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Exchange Rate Channel of Monetary Policy Transmission Mechanism in Rwanda

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Abstract

Understanding the channels of the monetary policy transmission mechanism is crucial for the proper implementation of monetary policy. For low-income countries and Rwanda in particular with recent history of economic reforms including modernization in the monetary policy framework and ongoing financial sector development, there are questions on the strength of monetary policy transmission and which channels actually work. This study aims at assessing the exchange rate channel in the case of Rwanda. Using quarterly data from 2006 to 2022, empirical results reveal that the transmission of monetary policy via the exchange rate channel exists. First, evidence confirms the first stage of transmission, as an increase in Central Bank Rate influences the exchange rate by reducing the rate of the depreciation of Franc Rwandais. Furthermore, results from Bayesian VAR estimation suggest that this transmission work mostly via the direct channel as this effect from policy rate on the Franc Rwandais exchange rate is transmitted to inflation and the peak impact is attained after four quarters. Meanwhile, the indirect channel, which implies the effect of monetary policy on inflation via effect of exchange rate on output, is quasi-ineffective, as the output response, though in the right direction, is not statistically significant. We argue that this is likely due to the limited impact of exchange rate movement on export sector and subsequently the current account, thus ongoing economic structural reforms, financial sector development, and policy implementation would be critical for enhancing the potency of NBR monetary policy.

Keywords: Monetary policy, transmission mechanism, exchange rate channel, exchange rate.

JEL Classification: E52, E31, F31

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1 Introduction

Monetary policy, one of the most important macroeconomic policies, influences economic activity and inflation through various channels. Understanding the channels of the monetary policy transmission mechanism and how it affects other macroeconomic variables is critical for the proper implementation of monetary policy. Central banks across the globe are interested in assessing how their policies and actions are transmitted to the economy and how long it takes for them to make an impact. The vast theoretical and empirical literature over many years ago also illustrates the importance of this topic.

Indeed, the literature has been instrumental in revealing the relative importance of different channels of monetary policy transmission, as well as estimates of the size and timing of the impact of the monetary policy action on output and prices for different economies across time, and these insights improved the understanding of monetary policy transmission mechanism and were crucial for policymaking because they help in making the right decisions regarding notably the degree and timing of policy action for an effective monetary policy.

Interest rates, credit, asset prices, and exchange rate channels are the four key avenues through which monetary policy is transmitted (Ouchchikh, 2018). Numerous studies have explored the functioning of these channels. However, the majority of them have been conducted in advanced countries, and evidence show the existence of cross-country heterogeneity in monetary policy transmission mechanism (e.g., Berben, Locarno, Morgan, and Vallés (2004), Montiel, Spilimbergo, and Mishra (2010), and Grandi (2019)). For developing economies, Montiel et al. (2010) argue that the monetary policy transmission mechanism could differ from advanced economies due to, among others, weak institutional frameworks, reduced role of securities markets, imperfect competition in the banking sector and the high cost of bank lending to the private sector.

In the meantime, developing countries have experienced noticeable improvements in many macroeconomic areas including the structure of their economies, more liberalization and development in financial markets, and modernization in economic policymaking including monetary policy frameworks among others. Nevertheless, challenges remain amid recurrent shocks at a global and local level and emerging uncertainties. Besides, as developing countries are at different stages of development, the transmission mechanism of monetary policy may differ.

The transmission mechanism of monetary policy in Rwanda has previously been studied (e.g. Davoodi, Dixit, and Pinter (2013), Berg, Charry, Portillo, and Vlcek (2013) and Mugisha (2018)) and showed some evidence of the interest rate, bank lending, and exchange channels while other studies such as Berg et al. (2013) highlighted some impediments on transmission such as policy regime and illiquid and underdeveloped financial markets. However, all these studies were conducted before the National Bank of Rwanda adopted the new monetary policy framework. This transition involved a shift in the intermediate target from broad monetary aggregate (M3) to the interbank rate, necessitating a re-examination of the transmission mechanism.

Furthermore, these previous studies did not explore any channel in-depth, providing a complete comprehension of that channel. Regarding exchange rate channel in particular, no previous study on Rwanda has attempted to contrast direct and indirect channels, and yet previous studies on exchange rate pass-through in Rwanda (e.g., Nuwagira (2015) and Hitayezu and Nyalihama (2019)) suggested a non-trivial influence of

FRW depreciation on CPI inflation.

Against this backdrop, this study examines monetary policy transmission through the exchange rate channel in the case of Rwanda. Firstly, it evaluates the first stage of transmission, that is, whether monetary policy impulses affect exchange rates, using various models. Secondly, it evaluates the whole channel using the structural VAR framework and compares the strength of direct and indirect channels.

Identification of monetary policy shock has often been a challenge, especially in developing markets without advanced financial markets and this prevents the use of some identification schemes. Regarding the whole transmission channel, this study builds on the past literature especially studies which used a VAR framework and uses recursive identification and Bayesian estimation, which has many advantages especially when the sample period is relatively short. Regarding the first stage of transmission, this study adopted two approaches. One is based on the traditional UIP condition adapted to Rwanda realities. The second one is based on small VAR to address the possibility of simultaneity between interest rate and exchange rate as highlighted by Alper, Ardic, and Fendoglu (2009).

