faster when there is a decrease than an increase in the policy rate.

Various studies found a nearly complete pass-through in deposit rates in the USA and Asia. For example, Huang and Wang (2009)'s recent study on the USA and some Asian countries, using monthly data from 1988 to 2000 to estimate an asymmetric threshold cointegration model and an EC-EGARCH (1,1) model, found that both in the short and long-run the pass-through to deposit and lending rate is close to one. Comparatively, Kwapil and Scharler (2009) looking at monthly data from 1995 to early 2003, with the use of Engle-Granger cointegrating relationship and autoregressive distributed lag model (ARDL), found a nearly complete pass-through for deposit but not for lending rates, both in the short and long-run for the USA. Interestingly, they did not find the presence of asymmetric adjustment for the USA.

Cottarelli and Kourelis (1994) focused on 31 industrial and developing countries, using monthly data to measure the degree of lending rates stickiness by the use of simple dynamic models. In the first step, lending rates (prime, non-prime, and average rates) are regressed on lagged money market rates (T-bill rates or interbank rates) and discount rates. It is found that the degree of lending rate stickiness differs across countries, with some countries having close to one and others nearly zero. In the second step, they try to explain the differences in the degrees of stickiness across countries by regressing a cross-section of impact multipliers against a set of variables that indicate different features of the financial system. Five factors are found to be more relevant in reducing lending rates stickiness. A developed market for short-term monetary instruments, absence of constraints on capital movements, absence of bank competition constraints such as barriers to entry, private sector ownership of the banking sector, and stability in the money market rates.

Tieman (2004) conducts a study on transition economies, comparing Romania with other European economies, using monthly data from 1995 to 2004. His study looks at short and long-term deposit and lend-

ing rates and the central bank policy rate using the error correction model. He finds that the pass-through is slow and incomplete in all interest rates, but the pass-through is greater and faster for the deposit rates than lending rates.

A number of studies have empirically studied the magnitude of interest rate pass-through in developing countries, especially from the policy rate to the lending and deposit rates. For the case of South Africa, (De Angelis, Aziakpono, & Faure, 2005) study the pass-through using an Engle-Granger cointegration method and Error Correction model (ECM), while (Guisan et al., 2005) used mixed dynamic model, for a sample of monthly data March 1998 to September 2001 and from September 2001 to November 2004. For the policy rate, they use the repo rate and look at prime interbank rate, prime lending rate, and negotiable certificates of deposit (NCD) rate. They found that in the long-run the pass-through is nearly complete for all interest rates, but was higher during the first period during the first repo system. Likewise, Aziakpono and Wilson (2013, 2015) found that in the long-run the pass-through are very high and the speed is very fast. They use is EG cointegration and ECM and asymmetric ECM on monthly data from 1973 to 2004, but they use the repo rate instead of the policy rate.

Using bank-level quarterly data for the 2006Q2 -2016Q4 period, (Bennouna, 2019) showed that the pass-through from the policy rate to the different lending rates varied between 0.02 and 0.99 in Morocco. Using monthly data for the 2009-2015 period, the pass-through was estimated to be between 0.02 and 0.089 for the deposit rates and between 0.01 to 0.09 for the lending rates in Malawi (Chiumia & Palamuleni, 2019). For Mongolia, Doojav and Kalirajan (2016) estimated the pass-through to the lending rate to range between 0.1 and 0.9 and 0.73 to 0.77 for the deposit rates. High pass-through was estimated for the case of the Dominican Republic, standing between 0.94 and 2.66 for the lending rates and between 0.73 to 1.65 for the deposit rates (Andújar-Scheker, 2012; Escudero, Gonzalez-Rozada, & Sola, 2014).

Using the 7-day interbank rate as a policy rate for the case of Uganda, Apaa (2014) found that the pass-through to the lending rate stood at 0.43 for the entire, was insignificant before the adoption of the Inflation Targeting Light (ITL) framework and 0.3 in the sample after the adoption of the ITL. Generally, the pass-through to time deposits ranged between 0.56 and 0.6, whereas the interbank rate affected most interest rates in the post-ITL period, suggesting that the interest rate pass-through is more suitable for

inflation-targeting regimes. Generally, similar findings were obtained for the case of Kenya by Misati, Nyamongo, and Kamau (2011), who argued that there is incomplete pass-through from policy rates to other interest rates in both the short and the long-run.

For the case of Rwanda, Kigabo and Mwenese (2016) found that the pass-through was incomplete for deposit rates ranging between 0.14 and 0.45 in the long-run, whereas, in the short-run it is even smaller, standing at around 0.15. For lending rates, they found an even smaller degree of pass-through, standing at around 0.06. Similarly, Rutayisire (2017) estimates the pass-through using a transformed ADL model on monthly data from 2008 to 2016. He finds that the adjustment of deposit rates is very small and slow, and there is the presence of asymmetric adjustment. This implies that banks will adjust deposit rates downward faster than upward. Additionally, He confirms that the pass-through to lending rates is also incomplete both in the short and long-run.

Using monthly data for the 2016:1 – 2018:6 period, Kigabo and Kamanzi (2018) estimated the pass-through from the repo rate to the interbank rate at 0.04 in the short-run and 0.03 in the long-run. Using monthly data for the 2015:1 – 2018:8 period, the short-term and long-term pass-through from the interbank rate to the weighted deposit rate was estimated at 0.03 and 0.02, respectively. Similarly, it stood at 0.22 and 0.24 for the 1-month deposit rates and at 0.2 and 0.16 for the 12-month deposit rates. When a larger sample (monthly data, 2004:1-2018:6) is used, the pass-through from the T-bills rate (weighted average and all maturities) to the deposit rates (weighted average and all maturities) weakens, with long-run & short-run coefficients ranging between 0.01 and 0.1. Similar results are obtained when the 2008:1 – 2018:6 sample is used. In all the sub-samples, the pass-through from all proxies of the policy rate to the lending rate is counter-intuitive, with relationships mostly being negative and significant.

In a recent study, Kigabo (2021) analyses the pass-through: (1) from repo rates to money market rates (interbank rate, T-bills rates for all maturities and its weighted average); (2) from interbank rates to Treasury bill rates of different maturities; and (3) from money market rates to banking rates (deposit rates and lending rates) as well as the link between deposit rates and lending rates. Findings show that there is a complete long-run pass-through from the repo rate to the interbank rate and T-bills rates for 4, 13 and 26 weeks, respectively. In the short run, there is a significant, albeit low, pass-through from the repo rate to the interbank

rate (with a coefficient of 0.4) and the 13-week T-bills rate (with a coefficient of 0.28). The pass-through from the interbank rate to the treasury bills rates is quite high, ranging between 0.9 and 1.09, with complete pass-through to 4 and 13-week T-bills rates. The short-run pass-through from repo to T-bills rates is significant but quite weak, ranging between 0.32 and 0.5. Lastly, there is a low/incomplete pass-through from the T-bills rates to the lending and deposit rates, significant in the long-run but insignificant in the short run.

