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A New Look at the Bank Lending Channel of the Monetary Policy Transmission Mechanism in Rwanda

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Abstract

This paper investigates the existence of the bank-lending channel in the transmission of monetary policy in Rwanda for the period 2014Q1 to 2022Q4. We directly estimate the loan-supply equation using the recently developed bootstrap bias-corrected Least Square Dummy Variable (BC-LSDV) technique. The findings indicate that there is evidence of an operational bank lending channel in Rwanda. The interaction term between central bank indicator with capital and liquidity does not appear to be a relevant factor in determining the differential impact of monetary policy on the lending behavior of banks. Further, segregating banks by size, we find that the effect of monetary policy is more pronounced for the medium-sized banks compared to larger sized banks. The findings provide support for the central bank's recent move from monetary targeting to price-based monetary policy to strengthen the effectiveness of the monetary policy. It is therefore important that the National Bank of Rwanda explores the set of tools in its purview to ensure that policy changes affect loan portfolios of the entire bank system as intended.

KeyWords: Monetary policy transmission mechanism, Bank lending channel, Panel data bootstrap bias-corrected least square Dummy variable.

JEL Classification Numbers: C33, E44, E52, G21.

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1. Introduction

The mechanism through which monetary policy is propagated to the real economy remains a puzzle in monetary policy analysis. Extensive studies such as Boukhatem and Djelassi (2022) , Disyatat (2010) and Mumbi (2018) have recently investigated the role played by banks in the monetary policy transmission mechanism aimed at uncovering a bank lending channel and assessing their relative significance in monetary policy. The monetary policy channels[1] behave differently across countries, widely due to variations in the level of financial sector development, and macroeconomic and structural conditions, among other factors. The perception of the mechanism through which monetary policy decisions are propagated becomes essential in achieving the central bank's ultimate objectives of price and macroeconomic stability, which would be particularly important for the National Bank of Rwanda.

In Rwanda, the financial system is dominated by banking institutions, leaving banks as the main sources of funding for individuals and businesses. According to studies such as Mishra et al. (2012); Kamanzi et al. (2019); Bernanke and Blinder (1988); Bernanke and Gertler (1995)has been observed that financial markets in developing countries exhibit lower changes in lending rates. As a result, the effectiveness of the monetary policy transmission mechanism is limited, and its impact is more noticeable in developed countries with developed financial systems. Bernanke and Gertler (1995) demonstrated that the possible effect of monetary policy on the supply of loans from the banking system highlighting the important role that banks play in the economy by facilitating savings– investment process known in the literature as the bank-lending channel. For example, an expansionary monetary policy injects new reserves into the banking system, which in turn triggers banks into raising the

[1] Interest rate, bank lending, exchange rate, expectations, and asset price channels

supply of loans, which in turn leads to an increase in investment spending and economic growth.

Literature shows that undeveloped financial markets and a rigid exchange rate regime leave little room for the interest rate to play a role in the monetary transmission mechanism, which requires more studies on the bank lending channel not only to have a better choice of intermediate targets but also to act as a basic channel for monetary policy decisions to influence economic activity. In particular, if the lending channel is an important part of the transmission mechanism, then the banks' asset items should be the focus of more attention. The importance of the lending channel depends on the extent to which banks adjust their loan supply following changes in bank reserves as a reaction function to central bank decisions. In such circumstances, there is little scope for the functioning of the conventional interest rate channel, because alternative channels are likely to be weak, and banks are by far the dominant formal financial intermediaries in developing economies (Mishra et al., 2012) .

While the previous empirical studies widely use time series techniques to examine the effectiveness of the interest rate channel of monetary policy in Rwanda, the more recent researches tend to focus on individual bank behaviour using panel data models. The only study specifically on the bank lending channel of monetary policy transmission in Rwanda conducted by Kamanzi et al. (2019) showed that the bank loan supply rises in response to expansionary monetary policy, although its effect remains limited.

The objective of this paper is to assess the existence of the bank lending channels of monetary policy transmission in Rwanda by utilizing disaggregated bank-level data and exploiting the heterogeneity of banks' responses to monetary policy decisions. The testing of the bank lending channel has gained importance not only due to the recent shift of monetary policy framework but also, the significant structural change witnessed by the Rwandan banking sector in both operation and regulation. This study departs from previous studies, particularly the study done by Kamanzi et al. (2019) on a specific case of Rwanda using the Generalized Method of Moments (GMM). The problem with the GMM estimator is that it is usually suitable for large cross-section units and can be severely biased and imprecise in panel data with a small number of cross-sectional units similar to the current study. Following the shortcomings of the GMM estimator, we apply the recently developed bootstrap bias-corrected LSDV estimator proposed by De Vos et al. (2015) which is shown to have superior small-sample properties compared to GMM estimators and maintain relatively small coefficient uncertainty while removing most of the bias. In addition, it allows for heteroscedasticity and has the potential to be applicable in non-standard cases through adequate modification of the bootstrap resampling scheme.

The rest of this study is organized as follows. Section 2 describes Literature Review. Section 3 presents the Rwandan sector. Section 4 indicates Econometric Framework and Data Issues, while Section 5 reports the empirical results and Section 6 describes the conclusion.

2. Literature Review

2.1. Theoretical Framework

Bernanke and Gertler (1995) provide a comprehensive theoretical framework that explains the bank lending channel and its role in the transmission of monetary policy. The authors highlight the significance of banks as financial intermediaries and their unique role in the credit creation process. In this study, we present an alternative view of the bank lending channel within the IS/LM framework. This alternative perspective enhances our understanding of the bank lending channel's role and contributes to a more nuanced analysis of monetary policy's impact on the economy. On the one hand, the model will help us to understand the identifying restrictions underlying the econometric approach, followed in the empirical literature to uncover the lending channel, and, on the other hand, will enable us to define a testing strategy. The model draws heavily on Bernanke and Blinder (1988); Opolot (2013); Kishan and Opiela (2000) and departs from their model in the way money supply modeled and monetary policy is implemented.