Results generally support the existence of the exchange rate channel in Rwanda. First, empirical evidence of the effect of policy impulse on the exchange rate suggests that the first stage of transmission exists, albeit with a partial pass-through. Secondly, the results show further evidence of transmission via the direct channel, where the effect of policy rate shock on the exchange rate is directly transmitted to inflation, and the peak impact is attained after four quarters. However, the indirect channel is quasi-ineffective, as the output response, though in the right direction, was not statistically significant.

The remainder of this study is as follows: the next chapter reviews the existing literature. Chapter 3 outlines the methodology including models, data, and identification strategy. Chapter 4 presents and discusses the empirical results and chapter 5 concludes.

2 Review of the Literature

This part mostly reviews previous studies on exchange rate channel. Recall that the empirical analysis focuses on whether and how monetary policy interventions affect FRW exchange rate as the first stage in the whole exchange rate channel of monetary policy transmission. Secondly, the transmission in the whole channel including both direct and indirect channels is assessed. Therefore, this literature review covers both areas.

On the first stage of transmission, this study assesses the uncovered interest parity (henceforth, UIP) condition in Rwanda as the main framework via which exchange rate dynamics are analyzed in new Keynesian monetary policy models. Considering that earlier studies on UIP conditions have yielded dismal results and the strong assumptions surrounding it, the first stage of transmission is also assessed via VAR framework.

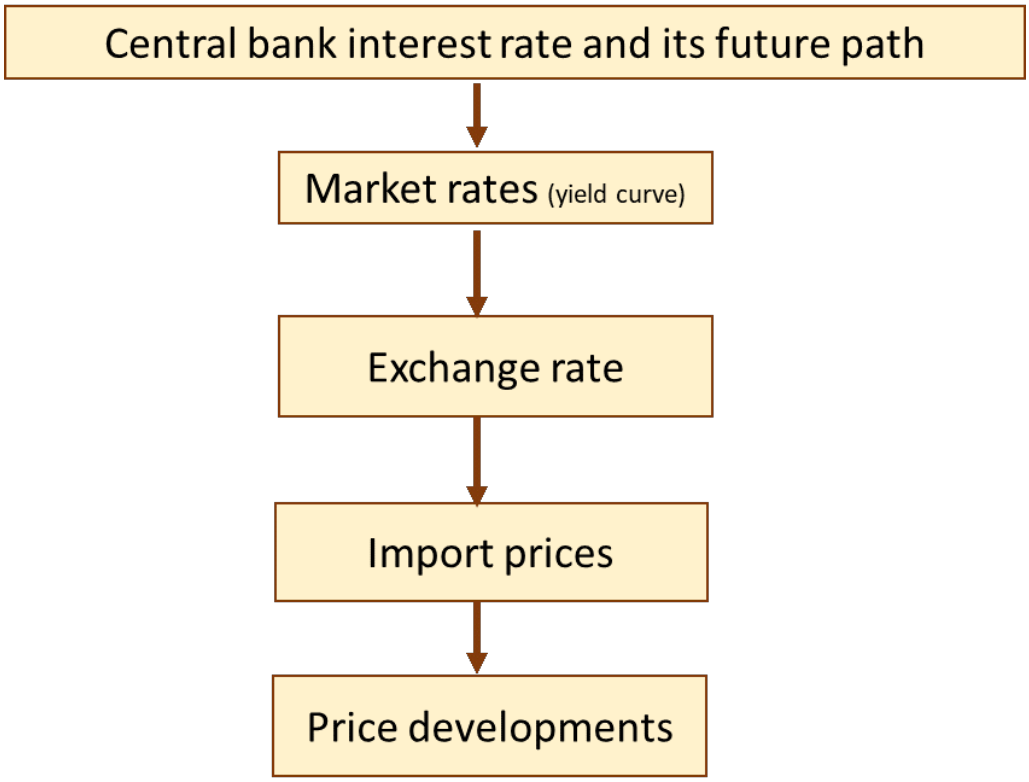
The second part encompasses the whole transmission channels notably how exchange rate movement affect domestic price inflation in a direct way, or indirectly via its effect on output and ultimately domestic price inflation in line with the Phillips curve.

Before discussing the literature, it is important to illustrate with figures, both direct and indirect exchange rate channels.