For the case of deposit rates, Kigabo (2021) found a low and significant pass-through from the weighted T-bills rate to the weighted deposit rate and from the 26-week T-bills rate to the 1-month deposit rate. Regarding the lending rates, a significant but low effect is found from the weighted deposit rate to the weighted lending rate, from the 3 and 6 months deposit rate to the weighted lending rate, from the six-month deposit rate to the short-term and long-term lending rates, from the weighted deposit rate to the long-term lending rate and from the 52 weeks T-bills rate to the weighted lending rate. The studies on Rwanda that estimated the level of interest rate pass-through stopped before adopting a price-based monetary policy and, therefore, do not capture recent developments in the money market and financial system developments. This study will extend the sample to June 2022 and cover a broad interest rate range.

2.3 Overview of monetary policy in Rwanda

Since its creation in 1964, the National Bank of Rwanda has implemented its monetary policy under different regimes. Between 1964 and 1990, the NBR used direct monetary policy instruments to regulate money supply but switched to indirect, market-based instruments in 1990 following the liberalization of the economy. Nonetheless, a clear monetary policy regime started in 1997, when the NBR started implementing its monetary policy under the monetary targeting framework, with reserve money (i.e. base money) used as an operating target, broad money (M3) as an intermediate target and inflation as the ultimate target. Under this regime, changes in reserve money affected the money supply (M3), which affected the inflation and output levels. By reaching the desired level of M3, the central bank could attain its ultimate goal of price stability. As explained by (Kigabo & Irankunda, 2012), the transmission mechanism under the monetary targeting framework started from base money to inflation via money supply: the NBR used its monetary policy instruments to influence the level of reserve money so as to affect money supply with an ultimate objective of affecting inflation.

For this transmission mechanism to work, two strong assumptions need to be satisfied: (1) Money supply and inflation should be strongly related, such that changes in M3 can lead to desired changes in inflation; (2) the NBR should be able to control the money supply, and this is only possible if there is a long-run, stable and predictable relationship between M3 and reserve money. From the supply side, strict money targeting was found to be cumbersome due to increased and frequent deviations of actual base money stocks from their target values. In addition, the NBR had limited control over the money supply given the significant share of currency in circulation in base money and the fact that the NBR could not control the former via the usual open market operations.

From the demand side, the effectiveness of the reserve money targeting program was also premised on the assumption of a stable money demand function such that NBR interventions focus on reducing deviations of M3 from its target and, therefore, push it closer to the estimated money demand level. Thus, the estimation of money demand should be accurate, stable and predictable. According to the quantity theory of money and recent empirical literature, the stability of the money demand function depends on the assumption that the velocity of money is either constant or grows at a constant, predictable rate. However, empirical work on Rwanda indicated that the velocity of money was not constant and was not growing at a constant rate, implying instability of money demand and often leading to the disequilibrium between the demand and supply of money, thus posing challenges to the effectiveness of monetary policy in Rwanda (Kigabo, 2021). Just like in Rwanda, the instability of the money multiplier, money velocity, and money demand function has been reported in many developing countries (Adam & Kessy, 2010).

As a result, the NBR introduced a flexible system in 2012, under which target misses were tolerated within the $\pm 2\%$ band around the central reserve money target. More reforms were introduced to this flexible regime, especially since 2008, which marked the beginning of the transition to a price-based monetary policy framework. In 2008, the Key Repo Rate (KRR) was introduced. Since then, the MPC has decided on the level of the KRR every quarter and communicated this to the market, just as a signalling tool of the monetary policy stance. The NBR also adjusted its Open Market Operations (OMOs) by introducing repo operations to replace the overnight facility and 7-day auctions. To help commercial banks manage liquidity, the NBR also introduced an interbank interest rate corridor system.

After the transition period, the National Bank of Rwanda adopted the price-based monetary policy regime in January 2019, which mainly emphasizes the importance of the interest rate channel of the monetary policy transmission mechanism. Under this regime, the National Bank of Rwanda sets the Central Bank Rate (CBR) to affect the short-term interest rates, mainly the 7-day-interbank rate, which ultimately affects other interest rates in the economy, notably the lending and deposit rates. The changes in interest rates then influence liquidity conditions and thereafter affect aggregate demand and prices if the transmission mechanism is effective. Thus, the effectiveness of the interest-rate-based policy regime hinges on the effectiveness of the interest rate pass-through.

According to Kigabo (2021), the analysis of the effectiveness of the interest rate channel is often done in two stages. The first stage focuses on assessing the interest rate pass-through to check how policy-controlled short-term interest rates affect both money market interest rates and banks' retail rates. Most of the empirical literature focuses on determining the magnitude and symmetry of the pass-through. Generally, it concludes that there is incomplete pass-through in developing countries, where a 1% increase in the policy rate leads to a less than 1% increase in the money market or retail rate. The second stage consists of examining the effectiveness of the whole monetary policy transmission mechanism, focusing on examining how monetary policy actions, such as changes in the policy rates, affect aggregate demand and price levels in an economy (Samba & Yan, 2010; Apaa, 2014; Kigabo, 2021).

3 Data and Methodology

All the monthly interest rate data used in this study were obtained from the National Bank of Rwanda (NBR). Data for the CBR start in January 2005, while that of the repo rate starts in January 2008. The starting period for other interest rates data is January 2004 for the interbank rate, treasury bills rate (4, 13, 26, and 52-week maturities), the deposit rate (average, and 1, 3, 6, 12 months maturities), and lending rates for all maturities (i.e., short-term, medium-term and long-term). Dejure, the CBR is the policy rate, while the repo is the defacto policy rate. The end of the sample for all interest rates is June 2022. The estimation samples, therefore, vary with respect to the proxy of the policy rate and the market rate used[2].

[2]Estimation samples for the pass-through to other interest rates from: the Repo rate (January 2008 - June 2022); CBR (January 2005 - June 2022); Interbank (January 2004 - June 2022); 4, 13 and 26 weeks T-bills rates (January 2004 - June 2022); 52-week T-bills (January 2005 - June 2022); Weighted T-bills rate (January 2008 - June 2022).