Let us assume that we have an economy with three different agents or sectors and four assets. The agents are the non-banking sector, the banking sector, and the central bank. The central bank sets monetary policy either by changing the reserve requirement ratio, setting the discount interest rate, or controlling the bond rate by conducting open market operations. In either case, banks react by changing the amount of reserves as well as the other items on their balance sheets. In our model, we explicitly assume that the central bank sets monetary policy by changing the discount rate or the money market rate, but the model can easily be adapted to deal with other monetary policy instruments. The four assets are deposits held by the private sector with banks, loans granted by banks to the private sector, reserves held by banks for legal and liquidity reasons and bonds held by banks for liquidity reasons and by the non-financial sector for liquidity and or portfolio motives. For the money market, we assume a conventional LM curve[2].

[2] The curvature of the conventional LM curve represents the shape or slope of the relationship between the interest rate and the level of real income or output. It is typically upward sloping with a moderate degree of curvature, indicating that as the interest rate increases, the impact on income or output diminishes. Factors such as money supply and money

The demand for money (in the form of deposits held with a typical bank) by the non-monetary sector is the conventional money demand function

$$d_t^d = \alpha_0 + \alpha_1 \underset{(+)}{y_t} + \alpha_2 \underset{(-)}{\pi_t} + \alpha_3 \underset{(-)}{I_t} \tag{2.1}$$

where d_t^dstands for the nominal deposits held by the private sector at a typical bank,y_t a scale variable (for instance real GDP), π_t the inflation rate, and i_t the interest rate on bonds. Below each coefficient in equation (2.1) is the corresponding expected sign according to the conventional economic theory.

We write the (real) money supply as

$$d_t^s = \beta_0 + \beta_1 \underset{(+)}{R_t} + \beta_2 \underset{(+)}{l_t} + \beta_3 \underset{(+)}{i_t} + \beta_4 \underset{(-)}{r_t} \tag{2.2}$$

where R_t stands for the bank reserves, l_t for the interest rate on loans, $i_t$for the interest rate on bonds, and $r_t$for the relevant monetary policy interest rate controlled by the central bank. We note that equation (2.2) should be perceived as a simplification of the textbook equation, according to which the money supply is equal to bank reserves times the money multiplier, which, in turn, is a function of $l_{t,}i_{t,}r_t$and the required reserve ratio (assumed constant for simplicity).

In equilibrium equations (2.1) and (2.2) determine the equilibrium interest and the equilibrium quantity of money for given$y_{t,}\pi_{t,}l_t$ and r_t. Let us now focus on the credit market. The loan demand by the non-banking sector may be specified as

$$c_t^d = \delta_0 + \delta_1 \underset{(+)}{y_t} + \delta_2 \underset{(-)}{\pi_t} + \delta_3 \underset{(-)}{i_t} + \delta_4 \underset{(+)}{l_t} \tag{2.3}$$

where y_t captures the transactions' demand for credit, π_t the uncertainty in the economy, and i_t the possibility of the private sector having access to sources of funding that are not perfect substitutes for bank loans. The null $\delta_3 \neq 0$captures the idea that borrowers cannot fully insulate their real spending from changes in the availability of bank credit.

For the loan supply, we have

$$c_t^s = \gamma_0 + \gamma_1 \underset{(+)}{d_t} + \gamma_2 \underset{(-)}{\pi_t} + \gamma_3 \underset{(+)}{i_t} + \gamma_4 \underset{(-)}{i_t} \tag{2.4}$$

It is assumed that loan supply depends on the level of total deposits held by the private sector with the banks, on the inflation rate as a measure of uncertainty in the economy as well as on the loan and bond interest rates (Bernanke and Blinder, 1988) . Assets held by banks in the form of bonds are seen as substitutes for loans, held mainly for liquidity reasons. The null $\gamma_1 \neq 0$in 2.4) captures the idea that banks cannot shield their loan portfolios from changes in monetary policy, i.e., from changes in deposits brought about by monetary policy, and plays a central role in our analysis. Also important is the coefficient γ_3 as it determines the slope of the supply curve[3] . Equilibrium in the credit market will determine the equilibrium loan interest rate l_t , and the equilibrium quantity of real bank credit, C_t^s for given y_t , $C_t^d\pi_t$, and i_t . Finally, plugging the equilibrium values for i_t and C_t^d obtained from the money market into the equilibrium equations for l_t and C_t^s, we find the reduced form equations for l_t and C_t^s as a function of the exogenous variables of the model: $R_t y_t$, π_t and r_t.

The lending channel operates through shifts in the loan supply curve in response to changes in monetary policy. To see how it operates in our model, let us assume, for instance, that the central bank increases the discount rate,r_t

This will reduce the equilibrium quantity of money in the economy, i.e., deposits in our model, through the interaction between money supply and money demand schedules i.e., (2.1) and (2.2). In turn, the drop in deposits held by the private sector with the banks shifts the loan supply schedule upwards if $\gamma_1 > 0$in (2.4). It is this additional transmission mechanism – the upward shift in the supply of loans – which is known in the literature as the bank-lending channel.

As mentioned above, at the micro level the existence of a lending channel rests on the assumption that banks cannot easily replace lost deposits with other sources of funds, such as certificates of deposits or new equity issues, or by selling securities. Otherwise, we would expect $\gamma_1$not to be significantly different from zero. Of course, for the upward shift to occur the supply curve cannot be horizontal. In other words, we need the additional assumption that γ_3 (2.4) is finite. To test the existence of the credit channel and evaluate its importance we need to estimate γ_1 and γ_3 in equation (2.4), test whether γ_1 is positive and significantly different from zero and that γ_3 is not very large. The credit channel is more important the larger γ_1 and the smaller γ_3.

Incorporating the bank lending channel into the IS/LM framework, have contributed to a more comprehensive understanding of the dynamics at play. These alternative perspectives have challenged traditional assumptions and

demand dynamics contribute to the curvature. However, the curvature can vary depending on assumptions and model specifications.