2.1 Conceptual framework

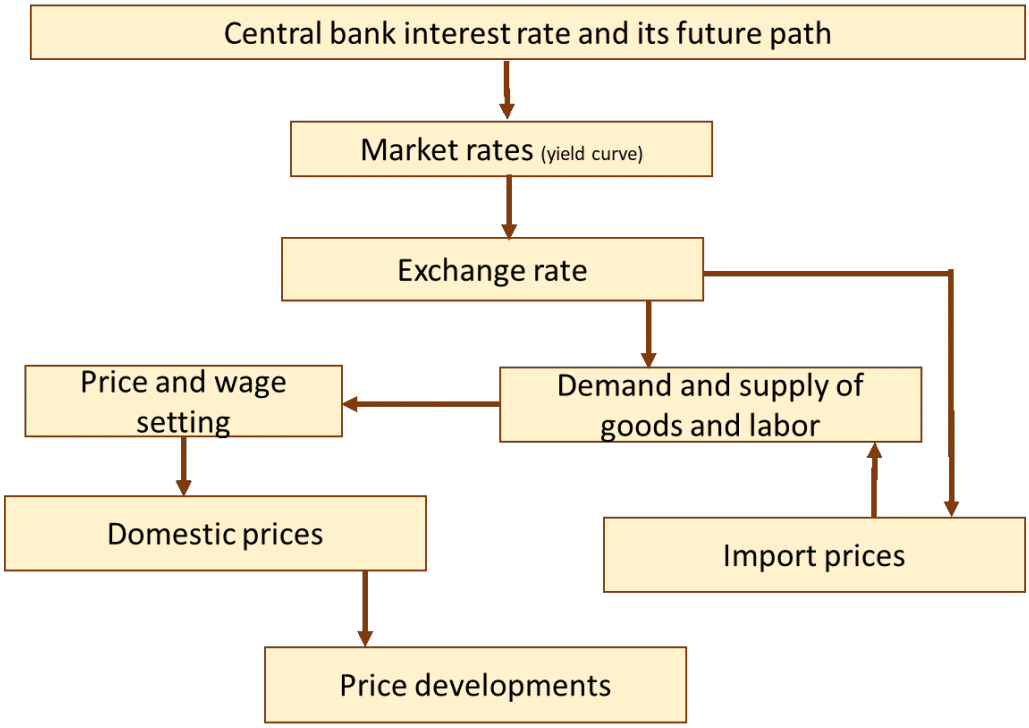
The figure 1 below depicts monetary policy transmission via the direct exchange rate channel. The channel operates through import prices. The transmission is rapid, and the impacts on prices (inflation) are immediate. From top to bottom, a change in the central bank rate directly affects market rates, then the exchange rate, which influences import costs, and finally, the total consumer price index components change.

Figure 1: Monetary Policy transmission, exchange rate channel (direct):



The figure 2 below illustrates the monetary policy transmission through the indirect exchange rate channel. In contrast to Figure 1, this channel operates via the influence on economic activity (demand and supply of goods and labor). The transmission is slow and has an indirect effect on prices (inflation). From top to bottom, a change in the central bank rate has an immediate impact on market rates, which affects the exchange rate. Exchange rate variations impact exports and imports following a substitution between foreign and domestic products and services. This impacts the overall demand and supply of goods, services, labor, and related prices. Finally, the components of the aggregate consumer price index change.

Figure 2: Monetary Policy transmission, exchange rate channel (indirect):



The following section reviews the literature on the first stage of transmission, focusing on the literature on the relationship between interest rate and exchange rate via UIP condition, its theoretical foundations, and results from some empirical studies.

2.2 Literature on the relationship between interest rate and exchange rate

In the new Keynesian monetary policy framework, the relationship between exchange rate and interest rates hinges on the UIP condition. The UIP is a no-arbitrage condition that tries to explain the relationship between the differential between the interest rate on an asset denominated in one currency and the interest rate on the same asset denominated in another currency and the expected change in the spot exchange rate between the two currencies (Isard, 2006).

The UIP concept is based on another close concept of covered interest parity (henceforth, CIP). The CIP postulates that an investor is indifferent between investing in an asset denominated in his country's currency with an expected return in the form of interest rate r_d and converting the sum in foreign currency at a future date and investing in foreign assets with interest r_f and converting it into domestic currency.

UIP condition hinges on interest arbitrage. Assumptions underlying the UIP condition include notably that assets are identical in terms of maturity, liquidity, and default risks, absence or negligible transaction costs and funds placed do not influence interest rate. Besides. UIP assumes exchange rate flexibility, perfect

capital mobility, and perfect asset substitutability and that agents have rational expectations and are risk neutral (Gandolfo & Federici, 2001).

Nevertheless, UIP has a number of challenges. The main is a lack of empirical evidence especially in studies on developed countries. In fact, while UIP postulates that the currency of a country with a higher interest rate will tend to depreciate, most empirical studies have refuted that and some have rather shown a currency appreciation (Rose & Flood, 2001).

One of the reasons suggested by Rose and Flood (2001) is that most of empirical test of UIP were on countries with low inflation and flexible exchange rate regime and that for countries with higher inflation and exchange rate volatility, or with lower financial depth, UIP can hold.

The empirical results from Rose and Flood (2001), show that for some countries, there are some signs of a UIP relationship as higher interest rates led to currency depreciation, although it was not a one to one relationship. Besides, country results were heterogeneous. Specifically, evidence of UIP condition was absent in countries with fixed exchange rate regimes.

Alper et al. (2009) argued that this absence of empirical evidence of UIP can be attributed to the fact that the two main assumptions in estimating the UIP conditions namely the rationality of agents and the absence of risk aversion, do not hold. In addition to other factors such as transaction costs, less developed financial markets, weaker institutions and macroeconomic fundamentals, and the possibility of central bank interventions, among others. Besides, differences in liquidity and credit risks between domestic and foreign assets would also affect UIP condition.