Regarding the methodology, empirical analysis of the interest rate pass-through is dominated by bi-variate regression analyses, assessing the sensitivity of the market rate to the changes in the policy rate, and this explains why most empirical studies are predominated by single-equation modelling (Chionis & Leon, 2006). The standard empirical models used in the interest-rate pass-through literature are the Autoregressive Distributed Lag (ARDL) models and bi-variate Engle-Granger cointegration. The Engle-Granger two-step procedure consists of first estimating a levels OLS model:

$$y_t = \alpha_1 + x_t'\beta + \epsilon_t \tag{1}$$

In the following equations, where y_t and x_t' are vectors of $I(1)$ variables representing the market rate (y_t) and policy rate (x), α is an intercept that indicates a mark-up or mark-down on the market or retail rate to reflect market conditions. It is important to test whether or not the stochastic error term (ϵ_t) is stationary. If not stationary, the OLS estimation of Equation (1) gives spurious results. However, if stationary, then a long-run regression (Equation (1)) is valid, and a short-term regression (Equation (2)) can also be estimated to give the long-run and short-run levels of the interest rate pass-through. Equation (1) is the long-run model, whereas Equation (2) is the Error Correction Model (ECM).

$$\Delta y_t = \alpha_2 + \gamma\hat{\epsilon}_{t-1} + \sum_{i=1}^{p-1} \phi_{xj}\Delta x_{t-j} + u_t \tag{2}$$

Where y_t and x_t are as defined above, $\hat{\epsilon}_{t-1}$ is the lag of the estimated residuals obtained from Equation (1), and u_t is the error term in the Error Correction Model (ECM). The ECM shows short-run adjustments to eliminate the disequilibrium, moving towards attaining the long-run equilibrium. Thus, under the Engle-Granger model, it is essential that γ is negative and statistically significant to ensure that the series are cointegrated. We thus test whether the $-1 \leq \gamma < 0$ assumption is valid.

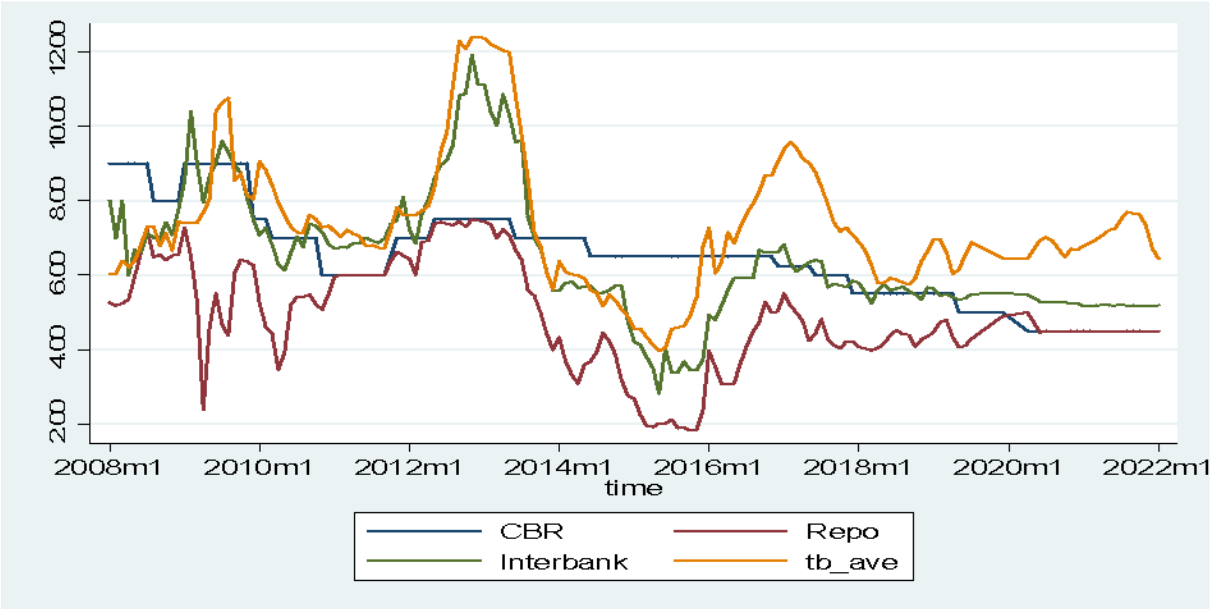
Some empirical studies, such as Kigabo (2021), combine equations (1) and (2) into a single-step estimation procedure, but the results and interpretations are similar. Before using the Engle-Granger model, one must ensure that the variables are all I(1). This study uses the Engle-Granger methodology to compare our results with those of Kigabo (2021). In addition, robustness checks indicated that the results of the ARDL and the

Engle-Granger methodologies are generally the same. We do estimations using the entire sample to capture average effects but also do estimations for the samples before and after adopting the price-based monetary policy regime to check whether there have been significant changes in the interest rate pass-through. We enrich our findings by comparing them to those of Kigabo (2021).

4 Discussion of descriptive and empirical results

Since July 2020, the CBR and the repo have been harmonized (i.e. the two are now equal). The first interesting empirical task will be to check if the CBR has been comoving with the repo and interbank rates. Despite the sluggishness in the CBR, there is broad comovement between the three interest rates, with more comovement observed between the repo rate and the interbank rate (Figure 2).

Figure 2: Co-movement between the policy and money market rates



Looking at the correlation coefficients in table 1, it is clear that the defacto policy rate (i.e. the repo rate) is highly and positively correlated with the interbank rate and the T-bills rates (weighted average and all maturities). The interbank rate is also positively and highly correlated with the T-bills rates (all maturities). Therefore, the repo rate, interbank rate and T-bills rates can and have been used as proxies

for the policy rate in most of the recent empirical literature on Rwanda (Kigabo & Kamanzi, 2018; Vlček, Pranovich, Hitayezu, Mwenese, & Nyalihama, 2020; Kigabo, 2021).

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	cbr	1.000							
(2)	repo	0.364	1.000						
(3)	Interb	0.602	0.825	1.000					
(4)	tb_4wk	0.315	0.786	0.837	1.000				
(5)	tb_13wk	0.356	0.739	0.869	0.923	1.000			
(6)	tb_26wk	0.257	0.645	0.771	0.817	0.906	1.000		
(7)	tb_52	-0.075	0.434	0.533	0.728	0.784	0.780	1.000	
(8)	tb_ave	0.303	0.685	0.833	0.901	0.979	0.911	0.836	1.000

Table 1: Correlation between policy and money market rates

Regarding the correlation between the deposit rates (average and all maturities) and the various proxies for the policy rates, the correlations in table 2 are positive but quite low, which may indicate weak pass-through from these respective policy rates to the deposit rates. Generally, the correlations are higher between deposit and T-bills rates than between deposit and repo rates.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)	dr_1m	1.000											
(2)	dr_3m	0.326	1.000										
(3)	dr_6m	0.322	0.665	1.000									
(4)	dr_12m	0.194	0.630	0.655	1.000								
(5)	dr_ave	0.199	0.661	0.698	0.882	1.000							
(6)	repo	0.195	0.294	0.148	0.144	0.101	1.000						
(7)	Interb	0.260	0.518	0.382	0.393	0.320	0.825	1.000					
(8)	tb_4wk	0.134	0.472	0.306	0.343	0.350	0.786	0.837	1.000				
(9)	tb_13wk	0.171	0.518	0.356	0.415	0.420	0.739	0.869	0.923	1.000			
(10)	tb_26wk	0.203	0.474	0.322	0.429	0.450	0.645	0.771	0.817	0.906	1.000		
(11)	tb_52	0.131	0.494	0.357	0.457	0.531	0.434	0.533	0.728	0.784	0.780	1.000	
(12)	tb_ave	0.180	0.532	0.359	0.437	0.455	0.685	0.833	0.901	0.979	0.911	0.836	1.000