[3]The slope of the loan supply curve indicates the responsiveness of loan supply to changes in the interest rate. A steeper slope suggests a higher cost of borrowing and a more elastic loan supply, while a flatter slope indicates a lower cost of borrowing and a less elastic loan supply. The slope provides insights into how lenders adjust their lending behavior in response to interest rate changes, influencing credit conditions and economic activity.

enriched the analysis of how changes in monetary policy affect bank lending and the broader economy and help us to identify important variables to be used in our model specification in the rest of the study.

2.2. Empirical Review

The empirical review on the bank lending channel examines the evidence from various studies investigating the relationship between monetary policy, bank lending, and its impact on the economy. Through rigorous analysis of data, methodologies, and econometric techniques, researchers have shed light on the existence and mechanisms of the bank lending channel. This review critically evaluates the empirical findings, highlighting key results and methodological nuances. By synthesizing the empirical evidence, we gain a deeper understanding of the role played by the bank lending channel in transmitting monetary policy effects to the broader economy.

Empirical findings on the effectiveness of the bank lending channel in the monetary transmission mechanism are rather mixed. Walker (2012); Matousek and Solomon (2017); Ehrmann et al. (2003); Havrylchyk and Jurzyk (2005); Nickell (1981); Everaert and Pozzi (2007) investigated the existence of bank lending channels in the East African Community (EAC) namely Burundi, Kenya, Rwanda, Tanzania, and Uganda. The study applied different GMM techniques to micro-level data for the period 1993 to 2008. The results revealed stronger evidence of bank lending channels for well-capitalized banks and smaller banks as compared to better-capitalized banks and larger banks. In addition, it established that this particular outcome was of a more economically significant magnitude. The findings alluded to the common supposition that a bank lending channel of monetary policy transmission exists for EAC economies when considered as a whole, and the study considered this as fundamental to a proposed creation of a monetary union. However, liquid asset ratios were found to be of less significance in explaining bank credit supply or the extent to which credit supply reacts to tight monetary policy.

Using GMM on bank-specific panel data, Opolot (2013) and Matousek and Solomon (2017) confirm the existence of bank lending channels in Uganda and Nigeria respectively. Both studies found that individual bank characteristics such as liquidity and capitalization influence loan supply. More liquid and highly capitalized banks in Uganda were found to react less strongly to monetary policy changes than less liquid, less capitalized banks supporting the findings by Walker (2012) for Uganda. In Nigeria however, bank characteristics were found to be more responsive to changes in money supply other than interest rates.

The Bank lending channel was also confirmed to be effective in South Africa by Sichel (2005), using quarterly bank-level data for the period 2000Q1-2004Q4. The dynamic panel estimation methods have been utilized and the results showed that an increase in the repo rate was associated with a decrease in the supply of loans. However, the loan supply of large and highly capitalized banks was found to be more resilient to adjustments in monetary policy confirming the assertion by Bernanke and Gertler (1995), Kishan and Opiela (2000), and Kashyap and Stein (1995) also report the existence of bank lending channels with small, less liquid undercapitalized banks being most responsive to monetary policy. Using micro-firm level data from Bank-Scope and macro country-level data from WDI databases, Amidu (2014) investigated broad determinants of credit supply in 26 sub-Saharan African (SSA) countries for the period 2000 to 2007. The study, which employed a two-step system GMM estimator, found that real interest rates significantly reduced bank lending in SSA in general but only for EAC when the study considered regional groupings. The analysis also found that bank size had significant positive effects on credit supply in ECOWAS, EAC SADC, and SSA in general. However, the results found significant adverse effects of capitalization only for ECOWAS and EAC where a capitalization reduction translated into a decrease in credit supply. Macroeconomic condition as expressed through GDP per capita growth was found to influence bank lending significantly only in SSA in general and SADC in particular, but not for other economic blocs.

Motivated by the lack of assessment of the financial reforms, deregulation, consolidations, financial innovations, and joint payment systems, Lungu (2008) assessed the process of monetary transmission mechanism by investigating evidence of a bank lending channel in SADC during the period 1990– 2006 using data from the banking sector. The study applied a vector autoregression (VAR) model to data from all SADC countries in the sample to identify shifts in the loan supply curve in response to changes in monetary policy. The findings revealed mixed results but overall the study found evidence of the existence of a bank-lending channel in all SADC countries in the sample. Further, the study found that the take-off point for monetary policy effects differs from one country to another.

Another study on bank lending channels involved a transition economy—Poland. Specifically, Havrylchyk and Jurzyk (2005) studied the impact of monetary policy upon lending channels. The data was obtained from balance sheets of 109 banks and 5 large credit unions in Poland during times of expansionary monetary policy from 1995 to 2002. Their results generally disagree with the bank lending channel hypothesis although they find some evidence of bank lending channels based on size characteristics. The findings of the study further revealed that there were significant differences between foreign and domestic banks in their responses to changes in short-term interest rates as foreign banks reacted more strongly than domestic banks.

In the specific case of Rwanda, the study done by Kamanzi et al. (2019) showed that bank loan supply increases following an expansionary monetary policy, although its effect is still limited. Therefore, the debate on the existence of bank lending channel remains inconclusive given mixed empirical findings. It is worth emphasizing that the majority of reviewed empirical literature reports the existence of bank lending channel, more generally dependent on the health and size of the banking sector. The healthier and bigger the sector, the weaker the expected effect of monetary policy actions; the weaker the banking sector the stronger the expected impact of monetary policy movements.

3. Rwandan Banking Sector

The banking sector plays an important role as a financial intermediary and primary source of financing for the private sector. Banks are the main providers of essential financial services, and their development has been of paramount importance in facilitating and supporting the economic growth, and transformation process in Rwanda.

The banking sector remains a dominant in the Rwandan financial sector, accounts for, on average, over 65.0 percent of the total financial sector assets in the last five years (see annex 1). Given its significant size in the financial system the banking sector remains the largest source of financing to the broader economy. Therefore, the usefulness of monetary policy through the bank lending channel is anticipated to reflect the market structure and intensity of competition in the financial system.

Despite an increase in the number of commercial banks during the past two decades, the Rwandan banking sector has remained highly oligopolistic in nature. The market structure indicates that the five large banks account for more than 80 percent of total loans and 77 percent of total assets of banking sector (see annex 2).