In particular, central bank interventions may also affect the UIP condition as the central bank interventions to influence exchange rate movement using the policy rate imply simultaneity between the expected changes in the exchange rate and interest rate differentials. According to Alper et al. (2009), this simultaneity would lead to a lower or even negative coefficient beta 1.

Earlier empirical studies on UIP generally found no evidence of UIP condition (e.g. (Froot & Thaler, 1990)). These studies found that coefficients on interest rate differential were less than 1 and even negative in some cases. This wrong direction in a change in the exchange rate is usually called the "forward premium puzzle". Other earlier studies estimated the equation including the proxy of risk premium. Taylor (1995) conducted a survey of some of these studies and show that the models with the risk premium failed to find evidence of UIP conditions.

According to Alper et al. (2009) most recent studies using more advanced quantitative techniques have come up with more UIP-compatible results. For instance, evidence of UIP was obtained in studies using short-term horizons like intraday frequency (e.g., Chaboud and Wright (2005)) and also for more than 1-year horizon (e.g., Chinn (2006)). Other studies (e.g. Choi and Zivot (2007)) highlighted the importance of taking into account structural breaks in estimating the UIP equations and show that considering structural break significantly improve the forward premium bias.

To address the simultaneity issue discussed above, a number of studies on the transmission from monetary policy impulse to exchange rate have used structural models such as VARs and DSGE. Some of these

intended to analyze the whole exchange rate channel, which is how monetary policy affects inflation via exchange, while others aimed only at the first stage of transmission, which is the effect of monetary policy shock on the exchange rate.

Similar to studies on UIP, empirical results highlighted a number of factors that influence the potency of the exchange rate channel including the level of economic development, liquidity, institutional strengths, and level of financial development among others (Hnatkovska, Lahiri, & Vegh, 2016).

For instance, Hnatkovska et al. (2016) study pointed out the difference between developed and developing countries regarding the response of exchange rate to monetary policy tightening where in developed countries, the exchange rate appreciated contrary to developing countries. (Eichenbaum & Evans, 1993)'s results for the US were in the same line and their approach was to some extent similar to (Hnatkovska et al., 2016), especially on identification as they used orthogonalized innovations in their VAR models. However, they considered alternative indicators of US monetary policy namely the federal funds rate, the ratio of non-borrowed to total reserves and Romer and Romer index. Other studies on developed countries (e.g., Kim and Roubini (2000)) have also yielded the same results.

Nevertheless, Cormun and De Leo (2018) highlighted the role of recursive identification in VARs as one of the reasons behind the puzzle of depreciation after monetary policy tightening. They argued that recursive identification confounds the effect of monetary policy shocks to the effect of news about the US business cycle and leads to the puzzle of depreciation after policy tightening. In their approach, they isolated the monetary policy response to US news, in order to identify pure monetary policy shock in developing countries and the results show that the puzzle disappeared as a monetary policy tightening led to exchange rate appreciation.

2.3 Literature on the whole exchange rate channel

Regarding studies on the whole transmission channel, the literature on both direct and indirect channel is vast. Apart from the DSGE approach, the structural VAR approach had been extensively used across different country cases, though the identification scheme could differ depending on the context. Variables used were more or less the same and included notably a measure of economic activity (real GDP or industrial production), a measure of price inflation, an indicator of monetary policy (policy interest rate or monetary aggregates), and the exchange rate (nominal, or nominal effective). Empirical evidence across numerous studies shows that transmission could be contingent on a number of factors including the monetary policy framework, the exchange rate regime, the level of dollarization the level of financial development.

Regarding the exchange rate regime as one of the important factors to be taken into account in studies on monetary policy transmission. Mishra, Montiel, and Spilimbergo (2012) discussed some characteristics of emerging and developing countries that may impair the transmission mechanism via the exchange rate channel, including the fact in these countries, central bank's intervention on exchange rate market is more likely. Previously, Goeltom et al. (2008) study for Indonesia had shown that the exchange rate regime was crucial as during the period when the exchange rate was managed, the transmission via the exchange rate channel was weak and when Indonesia adopted a floating exchange rate, the transmission got more significant especially via the direct channel. The possibility of an adverse effect of exchange rate management on transmission via exchange rate channel was also highlighted by Berg et al. (2013) in the case of East African Countries including Rwanda.

Another important factor is the level of dollarization as highlighted by Bordon and Weber (2010) in their study on Armenia. Using a Markov switching VAR to identify structural break separating the period before and after the adoption of inflation targeting and the period before and after dollarization. They analyzed different transmission channels and in particular, their results point out the strengthening of the exchange rate channel during the period of low dollarization. One of the explanations for this is the adverse effect of depreciation on agents' balance sheets which led to lower aggregate demand.