Table 2: Correlation between policy rates and deposit rates

According to Appendix A, the Augmented Dickey-Fuller (ADF) test shows that all the variables are I(1)[3], and thus, the empirical approach of Kigabo (2021) can be conveniently used by re-estimating the interest rate pass-through for the case of Rwanda, both in the short-run and long-run. Short-run estimations (table 3) show that there is a weak but statistically significant pass-through only from the 13-week T-bills rate (tb_13wk) to the 3-month deposit rate (dr_3m). Other estimations are not statistically significant[4].

	dr_1m	dr_3m	dr_6m	dr_12m
Interb				
Cons	-0.0	0.0	-0.0	0.0
coeff	-0.03	-0.04	-0.1	0.08
Ut-1	-0.7***	-0.4***	0.4***	-0.3***
Repo				
Const	0.04	0.02	0.04	0.011
coef	0.04	0.07	-0.041	-0.14
Ut-1	-0.6***	-0.3***	-0.3***	-0.2***
tb_4wk				
Const	-0.00	0.008	-0.00	0.006
coef	-0.019	0.058	-0.069	0.00724
Ut-1	-0.713***	-0.452***	-0.425***	-0.299***
tb_13wk				
Cons	0.006	0.0116	0.00798	0.00696
Coef	0.04	0.372**	-0.217	0.00426
Ut-1	-0.5***	-0.3***	-0.3***	-0.2***
tb_26wk				
Cons	-0.00	0.0	5.7	0.0
Coef	0.09	0.153	-0.04	0.09
Ut-1	-0.7***	-0.427***	-0.4***	-0.318***
tb_52wk				
Cons	-0.00	0.0	0.0	0.0
Coef	0.00222	0.2	-0.06	0.09
Ut-1	-0.7***	-0.4***	-0.4***	0.06

Note: * p<0.05, ** p<0.01, *** p<0.001

Table 3: Short-term pass-through from proxies of policy rates to the deposit rates

[3]Appendix A gives ADF tests for the entire sample. However, the same conclusions were reached for the sub-samples.
[4]Note that Ut-1 stands for the error correction term.

In the long-run estimations (table 4), there is a weak and statistically significant pass-through from the interbank rate, the repo rate, 4-week, 13-week and 26-week T-bills rates to the deposit rates of 1, 2,6 and 12 months maturity, respectively. The pass-through from the 52 T-bills rate is weak and only significant if it is to the 3, 6 and 12-month deposit rates.

	dr_1m	dr_3m	dr_6m	dr_12m
Interbank				
Cons	2.6***	2.4***	4.5***	6.8***
Coef	0.2***	0.5***	0.4***	0.3***
Repo				
Cons	3.2***	4.3***	6.5***	8.1**
Coef	0.3***	0.73***	0.6***	0.4***
tb_4wk				
Cons	3.4***	3.2***	5.3***	7.3***
Coef	0.1*	0.4***	0.3***	0.2***
tb_13wk				
Cons	3.4***	3.3***	5.5***	7.0***
Coef	0.1***	0.4***	0.2***	0.2***
tb_26wk				
Cons	2.9***	2.8***	5.0***	6.6***
Coef	0.2**	0.4***	0.3***	0.2***
tb_52wk				
Cons	3.2***	2.0***	4.352***	6.0***
Coef	0.1	0.4***	0.36***	0.3***
N	174	174	174	174
height				

Note: * p<0.05, ** p<0.01, *** p<0.001

Table 4: Long-term pass-through from proxies of policy rates to the deposit rates

In all the estimations (not reported here), the pass-through from different proxies of the policy rate to the lending rate (weighted average, short-term, medium-term and long-term) gave counter-intuitive results with unexpectedly negative relationships. As shown in Appendix C, it takes 7 months, 21 months, and 22 months for medium-term, short-term, and long-term lending rates to be positively correlated with the repo rate, respectively.

As indicated in Figure 3, both headline inflation and the repo rate have been generally and consistently trending downwards, while the lending rates have generally been trending upwards, which could be an explanation for the observed negative relationships between the policy rates and the lending rates.

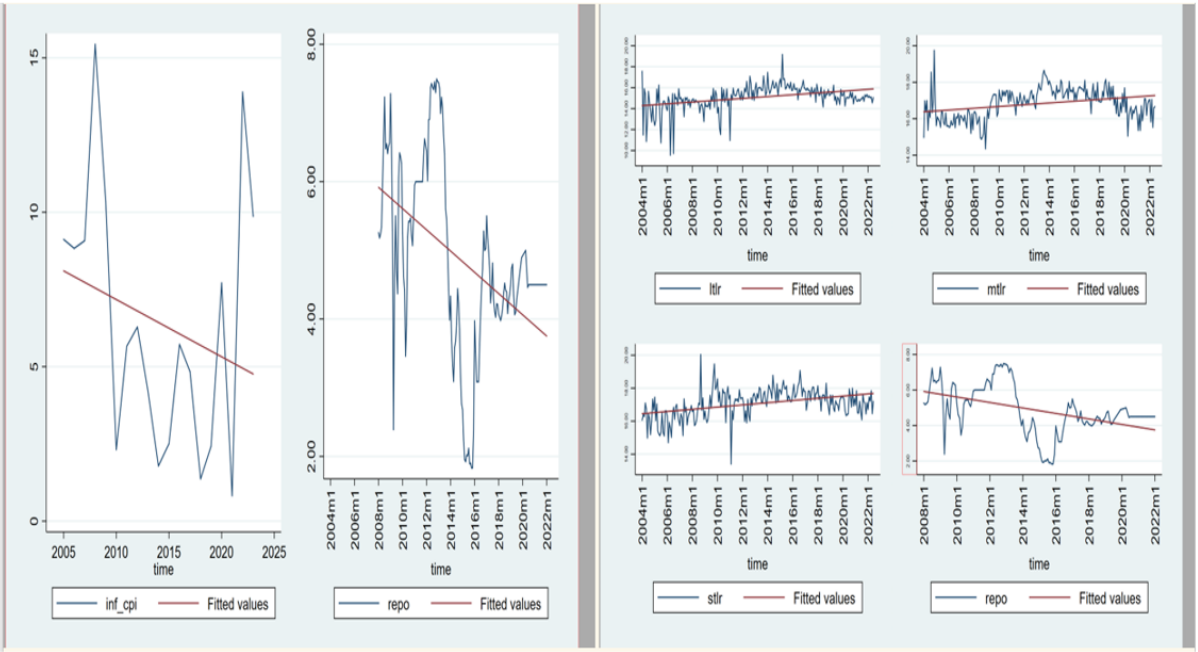
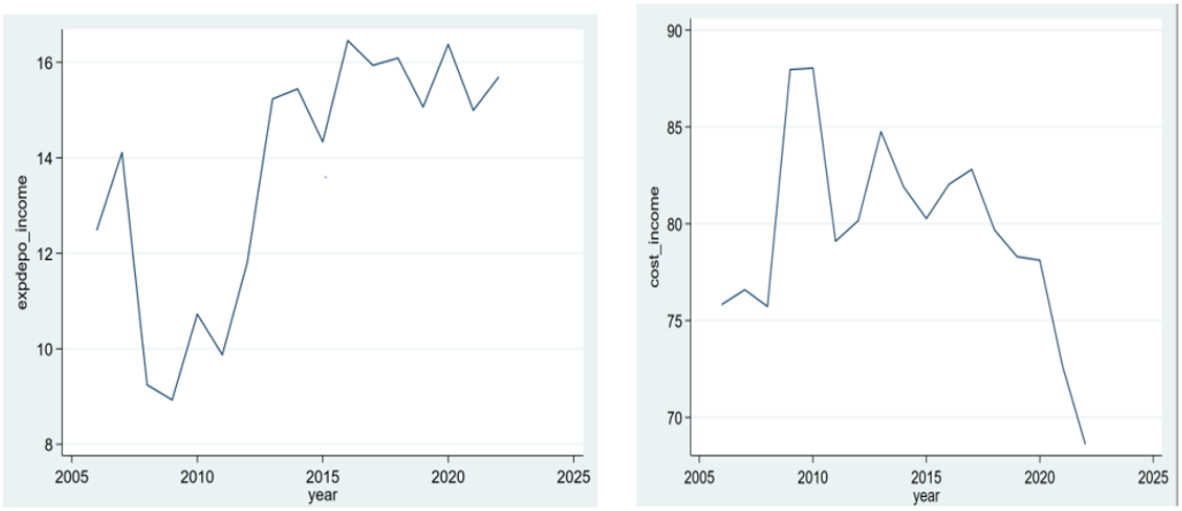