Figure 1 shows the heterogeneity of banks to react on monetary policy decisions. Thus, for large banks, monetary policy effects may be attenuated by the strength of their specific bank characteristics while tight monetary policy reduces loan supply for small and medium banks

4. Econometric Framework and Data Issues

4.1. Estimation strategy

This study relies on the panel data approach, where the behavior N of cross-sectional units is observed overtime, providing a solution to accommodate the joint occurrence

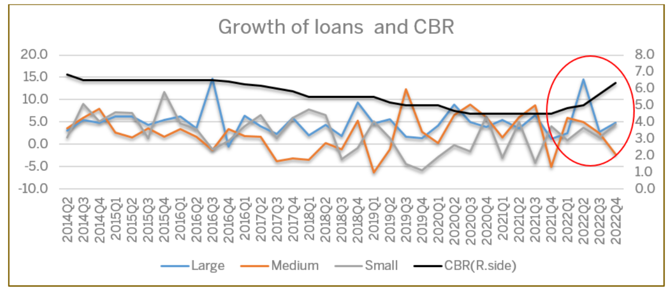

Figure 1: Growth of loans and Central Bank Rate (CBR)

of dynamics and unobserved individual heterogeneity in examining bank lending channels for Rwandan monetary policy. Let us consider a homogeneous dynamic panel data model of order ρ

$$Y_{it} = \alpha_i + \sum_{s=1}^{\rho} \gamma_s y_{i,t-s} + x_{it}\beta + \varepsilon_{it} \tag{4.1}$$

With$i = 1, ..., N$ and $t = 1, ..., T$ being the cross-section and time-series dimension respectively and where y_{it} is the dependent variable, x_{it} is a $(1 \times (k - \rho))$vector of strictly exogenous explanatory variables, where k is the total number of time-varying regressors, and α_i is an unobserved individual effect that may be correlated with x_{it} and ε_{it} is the error term, assuming that it is serially uncorrelated, both within and over cross-sections.

To simplify the notation, we assume that the initial values $(y_{i,-(\rho-1),...,}y_{i0})$ are observed such that T is the actual time series dimension available for estimation. However, since Nickell (1981) showed that the Least Square Dummy Variable estimator (LSDV) is not consistent for finite t in autoregressive panel data models, several consistent instrumental variables (IV) and Generalized Method of Moments (GMM) estimators have been proposed in the econometric literature as an alternative to LSDV (see Anderson and Hsiao (1982) Arellano and Bond (1991); Blundell and Bond (1998)). The IV and GMM estimators are consistent for N large, so they can be severely biased and imprecise in panel data with a small number of cross-sectional units which is our case (Bun and Kiviet (2006); Ziliak (1997); Bun and Windmeijer (2010)Roodman (2009)).

Following the shortcomings of the IV and GMM estimators, Kiviet (1995) introduced a group of bias-corrected LSDV estimators which are shown to have superior small-sample properties compared to GMM estimators and maintain relatively small coefficient uncertainty while removing most of the bias. Soon after, the bootstrap bias-corrected LSDV estimator merged in econometrics literature (De Vos et al., 2015), with a few modifications to the Kiviet (1995) estimator, allowing for heteroscedasticity, It is similar to those of the Kiviet (1995) correction but, has the potential to be applicable in non-standard cases through an adequate modification of the bootstrap resampling scheme.

Stacking observations over time and cross-sections we gain,

$$y = W\delta + D\alpha + \varepsilon \tag{4.2}$$

Where y is the $(NT \times 1)$ vector stacking the observations$y_{it}, W = (y_{-1,...,}y_{-\rho}X)y_{it}, W = (y_{-1,...,}y_{-\rho}, X)$, is the $(NT \times k)$ matrix stacking observations on the lags of the dependent variable $(y_{i,t-1,...,}y_{i,t-\rho})$ and the exogenous explanatory variables x_{it} , $\delta = (\gamma^{'}, \beta^{'})^{'}$is the $k \times 1$ parameter vector of interest, and D is a $NT \times N$ dummy variable matrix calculated as $D = I_N \otimes \iota_T$

$D = I_N \otimes \iota_T$ with $T \times 1$ a vector of ones. The variance-covariance matrix ε is denoted $\in$. Let $M_D D = I_N \otimes (I_T - D(D^{'}D)^{-1}D^{'})$

signifies the symmetric and idempotent matrix that transforms the data into deviations from individual specific sample means $M_D D = 0$, the individual effect α can be eliminated from the model by multiplying equation (4.2) by M_D.

$$\begin{aligned} M_D y &= M_D W\delta + M_D D\alpha + M_D\varepsilon \\ \widehat{y} &= \widehat{W}\delta + \widehat{\varepsilon} \end{aligned} \tag{4.3}$$

$\widehat{y} = M_{Dy}$indicates the centered dependent variable and similarly for the other variables. The least squares estimator δ in the model (4.3) defines the FE estimator:

$$\widehat{\delta} = (\widehat{W}W^{'}\widehat{W})^{-1}\widehat{W}^{'}\widehat{y} = (W^{'}M_D W)^{-1}W^{'}M_D y \tag{4.4}$$

We further need the bootstrap algorithm to correct the bias of the FE estimator which is an extended version of the approach presented in Everaert and Pozzi (2007) that the FE estimator is biased but still an unknown function of the true parameter vector, which means that

$$\in (\widehat{\delta}\,|\delta\ , \in, T) = \int_{-\infty}^{+\infty} \widehat{\delta} f(\widehat{\delta}\,|\delta, \in, T)\; d\widehat{\delta} \neq \delta \tag{4.5}$$

with $\in$ being the expected value and f the probability distribution of $\widehat{\delta}$ for the given population parameter vector δ, the covariance matrix of the error terms$\in$, and sample size T . If we can generate a sequence $(\widehat{\delta}_{1,...,}\widehat{\delta}_J\,|\delta\ , \in, T)$ of Jbiased FE estimates $\widehat{\delta}\delta$, the integral in equation