Indeed, the policy framework would heavily influence the transmission mechanism notably the adoption of inflation targeting-like frameworks, as indicated by evidences from studies on 40 emerging and developing countries (e.g. Brandao-Marques, Gelos, Harjes, Sahay, and Xue (2020)) and on 4 East African Countries (e.g. Berg et al. (2013)). On this one, Berg et al. (2013) showed that in 4 East African Community countries namely Kenya, Uganda, Tanzania and Rwanda, monetary policy framework impacted the transmission of monetary policy shock and across different channels notably interest rate, bank lending, and exchange rate channel. Using the narrative approach à la Romer and Romer, they argued that transmission was relatively more evident in Uganda and Kenya where regimes were similar to inflation targeting lite, contrary to Tanzania and Rwanda which at that time, had a less clear stance of their monetary policy according to the authors. Regarding the exchange rate channel in particular, they highlighted that central banks' intervention in forex market to smooth the exchange rate volatility could have impeded the transmission via the exchange rate channel in Rwanda. For the case of the three other countries, the transmission via direct exchange rate channel was evident. Other non-trivial factors include the level of financial development, central bank independence and transparency Brandao-Marques et al. (2020).

The identification of monetary policy shock has always been crucial in studies on monetary policy transmission mechanisms. On one side, most of the studies using the VAR framework identified monetary policy shock based on the Taylor rule relationship (removing the effect of output and inflation from the policy indicator) in some cases using recursive identification despite its shortcomings highlighted in previous sections. On the other side, the Romer and Romer narrative approach to identifying monetary policy shock is one of the alternatives to identification via structural VARs. In addition to the study by Berg et al. (2013) discussed in the previous section, another example using the Romer and Romer narrative approach is the study by De Fiore (1998) for the case of Israel, where the exchange rate channel as well as bank lending channel were found to be important and active.

Study by Brandao-Marques et al. (2020) on 40 emerging and developing economies used Taylor rule residual to identify monetary policy shock. They used the local projection method a la Jorda, in order to take into consideration, the interactions and possibility of non-linearities. Their model included the interaction of interest rate and nominal exchange rate and the results suggested that exchange rate amplifies the transmission of monetary policy shocks. Secondly, evidence of transmission via direct exchange rate channel as a contraction led to appreciation in the nominal effective exchange rate and a decline in prices.

In summary, studies with macro data used mostly VARs and DSGEs. For open developed economies with developed financial markets, most of the studies found evidence of transmission via the exchange rate channel (e.g.,Franta, Horváth, and Rusnak (2014) for the Czech Republic, Kearns and Manners (2018) for the case of Australia, New Zealand, Canada, and the UK). A number of studies on emerging economies generally found evidence of the transmission (e.g., Fetai and Izet (2010) for Macedonia).

For developing economies, empirical evidence is rather mixed, with the transmission but at different degree. For instance, transmission via exchange rate channel was found in Kenya by Davoodi et al. (2013)) and in Namibia by Sheefeni (2017), while results from other studies suggested limited transmission for Uganda ((Mugume, 2011)) and Morocco (Ouchchikh, 2018).

The present study borrows from these previous studies discussed above, while considering the realities of the Rwandan economy. Regarding the first stage of transmission, we adopt two approaches. First, considering the current policy framework, we assessed the relationship between interest rate and exchange rate, within UIP framework and take a more recent sample period, corresponding to the period when the NBR started to steer short-term interest rate. The risk premium will be proxied using the difference between the yields of 10Y Eurobonds with 10Y US T bonds. This first stage is assessed via single equation estimation as well as via VAR framework. This VAR framework help to deal with the simultaneity issues arising from the fact that monetary authorities may react to exchange rate movements using policy interest rate. The VARs will also include alternative indicators of monetary policy such as monetary aggregates, considering reforms made in monetary policy frameworks where in the past NBR used a monetary targeting framework before moving to price based monetary policy framework.

Secondly, we will analyze the whole MTM within structural VAR which has the advantage of considering many variables which may affect transmission from policy variable to exchange rate in line with the past studies summarized in the previous section.

3 Methodology

3.1 First stage of transmission

As mentioned in the previous section, the first stage of transmission is analyzed via the traditional UIP framework as well as via the VAR framework. The UIP assumes rational expectations, hence expected exchange rate at t+1 is equal to its realization.

These assumptions lead to the following equation:

$$S_{t+1} - S_t = b_0 + b_1(r_t - r^*) + u_{t+1} \tag{1}$$

This involves testing whether the error term is unbiased and orthogonal to information available at time t, and joint test whether $b_0 = 0$ and $b_1 = 1$.

Besides, this can be tested at different horizons. Important to note that empirical evidence has mostly rejected the two hypotheses at shorter horizons while some favorable evidence was found at longer horizons.

In line with Meredith and Chinn (1998) equation 5 can also be used to test for rational expectations in addition to the UIP condition. Under the assumption that the error term which combines both risk premia and errors is orthogonal, b1 should be equal to 1. Besides, Meredith and Chinn (1998) argued that even b_0 different from 0 can still be consistent with UIP if we assume that some investors are not risk neutral and the constant may represent a time-invariant risk premium.

Failure to find evidence of unbiasedness has led to different proposals to explain that bias. One is the existence of varying country risk premium given that market participants are less likely to be risk neutral. Another important one is the simultaneity between interest rate and exchange rate as monetary policy decisions on policy interest rate could take into account exchange rate movements.