Figure 3: General trend in the lending rates, inflation and policy rate

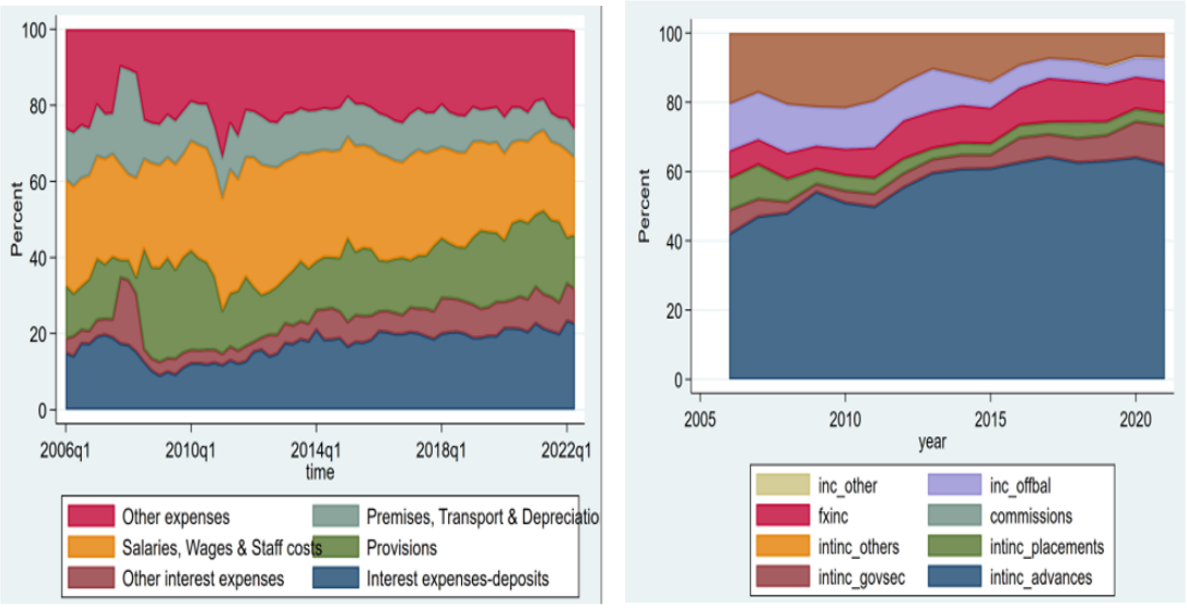
Also, the lending rate has been observed to be quite sticky and at a higher level compared to the deposit rate given that the banks still incur high operating costs, the credit risk is still high, there is monopoly power in the deposit market where big depositors negotiate for higher interest rates and hence push up the cost of funds, there is low competition in the loans market, among others (Karangwa & Nyalihama, 2014; Kigabo, 2021). Though the discussion of the reasons for the stickiness in lending rates is beyond the scope of this paper, a few examples can be cited. For example, the expenditure on deposits as a share of total income is quite high (figure 4), implying a high cost of funds. The share of total costs to income has declined over time, but it remains close to 70

Figure 4: Cost of funds and total costs of commercial banks



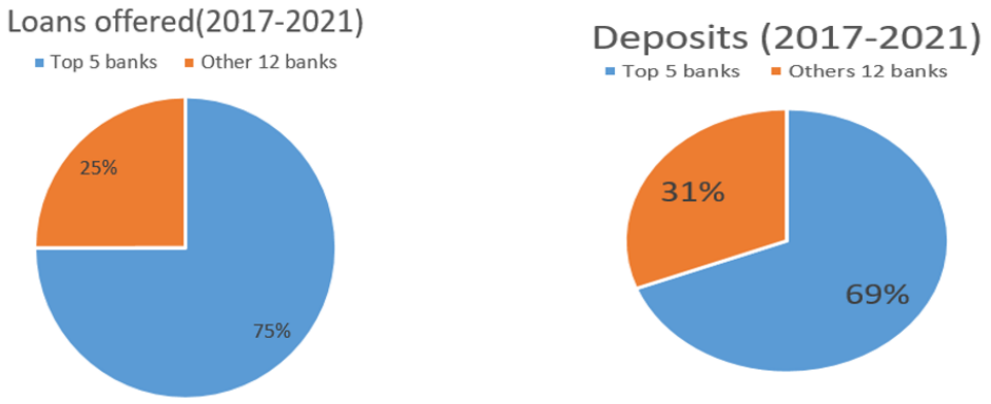
The main source of income for commercial banks is interest income from loans and advances (intinc_advances). The lack of a diversified portfolio may imply that commercial banks tend to maintain higher lending rates to remain profitable. Also, the operating costs of banks remain quite high, mainly pushed up by salaries, wages and staff costs, interest expenses on deposits, loan loss provisions and other expenses.

Figure 5: Decomposition of operating costs of commercial banks



There is less competition among commercial banks in Rwanda, where only a few banks dominate the loan and deposit markets, hence impeding the interest rate pass-through.