(4.5) can be written as:

$$\in (\widehat{\delta}\,|\delta, \in, T)\; = \lim_{J \to \infty} \frac{1}{J} \sum_{j=1}^{J} \widehat{\delta}_j\,|\delta, \in, T \tag{4.6}$$

Equation (4.6) shows that an unbiased estimator δ can be obtained as the value $\widehat{\delta}^{bc}$ that yields the FE to have a mean of $\widehat{\delta}$ over the J repeated samples. Formally, $\widehat{\delta}^{bc}$is an unbiased estimator for if it satisfies

$$\widehat{\delta} = \lim_{J \to \infty} \frac{1}{J} \sum_{j=1}^{J} \widehat{\delta}_j \left| \widehat{\delta}^{bc} \right., \in, T \tag{4.7}$$

The proposition in Everaert and Pozzi (2007) is that for any specific value of δ^* , the

condition in equation (4.7) can be evaluated by generating J bootstrap samples from the data-generating process in equation (4.2) and applying FE to each of the samples to obtain the sequence$(\widehat{\delta}_{1,...,}\widehat{\delta}_j\,|\delta^*\ , \in, T)$. The bias-corrected $\widehat{\delta}^{bc}$ can then be obtained by searching over different parameter values δ^* until equation (4.7) is satisfied. Everaert and Pozzi further suggest that the search $\widehat{\delta}^{bc}$ can be performed well in iterative to update the parameter vector δ^* used for the creation of bootstrap samples, taking the original biased FE estimate as the best initial guess $(\delta^*_{(0)} = \widehat{\delta})$. To hold various distributional assumptions about the error termε_{it} , our bootstrap algorithm includes several parametric error sampling and non-parametric error resampling options. All of these rely in some way on the rescaled error terms $\overset{r}{\varepsilon}_{it}$

$$\overset{r}{\varepsilon}_{it} = \widehat{\varepsilon}_{it}\sqrt{\frac{NT}{NT-k-N}}$$

where rescaling is necessary to correct for the fact that the estimated error terms ε_{it},obtained in the bootstrap algorithm, have a lower variance than the population error terms$\overset{r}{\varepsilon}_{it}$.

4.2. Empirical strategy

To assess the extent to which monetary policy may affect banks' lending behavior, we use a dynamic panel data model which is the most used in the existing stock of knowledge (see, for example, Berrospide and Edge (2010) Ehrmann et al. (2003)). We specify an empirical model to examine the effect of monetary policy on banks' loan supply while controlling for a wide range of factors possibly affecting loan supply as follows:

$$Loan_{it} = \omega_i + \omega_1 cbr_t + \omega_2 Z_{it} + \omega_3 cbi_t Z_{it} + \omega_4 rgdp_t + \omega_5 inf_t + \omega_6 npl_{it} + \omega_7 rgdp_t Z_{it} + \omega_8 inf_t Z_{it} + \varepsilon_{it}$$

where$Loan_{it}$ stands for bank loans, cbr_t the monetary policy rate, and $Z_{it}$for a measure of a bank-specific characteristic (size, liquidity, or capitalization) and where interactions appear in all the potentially relevant variables. Under our empirical specification, the fact that the estimated ω_1 is (significantly) negative and $\omega_3$is (significantly) positive is taken as evidence of the existence of the bank-lending channel. It captures the combined effect of monetary policy actions and individual bank characteristics on lending. The conventional practice is to include bank-specific characteristics such as bank size (SIZE), liquidity ratio (LIQR), and capital ratio (CAPR) in the empirical model. Key macroeconomic control variales included in the model are real GDP ($rgdp_t$) to capture loan demand effects; the inflation rate (inf_t).These two macroeconomic indicators are inclded in the estimator order to capture the monetary transmission mechanism. They also control for demand shocks. According to the interest rate channel, business cycle expansion increases the number of profitable projects and therefore the demand for credit.

We also include the ratio of non-performing loans to total loans (NPL) as a proxy for credit risk. We assume that the risk of loan default is mainly reflected in the proportion of realized bad loans to total loans. The increase in the proportion of realized NPLs would in turn induce banks to reduce exposure to high-risk borrowers to maintain a strong loan book. It is equally importatnt to measure the interaction between individual bank-specific characteristics and macroeconomic factors. A positive and statistically significant interactive coefficients of bank specific chracteristics and GDP indicate that ceteris paribus, boost loan demand as well as provide banks with an incentive to increase their lending, while the interaction between individual bank-specific factors with inflation may increase the likelihood of reducing the rate of loan demand.

4.3. Data Issues

In this paper, quarterly micro-bank level and macroeconomic data spanning 2014Q1 until 2022Q4 are utilized to test the validity of the bank lending channel of monetary policy transmission in Rwanda. All variables, except those expressed in percentage, are expressed in log difference to account for the panel-data level effects. In the estimations, we use balance sheet information on a sample of 14 banks.

4.4. Empirical Evidence

This section describes some important statistics and empirical findings derived from the estimation of equation (4.9) with a panel data of 14 banks operating in Rwanda.

The annex 3 provides descriptive statistics of the banking sector in Rwanda and some macroeconomic indicators. During the period between 2011Q1 and 2022Q4, the change in growth in bank loans was 2% on average. The central bank rate was around 5.7%, reflecting NBR's policy of containing inflation. There has also been significant volatility in a change in the growth rate of loans ranging from a decline of 5.1% to a growth of 4.7%. In addition, the standard deviation and the range in the change of lending growth rate are quite considerable, suggesting diverse loan growth rates. For the bank characteristics, the average growth in the size of banks has been around 0.6%, and liquidity and capitalization decreased by an average of 39% and 7% respectively. Furthermore, the table also shows that there has been substantial variation in the growth of these bank characteristics. Key macroeconomic indicators of inflation, and real GDP growth rate are, on average, approximately 4.5% and 6.6% respectively.

Annex 4 displays the correlation coefficients for our identified variables and the matrix depicts the correlation between all the possible pairs of values. There is a negative significant correlation between the central bank rate and loan supply. The bank size is statistically correlated with bank loans and other variables of interest broadly have consistent relations which is a good indication for the empirical exercises. Most correlation coefficients are quite moderate, which suggests that multicollinearity should not be a major concern and multiple regressions should be conducted so that the results are appropriate for statistical inferences.