To address the issue of simultaneity and considering the fact that the journey of monetary policy framework modernization involved evolution in monetary policy instruments, several bivariate VARs have been estimated, ranging from using the repo rate and reserve money as proxies of monetary policy and alternatively indicators of the FRW exchange rate, namely the FRW USD exchange rate and NEER. These include:

- Bivariate VAR with interest rate differential and log exchange rate;
- The same VAR model augmented with country risk premium;
- Bivariate VAR with reserve money/excess reserve with the exchange rate.

3.2 The whole exchange rate channel

To examine the whole exchange rate channel in Rwanda, a Bayesian VAR model was applied. From the literature, Bayesian methods have proven useful in the estimation of straightforward reduced-form VAR and deal with issues of lack of long series and risk of over-parameterization. The BVAR models started since the work of Doan, Litterman, and Sims (1984) based on Minnesota prior, which includes the prior mean of the VAR parameters to zero, and with a prior variance depending on two hyper parameters. This model estimation gives a good way of dealing with the issue of over-parameterization by integrating the past attained information.

Minnesota priors developed by Doan et al. (1984) and Litterman (1986) that include approximating the variance-covariance matrix, Σ ,with an estimate, $\Sigma^{\wedge}$. Therefore, priors need to be formed only for α,which considers this form:

$$\alpha \sim N(\bar{\alpha}_{Mn}, \bar{V}_{Mn}) \tag{2}$$

The Minnesota prior includes setting the elements of the parameter-prior $\bar{\alpha}_{Mn}$ and the covariance-prior $\bar{V}_{Mn}$. Still, the Minnesota prior considers the prior variance-covariance matrix, where $\bar{V}_{Mn}$ refers to the diagonal, meaning that there is no association among the coefficients of the different Vector Autoregressive equations. Besides, the diagonal elements of the prior variance-covariance matrix are such that the most current lags of a variable are likely to cover more information about the variable's recent value than previous lags. Furthermore, lags of other variables are expected to have less information than lags of own variables.

The benefit of the Minnesota prior is that the subsequent posterior of the parameter vector α has a normal distribution. This permits us to compute the posterior mean of the estimates without having to recourse to different sampling techniques, which also decreases computational time significantly. The recursive identification scheme used for the benchmark SVAR is conserved in the Bayesian VAR description.

Thus, our BVAR specification is presented in the form below: BVAR includes n variables and P lags

$$y_t = c + A(L)y_{t-1} + e_t \tag{3}$$

$$E(e_t,{}_t') = \varepsilon_t \tag{4}$$

y_t is $Kx1$ vector of endogenous variables in period t, A_i is the coefficient matrix matching to the ith lag of y_t, c is the constant deterministic term and ε is an error term with zero mean and variance-covariance. Furthermore, the number of parameters in c and A is $n(1 + np)$. In addition to autoregressive adjustment throughout the prior's settings, some other adjustments of the degree about the overall tightness hyper-parameter, the relative cross-variable weight hyper-parameter, the lag decay hyper-parameter and the exogenous variables hyper-parameter were vital to be identified. Generally, Bayesian coefficient estimates combine information in the prior with evidence from the data. It captures changes in beliefs about parameters, priors, which means initial beliefs (e.g., before data are seen), while the posterior means new beliefs (initial beliefs + evidence from data). The BVAR estimation focused on the equation made by food inflation, GDP non-agriculture, headline inflation, credit to private sector, nominal exchange rate and policy rate.

By applying the Minnesota prior to equation on equation (2), the values for the prior are: $l1 = 0.3, l2 = 0.8, l3 = 1.5$, and $\mu_1 = 100$, to represent the overall tightness hyper-parameter, the relative cross-variable weight hyper-parameter, the lag decay hyper-parameter, the exogenous variables hyper-parameter, respectively.

3.3 Data and motivation

This section describes data used for both first stage of transmission and the whole transmission channel. Starting with the first stage, specifically on the UIP, the expected exchange rate is equal to realized one as data on expectations are not available. Interest rate are alternatively, interbank rate or the T-bills rate. Country risk premium is proxied by the spread between the yield of Rwanda 10 years Eurobond and the 10 years US Bond. The data on these to variables are obtained from Bloomberg.

Regarding the whole transmission channel, some of the macroeconomic indicators are selected based on their significance on the domestic economy, and theoretical literature, which are considered in the analysis including international food prices, domestic economy proxied by non-agriculture output, headline inflation, credit to the private sector, nominal exchange rate and policy rate which is a weighted average of repo and reverse repo. International food prices are sourced from World Bank ; non-agriculture output and headline inflation from National Institute of Statistics of Rwanda and the rest are obtained from National Bank of Rwanda.

The study uses quarterly data from 2006q1 until 2022q2, and these were treated to facilitate the interpretations and have good estimates with precision to guide policymakers especially when it comes to monetary policy decision-making. Data are seasonally adjusted, and transformed into log difference. Thus, all series were stationary. On the UIP condition, data used are monthly and the sample began in 2013 when the NBR started to pursue flexible monetary targeting with the aim of steering the interest rate in preparation to move to an interest rate-based monetary policy framework.