Figure 6: Share in loans and deposits market



In both the Kigabo (2021) paper and this current study, there is a strong and complete long-run pass-through from the repo rate to the interbank rate, from the repo rate to the 4-week T-bills rate, from the repo rate to the 13-week T-bills rate, and from the interbank to the 4-week T-bills rate. The pass-through from the repo to 26 weeks T-bills and from the interbank rate to the 13 weeks T-bills rate has declined (from complete pass-through) but remains strong and statistically significant. Also, the pass-through from the interbank rate to the weighted T-bills rate and from the interbank to the 26-week T-bills rate has declined but remains quite strong. Though still weak, there has been some slight improvement in the pass-through from the 26-week T-bills rate to the 1-month deposit rate and from the 3-month deposit rate to the weighted lending rate. Overall, the (Kigabo, 2021) estimations are statistically significant at 5%, which has improved to 1% in the current estimations. However, the corresponding short-term pass-through is generally weak.

To confirm whether the interest rate pass-through has declined since January 2019, compared to the sample before, we re-run estimations after adding a dummy variable on the various bi-variate regressions. We define the dummy as equal to 1 for the sample since January 2019 and 0 otherwise. Results in Appendix B show that the interest rate pass-through has generally declined since the NBR's adoption of the price-based monetary policy framework[5]. While this could be attributed to the fact that the recent past has been hugely affected by the shocks (COVID-19, Russia-Ukraine war & adverse weather), the small size of the sample

[5]The exception is that the pass-through from the weighted interbank rate to the weighted deposit rate has increased in the January 2019 - June 2022 sample.

Pass-through from	Kigabo (2021) Jan 2008 – May 2020		Current study Jan 2008 – June 2022	
	Long-T	Short-T	Long-T	Short-T
Repo to interb	1.09**	0.40**	1.03***	0.39***
Repo to TB_4W	1.18**	0.21	1.09***	0.19
Repo to 1TB_13W	1.16**	0.28**	1.06***	0.28***
Repo to TB_26W	1.01**	0.13	0.90***	0.11
Interbank to WTB	0.9**	0.40**	0.84***	0.40***
Interbank to TB_4W	1.03**	0.50**	1.04***	0.62***
Interbank to TB_13W	1.09**	0.47**	0.87***	0.49***
Interbank to TB_26W	0.94**	0.32**	0.84***	0.45***
WTB to WDR	0.29**	0.05	0.29***	0.04
TB26 to DR1	0.16**	0.09	0.28***	0.08
DR3 to WLR	0.11**	0.005	0.15**	0.20

Note: * p<0.05, ** p<0.01, *** p<0.001
Table 5: Benchmarking empirical findings

cannot also be disregarded. Thus, it is important to always update the estimations from time to time.

5 Conclusion and Recommendation

For monetary policy to be effective, policy decisions should be translated into policy actions that can affect inflation and output. This requires the effectiveness of the monetary policy transmission mechanism (MPTM), which includes several channels, such as the interest rate channel, the bank lending channel, the asset price channel and the exchange rate channel. This paper analyses the effectiveness of the interest rate channel, focusing on the pass-through from policy rates to the lending and deposit rates. We use data from January 2008 to June 2022 and use both simple descriptive analysis and an empirical strategy employed by Kigabo (2021). Our results are generally robust and align with those obtained by Kigabo (2021). The pass-through is, however, slightly lower in our estimations but is also more statistically significant compared to Kigabo (2021). Also, our estimations show improved pass-through from the 26-week to the 1-month deposit rate and from the 3-month deposit rate to the weighted lending rate. Our estimations show a weak but statistically significant short-run pass-through from the 13-week T-bills to the 3-month deposit rate. In the long-run, there is weak and statistically significant pass-through from the interbank rate, the repo rate, and the 13-week and 26-week T-bills rates to the deposit rates of 1, 2, 6 and 12 months, respectively.

The estimations of the pass-through from policy rates to the lending rates are generally counter-intuitive as lending rates have been moving in opposite directions with the policy rate and monetary policy objective. The challenges impeding effective MPTM include low financial sector development and the still high level of informality of the Rwandan economy (Kigabo, 2021). Also, the lending rate has been observed to be quite sticky and at a higher level compared to the deposit rate given that the banks still incur high operating costs, the credit risk is still high, there is monopoly power in the deposit market where big depositors negotiate for higher interest rates and hence push up the cost of funds, there is low competition in the loans market, among others (Karangwa & Nyalihama, 2014; Kigabo, 2021).

Given the relatively weakening interest rate pass-through to deposit rates, this paper recommends thoroughly analysing the dynamics in the deposit market. Given the counter-intuitive results regarding the pass-through to the lending rates, we recommend a detailed loan market analysis. We suggest that a similar analysis be conducted from time to time using updated data to check if there has been an improvement in the interest rate pass-through, which is required for the efficient functioning of the interest rate channel. NBR should continue working with other stakeholders to increase financial sector development and implement other policies aimed at attaining the desired structural transformation of the Rwandan economy, as this can potentially lead to the improvement of the MPTM. There is a need to encourage banks to devise mechanisms for diversifying their portfolios, cutting their operating costs and embracing competition in both the loans and deposit markets. This can be done via different engagements, taking appropriate supervisory measures and moral suasion.

References

Adam, C., & Kessy, P. (2010). Assessing the Stability and Predictability of the Money Multiplier in the EAC: the case of Tanzania. *International Growth Centre Discussion Paper. London School of Economics.*.

Andújar-Scheker, J. G. (2012). Efecto Traspaso de Tasas de Interés: Análisis Econométrico de los Efectos de las Decisiones de Política Monetaria en República Dominicana. *Universidad Católica de Colombia. Facultad de Ciencias Económicas*.

Apaa, J. (2014). Interest Rate Pass-through in Uganda. *Bank of Uganda Working Paper Series*(02).

Aziakpono, M. J., & Wilson, M. K. (2013). Interest Rate Pass-through and Monetary Policy Regimes in South Africa. *African Economic Research Consortium Paper, No. 259*.

Aziakpono, M. J., & Wilson, M. K. (2015). Interest Rate Pass-through, Financial Structure and Monetary Policy in South Africa. *African Finance Journal*, *17*(1), 67–90.

Bennouna, H. (2019). Interest Rate Pass-through in Morocco: Evidence from Bank-level Survey Data. *Economic Modelling*, *80*, 142–157.

Borio, C. E., & Fritz, W. (1995). The Response of Short-term Bank Lending Rates to Policy Rates: A Cross-country Perspective. *BIS Working Paper No. 27*.

Chionis, D. P., & Leon, C. A. (2006). Interest Rate Transmission in Greece: Did EMU Cause a Structural Break? *Journal of Policy Modeling*, *28*(4), 453–466.

Chiumia, A., & Palamuleni, A. (2019). Interest Rate Pass-through in Malawi: Implications for the Effectiveness of Monetary Policy. *South African Journal of Economics*, *87*(4), 515–531.