The scatter plots and the best-fitting linear lines of the central bank rate versus the variables' bank-specific characteristics are presented in figure 2.

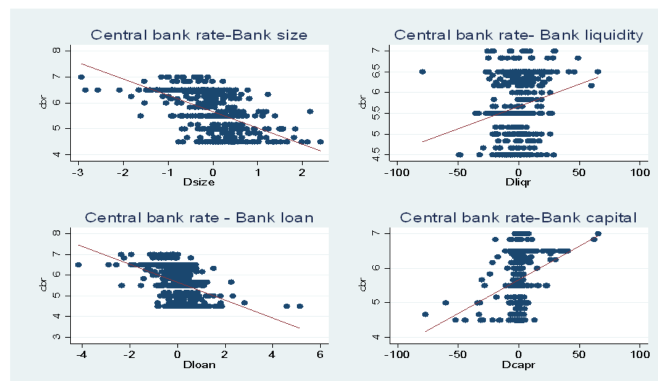

Figure 2: Scatter plots central bank rate with bank characteristics

4.5. Full sample baseline results

The impact of monetary policy within the bank lending channel necessitates banks to modify their deposits in response to a central bank's decision. Thus, our expect signs are a negative coefficient on the indicator of central bank decision and a positive coefficient on the interactive terms for central bank decision and bank-specific characteristics, signifying that banks' indicators are the payoff for monetary policy shocks. We employ multiple models (model 1 to model 8) to assess whether the inclusion of additional variables enhances the accuracy of the estimates.

The results from the baseline regression show that monetary policy has a lagged effect on banks' loan supply behavior since its coefficient is negative and statistically significant. The coefficient for bank size exhibits a positive and statistically significant relationship, aligning with the expected outcome based on prior knowledge. This suggests that greater capitalization levels are indicative of improved financial health, enabling banks to extend loans

Table 1: Baseline estimation (full sample)

	Mdel1	Mdel2	Model3	Model4	Model5	Model6	Model7	Model8
Dloan(-1)	-0.139***	-0.146***	-0.284***	-0.376***	-0.166***	-0.272***	-0.376***	-0.041
	(0.040)	(0.044)	(0.048)	(0.098)	(0.047)	(0.043)	(0.098)	(0.045)
Cbr(-1)	-0.115**	-0.104*	0.013	0.051	-0.107**	0.032	0.051	-0.093*
	(0.055)	(0.056)	(0.053)	(0.072)	(0.045)	(0.059)	(0.072)	(0.051)
Dlsize	0.839***							0.859**
	(0.083)							(0.345)
Dliqr	-0.009***							-0.029
	(0.002)							(0.018)
Dcapr	-0.016***							-0.014
	(0.004)							(0.035)
rgdp	0.005*	-0.002	-0.017***					-0.001
	(0.003)	(0.003)	(0.006)					(0.002)
infl	0.006	0.004	0.016**					0.002
	(0.006)	(0.006)	(0.007)					(0.005)
Dnpl	-0.010	-0.013	-0.010	-0.010	-0.012	-0.009	-0.010	-0.011
	(0.011)	(0.014)	(0.013)	(0.019)	(0.014)	(0.015)	(0.019)	(0.013)
Cbr×size		0.129***			0.141***			-0.004
		(0.018)			(0.011)			(0.049)
cbr×liqr		0.000			-0.001***			0.004
		(0.001)			(0.000)			(0.003)
cbr×capr		-0.002			-0.003***			-0.000
		(0.001)			(0.001)			(0.005)
rgdp×size		0.011	0.077***			0.073***		0.007
		(0.007)	(0.005)			(0.005)		(0.006)
rgdp×liqr		-0.001**	-0.001***			-0.001**		-0.001*
		(0.000)	(0.000)			(0.000)		(0.000)
rgdp×capr		-0.001	-0.001			-0.001		-0.001
		(0.001)	(0.001)			(0.001)		(0.001)
infl×size		0.005		0.067***			0.067***	0.003
		(0.010)		(0.008)			(0.008)	(0.012)
infl×liqr		-0.001		-0.001***			-0.001***	-0.000
		(0.001)		(0.000)			(0.000)	(0.000)
infl×capr		0.000		-0.002			-0.002	0.001
		(0.001)		(0.001)			(0.001)	(0.001)
N	375	375	375	441	441	375	441	384
N_g	14.000	14.000	14.000	14.000	14.000	14.000	14.000	14.000

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

to businesses more effectively.

We do not find the expected signs for bank liquidity and capital individually, this could imply that increases in both capital and liquidity might have a strong desire to meet regulatory requirements, so as reducing lending growth.

The estimated coefficients for the interactive terms between the central bank indicator and bank-specific indicators exhibit mixed results. Specifically, the interactive coefficient between the central bank indicator and bank size is positive and statistically significant, suggesting that in an environment where banks possess sufficient asset bases, the monetary policy stance encourages them to provide a greater supply of loans. However, the coefficients for other interactive terms, such as the interaction of policy rates with levels of liquidity and capital, are found to be statistically insignificant. This indicates that the interaction between these variables does not have a significant influence on the supply of loans.

Moreover, the the coefficient on the scale variable real GDP is positive and statistically significant implying that an increase in economic growth will lead to an increase loan supply while the coefficient on inflation is statistically insignificant. Surprisingly, deterioration in banks' asset quality reflected in an increase in the share of non-performing loans (credit risk) does not affect banks' credit supply. This observation can be attributed to the relatively low levels of non-performing loans (NPLs) in the Rwandan banking sector. As a result, any increases in NPLs are likely to remain within the risk tolerance thresholds set by the banks.

The impact of the monetary policy stance on the supply of loans may also depend on the size of the bank, thus we isolate banks into big and medium banks to assess the impact of the monetary policy stance. The rule of thumb is that large banks tend to be much more liquid and better-capitalized than smaller banks. Thus, for large banks, monetary policy effects may be attenuated by the strength of these specific bank characteristics.