Regarding the identification strategy, on the Bayesian VAR, we apply recursive identification with Cholesky decomposition in line with some past literature on monetary policy transmission (e.g. (Eichenbaum and Evans (1993), Davoodi et al. (2013)) and considering the reality of the Rwandan economy.

This identification scheme requires a specific ordering of variables, starting from the most exogenous onwards. Thus variables were ordered starting with global food prices, followed by non-agriculture GDP, headline inflation, credit to the private sector, nominal exchange rate of FRW against USD, and policy rate proxied by weighted average of interest rate on repo and reverse repo operations. The policy rate is ordered last as it has been the main monetary policy instrument since the end of 2012 when NBR started to use flexible monetary targeting. This allows for controlling innovations in other variables ordered ahead and this is in line with the policy framework where the policy rate is endogenous to those macroeconomic variables.

4 Results

4.1 Estimation results

Equation 1 was estimated using the least square methods and results show no evidence of UIP as the coefficient of interest rate differential was not statistically different from zero. The alternative specification which included the risk premium as the additional independent variable also didn't yield evidence of UIP in Rwanda. Results from a simple VAR model with interest rate differential and change in log of FRW exchange rate also did not provide empirical evidence of UIP relationship in Rwanda. However, knowing the issue of endogeneity between interest rate and exchange rate, this would not necessarily imply the absence of a relationship between interest rate differential and exchange rate.

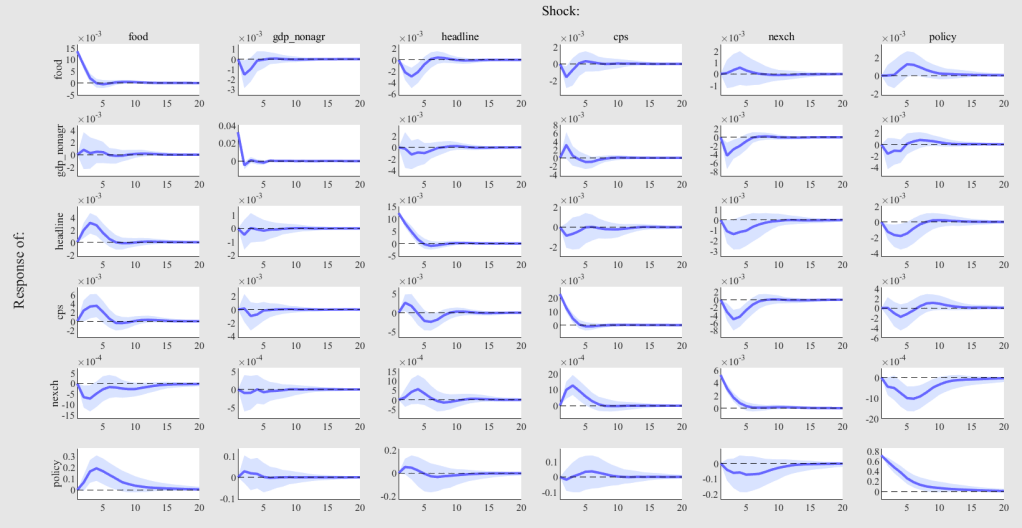
Meanwhile, a simple bivariate VAR estimation with the policy rate and the change in log of FRW exchange rate show rather some signs of transmission in the first stage. The increase in repo rate leads to a deceleration in depreciation as expected, while an increase in the rate of change in reserve money leads to more depreciation although not statistically significant. Considering the NEER as an alternative indicator for the exchange rate, its reaction to either the shock on repo rate is in the right direction as an increase in policy rate lead to a deceleration in depreciation, however, it is not statistically significant.

Regarding the whole transmission channel, results from the Bayesian VAR estimation described in the previous section, indicate the presence of transmission via direct channel. An increase in policy rate leads to a deceleration of the FRW depreciation and headline CPI inflation. The effect on headline inflation starts to appear in the next quarter and peaks in the 4th quarter as shown in the next figure. In addition, the transmission is incomplete as the dynamic pass-through elasticity is very low (-0.0012).

Nevertheless, there is no solid evidence of an indirect channel. In fact, there are encouraging signs as the reaction of the output is in the right direction as the appreciation of the exchange rate leads to a decline in the output, but not statistically significant; This may be due to the limited impact of the changes in relative prices on net exports and output (lower price elasticity of import and export).

In terms of speeds of transmission, prices react relatively more quickly to the initial impact of a monetary policy shock and after reaching the maximum in the fourth quarter, the impact of these shocks becomes weaker over time and produces less persistent effects on prices. This is relatively quicker compared to other case studies such as the study of Franta et al. (2014) showed that the extreme impact of a monetary policy shock on prices/inflation occurs approximately four to eight quarters after the shock in Czech Republic.

Figure 3: Impulse response function from Bayesian VAR estimation



Source:Author's computation

4.2 Discussion of results

Previous studies on Rwanda (Berg et al. (2013) and Davoodi et al. (2013)) had not found evidence of an exchange rate channel of monetary policy transmission. Important to note that the sample period was mostly prior to monetary policy reforms. Berg et al. (2013) argued that it was hard to disentangle the channel due to the prevailing exchange rate policy regime during the decade 2000-2010.