Cottarelli, C., & Kourelis, A. (1994). Financial Structure, Bank Lending Rates, and the Transmission Mechanism of Monetary Policy. *IMF Staff Papers*, *41*(4), 587–623.

De Angelis, C., Aziakpono, M., & Faure, A. P. (2005). The Transmission of Monetary Policy under the Repo System in South Africa: An Empirical Analysis. *South African Journal of Economics*, *73*(4), 657–673.

De Bondt, G. (2002). Retail Bank Interest Rate Pass-through: New Evidence at the Euro Area Level. *ECB Working Paper, No. 136*.

Doojav, G.-O., & Kalirajan, K. (2016). Interest Rate Pass-through in Mongolia. *The Developing Economies*, *54*(4), 271–291.

Escudero, M., Gonzalez-Rozada, M., & Sola, M. (2014). Toward a " New" Inflation-Targeting Framework:

The Case of Uruguay. *Economía*, *15*(1), 89–131.

Fried, J., & Howitt, P. (1980). Credit Rationing and Implicit Contract Theory. *Journal of Money, Credit and Banking*, *12*(3), 471–487.

Guisan, M.-C., et al. (2005). EXCHANGE RATES, FOREIGN TRADE PRICES AND PPPs IN OECD COUNTRIES: AN ANALYSIS OF THE PERIOD 1960-2003. *University of Santiago de Compostela, Working Paper Series Economic Development, No. 84*.

Hannan, T., & Berger, A. (1991). The Rigidity of Prices: Evidence from the Banking Sector. *American Economic Review*, *81*, 938–945.

Huang, J., & Wang, J. (2009). Liquidity and Market Crashes. *The Review of Financial Studies*, *22*(7), 2607–2643.

Hülsewig, O., Mayer, E., & Wollmershäuser, T. (2009). Bank Behaviour, Incomplete Interest Rate Pass-through, and the Cost Channel of Monetary Policy Transmission. *Economic Modelling*, *26*(6), 1310–1327.

Karangwa, M., & Nyalihama, C. (2014). Determinants of Interest Rate Spread in Rwanda. *BNR Economic Review*, *6*, 123–169.

Kigabo, T. R. (2021). *Monetary Policy in Rwanda: 1964—present*. Springer.

Kigabo, T. R., & Irankunda, J. (2012). Assessing the Stability of Money Multiplier in Rwanda. *BNR Economic Review*, *5*, 41–55.

Kigabo, T. R., & Kamanzi, C. (2018). Requirements for using Interest Rate as an Operating Target. *BNR Economic Review*, *13*, 1–26.

Kigabo, T. R., & Mwenese, B. (2016). Interest Rate Pass-through in EAC. *BNR ECONOMIC REVIEW, Vol. 9*.

Klemperer, P. (1987). Markets with Consumer Switching Costs. *The Quarterly Journal of Economics*, *102*(2), 375–394.

Kwapil, C., & Scharler, J. (2009). Expected Monetary Policy and the Dynamics of Bank Lending Rates. *Working Paper, No. 149, Oesterreichische Nationalbank (OeNB), Vienna*.

Medina, C. S., Carrión-Menéndez, A., & Frantischek, F. (2011). The Policy Interest-rate Pass-through in Central America. *IMF working paper, WP/11/240*.

Misati, R. N., Nyamongo, E. M., & Kamau, A. W. (2011). Interest Rate Pass-through in Kenya. *International Journal of Development Issues*, *10*(2), 170–182.

Mojon, B. (2000). Financial Structure and the Interest Rate Channel of ECB Monetary Policy. *ECB Working Paper, No. 40*.

Neumark, D., & Sharpe, S. A. (1992). Market Structure and the Nature of Price Rigidity: Evidence from the Market for Consumer Deposits. *The Quarterly Journal of Economics*, *107*(2), 657–680.

Rutayisire, M. J. (2017). Modelling Interest Rate Pass-through in Rwanda: is the interest rate dynamics symmetric or asymmetric? *MPRA Paper No. 90178*.

Saborowski, C., & Weber, S. (2013). Assessing the Determinants of Interest Rate Transmission Through Conditional Impulse Response Functions.

Samba, M. C., & Yan, Y. (2010). Interest Rate Pass-through in the Central African Economic and Monetary Community (CAEMC) Area: Evidence from an ADRL Analysis. *International Journal of Business and Management*, *5*(1), 31.

Sorensen, . W. T., Kok C. (2006). Bank Interest Rate Pass-through in the Euro Area: A Cross-country Comparison. *ECB Working Paper, No. 580*.

Stiglitz, J. E., & Weiss, A. (1981). Credit Rationing in Markets with Imperfect Information. *The American Economic Review*, *71*(3), 393–410.

Sudo, N., & Teranishi, Y. (2008). Optimal Monetary Policy under Heterogeneous Banks. *unpublished paper, Bank of Japan*.

Tieman, A. F. (2004). Interest Rate Pass-through in Romania and other Central European Economies. *IMF Working Paper, WP/04/211*.

Vlček, J., Pranovich, M., Hitayezu, P., Mwenese, B., & Nyalihama, C. (2020). Quarterly Projection Model for the National Bank of Rwanda. *International Monetary Fund Working Paper, WP/20/295*.

Appendix A. Stationarity tests

Figure 7: Stationarity test

Period	Variable	ADF 1st Diff Statistic
Entire Period	tb_4wk	18.63***
Entire Period	tb_13wk	8.9***
Entire Period	tb_26wk	16.93***
Entire Period	tb_52	9.87***
Entire Period	INTERB	7.18***
Entire Period	CBR	12.78***
Entire Period	dr_1m	8.23***
Entire Period	dr_3m	10.75***
Entire Period	dr_6m	11.6***
Entire Period	dr_12m	10.21***
Entire Period	stlr	7.44***
Entire Period	mtlr	10.74***
Entire Period	ltlr	8.43***
Entire Period	REPO	10.52***
Entire Period	dr_ave	13.37***
Entire Period	lend_ave	7.81***
Entire Period	tb_ave	9.5***