Thus, we run a regression on different sub-samples vis-à-vis the benchmark equation (4.8) without any modifications and the results are reported in two subsequent tables 2 and 3.

The estimated results show that medium-sized banks moderately respond to monetary policy action as indicated by the statistical significance of the coefficient on the lagged measure of monetary policy and its interaction term with bank size, this implies that medium-sized banks also apply size effects in mitigating the adverse effects of monetary policy.

The deterioration in the medium banks' asset quality reflected in an increase in the share of non-performing loans (credit risk) does not reduce banks' loan supply, since its coefficient is statistically insignificant. However, liquidity levels of banks are found to be negatively related to the supply of loans and are statistically significant.

The negative relationship may imply that banks may turn to their liquid assets to offer more loans, especially during periods of tight monetary policy, thus maintaining their loan portfolio. However, the more loans a bank disburses, the less the liquid assets it holds consistent with the findings by (Kabiro and E, 2014).

The estimated coefficient for monetary policy stance is moderately positive and significant for large banks. This could imply that the tight monetary policy condition is beneficial to big banks as they can increase their margins with higher policy rates and at the same time able to extend more loans given their adequate assets levels.

We also find that the interaction terms for liquidity and capitalization with the monetary policy indicator are insignificant, implying that monetary policy stance interacting with liquidity and capitalization for big banks does not have an impact on loan supply behavior.

There could be an equity-at-risk effect, meaning that banks would have less risk-taking incentive if there is a high level of equity in the place. In other words, even when banks with high capital are capable of raising deposits, they might still refrain from making more loans. However, the interaction term between monetary policy indicator and bank size, is positive and significant, consistent with theoretical propositions buy Bernanke and Gertler (1995) and other empirical findings Kamanzi et al. (2019) (Walker, 2012; Matousek and Solomon, 2017).This implies that banks with large asset values can maintain their loan supply in the face of tight monetary policy conditions.

Conversely, deterioration in large banks' asset quality reflecting an increase in the share of non-performing loans (credit risk) does not reduce the appetite of large banks' loan supply. In broad consideration, the result from both sub-sample estimations is consistent with our baseline estimates (full sample).

Table 2: Monetary policy and bank lending among medium banks

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Dloan(-1)	-0.182*	-0.067	-0.436***	-0.269	-0.172	-0.451***	-0.269	0.008
	(0.094)	(0.167)	(0.072)	(0.185)	(0.110)	(0.061)	(0.185)	(0.130)
cbr(-1)	-0.083	-0.059	-0.003	0.028	-0.097	-0.018	0.028	-0.099*
	(0.060)	(0.054)	(0.096)	(0.081)	(0.094)	(0.126)	(0.081)	(0.055)
Dlsize	0.753***							1.587**
	(0.158)							(0.677)
Dliqr	-0.005							0.010
	(0.005)							(0.015)
Dcapr	-0.033**							-0.057
	(0.016)							(0.055)
rgdp	-0.012	0.006	-0.010					0.005
	(0.011)	(0.021)	(0.030)					(0.005)
infl	0.006	0.038**	0.038					0.031***
	(0.018)	(0.018)	(0.038)					(0.009)
Dnpl	0.003	0.008	-0.023	-0.005	-0.001	-0.023	-0.005	0.007
	(0.011)	(0.026)	(0.044)	(0.017)	(0.015)	(0.042)	(0.017)	(0.006)
cbr×size		0.155***			0.136***			-0.095
		(0.050)			(0.023)			(0.108)
cbr×liqr		0.001			-0.001			-0.001
		(0.003)			(0.001)			(0.002)
cbr×capr		-0.008			-0.004			0.005
		(0.008)			(0.003)			(0.008)
rgdp×size		-0.017	0.041			0.045***		-0.024***
		(0.022)	(0.027)			(0.013)		(0.008)
rgdp×liqr		-0.001	-0.001			-0.000		-0.001
		(0.002)	(0.001)			(0.001)		(0.001)
rgdp×capr		0.005	-0.001			-0.002		0.004**
		(0.006)	(0.003)			(0.002)		(0.002)
infl×size		-0.028		0.027*			0.027*	-0.036
		(0.072)		(0.015)			(0.015)	(0.023)
infl×liqr		-0.001		-0.000			-0.000	-0.002
		(0.001)		(0.001)			(0.001)	(0.001)
infl×capr		-0.004		-0.005*			-0.005*	-0.004*
		(0.004)		(0.002)			(0.002)	(0.002)
N	129	129	129	162	162	129	162	132
N_g	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000

Table 3: Monetary policy and bank lending among large banks

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Dloan(-1)	-0.064	-0.057	-0.217	-0.270***	-0.073**	-0.208	-0.270***	-0.027
	(0.040)	(0.061)	(0.135)	(0.065)	(0.032)	(0.139)	(0.065)	(0.029)
cbr(-1)	-0.037	-0.012	0.184**	0.119	-0.030	0.157**	0.119	-0.017
	(0.040)	(0.056)	(0.085)	(0.079)	(0.027)	(0.071)	(0.079)	(0.023)
Dlsize	0.938***							1.078***
	(0.036)							(0.204)
Dliqr	-0.009***							0.003
	(0.002)							(0.010)
Dcapr	0.011							0.013
	(0.010)							(0.043)
rgdp	0.001	0.008	-0.004					0.003**
	(0.003)	(0.006)	(0.009)					(0.002)
infl	0.005	0.019	0.029					0.013**
	(0.005)	(0.011)	(0.024)					(0.005)
Dnpl	0.006	0.006	0.006	-0.011	-0.001	0.001	-0.011	0.011**
	(0.009)	(0.011)	(0.028)	(0.023)	(0.011)	(0.025)	(0.023)	(0.005)
cbr×size		0.148***			0.155***			-0.022
		(0.025)			(0.008)			(0.032)
cbr×liqr		-0.000			-0.002***			-0.002
		(0.001)			(0.000)			(0.001)
cbr×capr		0.000			0.001			0.001
		(0.005)			(0.001)			(0.006)
rgdp×size		0.014	0.070***			0.076***		0.004
		(0.015)	(0.007)			(0.006)		(0.008)
rgdp×liqr		0.000	-0.001			-0.000		0.000
		(0.001)	(0.001)			(0.001)		(0.000)
rgdp×capr		0.001	0.003			0.004*		-0.001
		(0.003)	(0.004)			(0.002)		(0.002)
infl×size		-0.011		0.069***			0.069***	-0.017**
		(0.021)		(0.007)			(0.007)	(0.008)
infl×liqr		-0.002		-0.002***			-0.002***	-0.001
		(0.001)		(0.001)			(0.001)	(0.001)
infl×capr		-0.000		0.003			0.003	-0.001
		(0.005)		(0.004)			(0.004)	(0.003)
N	114	114	114	165	165	114	165	117
N_g	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusions

This study examines the existence of bank lending channel in Rwanda using the bootstrap bias-corrected LSDV estimator proposed by De Vos et al. (2015) which is shown to have superior small-sample properties compared to GMM estimators and maintain relatively small coefficient uncertainty while removing most of the bias.

The results from the baseline regression (full sample) show that monetary policy affects banks' loan supply behavior since its coefficient is negative and statistically significant. The coefficient of bank size exhibits a positive and statistically significant relationship, consistent with our prior expectations. This suggests that higher levels of capitalization are associated with improved financial health, enabling banks to provide loans to businesses more effectively. We do not find the expected signs for bank liquidity and capital individually, this could imply that increases in both capital and liquidity might be strongly linked to meet regulatory requirements, thereby reducing lending growth.

The interactive terms between central bank indicator and bank-specific indicators are somehow mixed. The interactive coefficient for central bank indicator and bank size is positive and statistically significant, implying that a tight monetary policy stance in an environment of banks with adequate assets base leads to rising loan supply. Others are statistically insignificant, meaning that the interaction of policy rates with levels of liquidity and capital does not influence the supply of loans. Moreover, the scale variable, real GDP is positive and statistically significant implying that increases in economic growth rates will lead to rising loan supply while the effect of inflation on loan supply is insignificant.

Given the landscape of the banking system in Rwanda where large banks dominate, one possible explanation for this is that the large banks are still able to expand their loan portfolio despite increases in central bank rates due to their bigger asset base. In terms of bank-specific factors, the study reveals that the asset base is statistically significant and positively related to the supply of loans. The estimated coefficient for monetary policy stance is moderately positive and significant for large banks. This could imply that the tight monetary policy condition is beneficial to big banks as they can increase their margins with higher policy rates while, at the same time, able to extend more loans given their adequate assets levels. Conversely, deterioration in large banks' asset quality reflecting an increase in the share of NPLs (credit risk) does not reduce the appetite of large banks to increase their loan supply. The findings provide support for the central bank's recent move from monetary targeting to price-based monetary policy to strengthen the effectiveness of the monetary policy

The policy implication from the findings is that, the central bank's monetary policy decisions would continue to produce large distributional effects on the reserves of banks with large-sized banks better equipped to cope with tight monetary policy stance. Therefore, the central bank should explore the set of tools in its purview to ensure that its policy actions do not disproportionately disadvantage the relatively smaller banks within the Rwandan banking sector.

Annex 1 : Structure of Rwandan Financial system

	Dec_10		Dec_18		Dec_19		Dec_20		Dec_21		Dec_22	
	Number	share in TA	number	share in TA	number	share in TA	Number	share in TA	Number	Share TA	number	share in TA
Banking sector	14	71.3	16	66.4	16	65.9	16	68.0	16	67.2	15	67.3
Insurers	8	10.2	16	9.7	14	9.7	15	9.3	15	9.3	17	9.4
Pension schemes	1	14.9	13	17.4	13	17.8	13	16.5	13	17.4	13	16.2
MFIs	11	3.7	459	6.0	457	6.1	457	5.6	457	5.6	457	5.8

Source: Authors' own computations

Annex 2. Bank's size

Size	Count	Share of total assets	Share of total loans
Large	5	77.0%	83.0%
Medium	6	21.6%	15.0%
Small	3	1.4%	1.0%

Source: Authors' own computations

Annex 3. Summary statistics

VARIABLES	N	mean	sd	Min	max	skewness	Kurtosis
Dloan	482	0.0240	0.904	-5.136	4.758	-0.235	12.38
Cbr	504	5.671	0.803	4.500	7	-0.135	1.582
Dlsize	486	0.00645	0.723	-2.798	2.829	-0.102	5.403
Dliqr	484	-0.391	12.83	-51.48	42.54	-0.0408	3.752
Dcapr	486	-0.0721	12.08	-74.95	75.40	-0.249	16.77
Rgdp	490	6.557	5.346	-12.40	20.60	-1.007	6.563
Infl	504	4.570	4.558	-0.632	21.10	1.796	6.526
Dnpl	490	0.0607	7.882	-73.09	65.38	-0.423	29.40

Source: Authors' own computation

Annex 4. Correlation matrix of variables

	Dloan	Cbr	Dlsize	Dliqr	Dcapr	Rgdp	infl	Dnpl
Dloan	1.00							
cbr	-0.42*** (0.00)	1.00						
Dlsize	0.89*** (0.00)	-0.53*** (0.00)	1.00					
Dliqr	-0.43*** (0.00)	0.19*** (0.00)	-0.29*** (0.00)	1.00				
Dcapr	-0.65*** (0.00)	0.27*** (0.00)	-0.56*** (0.00)	0.25*** (0.00)	1.00			
rgdp	0.01 (0.89)	0.05 (0.24)	0.00 (0.96)	-0.00 (0.98)	0.03 (0.52)	1.00		
infl	0.15** (0.00)	0.02 (0.59)	0.19*** (0.00)	0.07 (0.13)	-0.05 (0.31)	-0.42*** (0.00)	1.00	
Dnpl	0.03 (0.52)	0.07 (0.12)	-0.00 (0.92)	-0.00 (0.99)	-0.23*** (0.00)	-0.14** (0.00)	-0.03 (0.52)	1.00

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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