Our findings suggest that with reforms in policymaking and monetary policy framework in particular, the exchange rate channel has become potent in monetary policy transmission in Rwanda. Nevertheless, the bulk of evidence points out to the direct channel where the effect on the exchange rate is directly transmitted to price inflation while the effect via the indirect channel is quasi-absent as the impact on output is not statistically significant though in the right direction.

The absence of an indirect channel can be associated to among others the inelasticity of tradable goods, services, and factors of production in Rwanda. Nuwagira and Muvunyi (2016) found some impact of change in the exchange rate on the current account in Rwanda. However, the export sector was less sensitive to changes in exchange rates. This is mostly due to the structure of Rwanda's exports which has historically been dominated by commodities such as minerals, tea, and coffee whose prices and demand are more dependent on the global economic situation.

On this, ongoing initiative to diversify Rwanda exports could lead to more responsiveness of exports on change in FRW exchange rate and subsequently more potent exchange rate channel. Due to data unavailability, we could not properly analyze whether these initiatives undertaken in the last 5 years have led to some improvements. Future analysis would shed more light on this.

4.3 Robustness check

We checked the robustness of our results by estimating the same version of VAR model but using maximum likelihood estimation and with recursive identification of monetary policy shock and the change in log of FRW nominal exchange rate instead of the nominal effective exchange rate.

Results were generally in line with the Bayesian estimation discussed above, with minor exceptions. One is the response of FRW exchange rate depreciation on policy shock. Though it is in the right direction, it seems to appear in the 3rd and 4th quarter after the policy shock. This may be attributed to the fact that maximum likelihood estimation gives more weight to information from data compared to Bayesian estimation and our sample period includes the period prior to 2013 monetary policy reforms where the repo rate was not always reflecting the policy rate and the nominal FRW exchange rate was relatively less flexible as it currently is. Another exception is the reaction of output gap to shock on repo rate, which is statistically significant this time contrary to the case of Bayesian estimation.

5 Conclusion and policy recommendation

The effective implementation of monetary policy requires to understanding of the channels of the transmission mechanism for monetary policy and how it influences other macroeconomic variables. This study assessed how the monetary policy is transmitted through the exchange rate channel in the case of Rwanda. The examination of this channel was performed using bivariate VARs to examine the first stage and Bayesian VARs models to evaluate the whole channel. Empirical results revealed that in Rwanda, the transmission of the monetary policy via the exchange rate channel exists.

First, there is evidence of the first stage of transmission, which is the effect of policy impulse on the exchange rate. Secondly, the results show further evidence of transmission via the direct channel, where the effect of policy rate shock on exchange rate is directly transmitted to inflation, and the peak impact is attained after four quarters. However, the indirect channel is ineffective, as the output response, though in the right direction, was not statistically significant.

Taking stock of these results, the effectiveness of NBR policy move is reinforced by subsequent change in FRW exchange rate and this can be crucial in achieving price stability. Besides, the current analysis of monetary conditions which combines both policy rate and exchange rate provides a better picture especially in terms of future inflation path. Therefore, NBR interventions to tame exchange rate volatility via selling or buying of foreign currencies to the market, can be equally important in the current framework, if this is not excessive to alter the trend of exchange rate depreciation and take into consideration the level of reserves.

The quasi-absence of the indirect channel is a reminder that economic structural reforms that could boost productivity in tradable sector and reduce Rwanda's external imbalance, as well as financial sector development, and policy implementation must continue.

Lastly, with past evidence of bank lending channels in Rwanda, both channels can supplement each other and reinforce NBR policy transmission. Further research is needed with the enriched dataset to continue monitoring the functioning of the transmission mechanism in Rwanda and support evidence-based decision-making.

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Appendices

Appendix A Appendix A : OLS estimation of UIP equation

Dependent Variable: DL_RWF_USD
Method: Least Squares
Date: 08/03/23 Time: 11:53
Sample (adjusted): 2013M05 2022M06
Included observations: 110 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INTEREST_DIFF	-0.01263	0.020046	-0.63014	0.5299
C	0.475307	0.075065	6.331937	0

R-squared	0.003663	Mean dependent var	0.430273
Adjusted R-squared	-0.00556	S.D. dependent var	0.240202
S.E. of regression	0.240869	Akaike info criterion	0.008888
Sum squared resid	6.265937	Schwarz criterion	0.057988
Log likelihood	1.511138	Hannan-Quinn criter.	0.028803
F-statistic	0.397078	Durbin-Watson stat	0.592477
Prob(F-statistic)	0.529933		

Appendix B Appendix B : OLS estimation of UIP equation with risk premium

Dependent Variable: DL_RWF_USD
Method: Least Squares
Date: 08/03/23 Time: 11:53
Sample (adjusted): 2013M05 2022M06
Included observations: 110 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INTEREST_DIFF	-0.01263	0.020046	-0.63014	0.5299
C	0.475307	0.075065	6.331937	0

R-squared	0.003663	Mean dependent var	0.430273
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Log likelihood	1.511138	Hannan-Quinn criter.	0.028803
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