Appendix B. Time-varying estimations

Repo to:	**Slope**	**Dummy**	**Interbank to:**	**Slope**	**Dummy**
dr_ave	0.06941	-0.24614	dr_ave	0.21668***	0.05131
lend_ave	-0.11717***	-0.64644***	lend_ave	-0.06729***	-0.71818***
dr_1m	0.16592*	-0.76078***	dr_1m	0.19700***	-0.51252*
dr_3m	0.28723***	-1.40296***	dr_3m	0.45173***	-0.81358***
dr_6m	0.13079	-1.28443***	dr_6m	0.34566***	-0.81425***
dr_12m	0.11875*	-0.49349**	dr_12m	0.28547***	-0.1075
stlr	-0.12538***	-0.34845***	ltlr	-0.08974**	-0.45081***
mtlr	-0.16266***	-0.67660***	mtlr	-0.07721**	-0.75284***
ltlr	-0.17800***	-0.38726**	ltlr	-0.14347***	-0.55572***
CBR to:	**Slope**	**Dummy**	**tb_ave**	**Slope**	**Dummy**
dr_ave	-0.08321	-0.44063	dr_ave	0.28784***	-0.07061
lend_ave	-0.14905***	-0.94274***	lend_ave	-0.01253	-0.62946***
dr_1m	0.14761	-0.47811	dr_1m	0.14244**	-0.70230**
dr_3m	0.09913	-1.25104***	dr_3m	0.46959***	-1.15413***
dr_6m	0.16634	-0.95378**	dr_6m	0.33508***	-1.09088***
dr_12m	0.10159	-0.29991	dr_12m	0.30817***	-0.31515
stlr	-0.14038**	-0.62428***	stlr	-0.02202	-0.33598**
mtlr	-0.30330***	-1.29587***	mtlr	-0.00712	-0.64623***
ltlr	-0.27683***	-0.94611***	ltlr	-0.07693*	-0.39977**

Appendix C. Correlations between the repo and lending rates

	repo	L. repo	L2. repo	L3. repo	L4. repo	L5. repo	L6. repo	L7. repo	L8. repo	L9. repo	L10. repo	L11. repo
repo												
--.	1.0000											
L1.	0.9684	1.0000										
L2.	0.9220	0.9687	1.0000									
L3.	0.8752	0.9224	0.9686	1.0000								
L4.	0.8202	0.8680	0.9147	0.9635	1.0000							
L5.	0.7799	0.8158	0.8636	0.9123	0.9637	1.0000						
L6.	0.7502	0.7798	0.8157	0.8642	0.9103	0.9625	1.0000					
L7.	0.7068	0.7453	0.7747	0.8125	0.8641	0.9105	0.9612	1.0000				
L8.	0.6452	0.6814	0.7189	0.7529	0.8073	0.8563	0.8942	0.9526	1.0000			
L9.	0.6078	0.6444	0.6803	0.7184	0.7513	0.8071	0.8567	0.8934	0.9378	1.0000		
L10.	0.5564	0.6112	0.6473	0.6819	0.7115	0.7474	0.8071	0.8513	0.8647	0.9355	1.0000	
L11.	0.5091	0.5617	0.6158	0.6493	0.6703	0.7031	0.7450	0.7968	0.8122	0.8594	0.9356	1.0000
L12.	0.4692	0.5135	0.5657	0.6182	0.6429	0.6664	0.7033	0.7400	0.7697	0.8106	0.8608	0.9355
L13.	0.4114	0.4738	0.5178	0.5685	0.6123	0.6392	0.6668	0.6987	0.7145	0.7685	0.8124	0.8616
L14.	0.3471	0.4159	0.4778	0.5204	0.5633	0.6094	0.6400	0.6629	0.6754	0.7137	0.7702	0.8134
L15.	0.3001	0.3524	0.4203	0.4805	0.5148	0.5605	0.6105	0.6359	0.6387	0.6744	0.7159	0.7723
L16.	0.2615	0.3053	0.3567	0.4229	0.4753	0.5126	0.5620	0.6069	0.6132	0.6380	0.6766	0.7183
L17.	0.2253	0.2697	0.3125	0.3610	0.4148	0.4709	0.5138	0.5555	0.5758	0.6109	0.6416	0.6825
L18.	0.1833	0.2310	0.2747	0.3156	0.3560	0.4129	0.4728	0.5103	0.5333	0.5752	0.6136	0.6452
L19.	0.1322	0.1862	0.2333	0.2759	0.3126	0.3555	0.4146	0.4711	0.4956	0.5332	0.5759	0.6138
L20.	0.0823	0.1321	0.1855	0.2323	0.2744	0.3127	0.3561	0.4139	0.4627	0.4951	0.5313	0.5720
L21.	0.0347	0.0818	0.1310	0.1841	0.2309	0.2745	0.3131	0.3554	0.4070	0.4621	0.4927	0.5269
L22.	0.0043	0.0337	0.0800	0.1289	0.1825	0.2312	0.2748	0.3124	0.3495	0.4060	0.4592	0.4881
L23.	-0.0140	0.0039	0.0325	0.0784	0.1272	0.1827	0.2316	0.2740	0.3063	0.3486	0.4037	0.4555
stlr	-0.3094	-0.3001	-0.3141	-0.2942	-0.2772	-0.2517	-0.2237	-0.2129	-0.2153	-0.1731	-0.1143	-0.1146
mtlr	-0.1878	-0.1543	-0.1343	-0.0858	-0.0409	-0.0123	-0.0024	0.0503	0.0919	0.0745	0.0990	0.1136
ltlr	-0.1852	-0.2020	-0.2012	-0.2242	-0.2241	-0.1888	-0.1543	-0.0854	-0.0090	0.0066	-0.0330	-0.0276

	L12. repo	L13. repo	L14. repo	L15. repo	L16. repo	L17. repo	L18. repo	L19. repo	L20. repo	L21. repo	L22. repo	L23. repo
L12.	1.0000											
L13.	0.9361	1.0000										
L14.	0.8627	0.9366	1.0000									
L15.	0.8150	0.8640	0.9372	1.0000								
L16.	0.7742	0.8168	0.8651	0.9376	1.0000							
L17.	0.7216	0.7768	0.8181	0.8659	0.9373	1.0000						
L18.	0.6852	0.7241	0.7785	0.8193	0.8666	0.9372	1.0000					
L19.	0.6462	0.6863	0.7248	0.7785	0.8192	0.8647	0.9366	1.0000				
L20.	0.6121	0.6447	0.6847	0.7226	0.7763	0.8140	0.8622	0.9359	1.0000			
L21.	0.5699	0.6102	0.6428	0.6821	0.7200	0.7706	0.8111	0.8612	0.9358	1.0000		
L22.	0.5246	0.5678	0.6080	0.6398	0.6790	0.7139	0.7673	0.8097	0.8608	0.9357	1.0000	
L23.	0.4863	0.5230	0.5661	0.6054	0.6372	0.6737	0.7110	0.7661	0.8093	0.8605	0.9355	1.0000
stlr	-0.0963	-0.1148	-0.1665	-0.1886	-0.1654	-0.0905	-0.0468	-0.0569	-0.0486	-0.0031	0.1078	0.0830
mtlr	0.1279	0.1236	0.1313	0.1598	0.1303	0.1323	0.1727	0.1679	0.1901	0.2055	0.2089	0.2082
ltlr	-0.0543	-0.1456	-0.1465	-0.1434	-0.0931	-0.0617	-0.0473	-0.0419	-0.0033	0.0664	0.0364	0.0491

	stlr	mtlr	ltlr
stlr	1.0000		
mtlr	0.1453	1.0000	
ltlr	0.0825	0.1502	1.0000