Does monetary policy affect the net interest margin of credit institutions? Evidence from Colombia

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Afecta la política monetaria el margen neto de intermediación de los establecimientos de crédito? Evidencia para Colombia

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Resumen

Este documento analiza empíricamente la relación entre las intervenciones de política monetaria y el margen neto de interés de los establecimientos de crédito en Colombia entre 2003 y 2019. Con el fin de controlar por la endogeneidad que subyace a esta relación, se calcula una serie de choques de política monetaria. Estos choques corresponden a los residuales de una regresión entre la tasa de política monetaria y un conjunto de variables cuantificables disponibles para la Junta Directiva del Banco de la República al momento de cada una de sus reuniones de política monetaria. Seguido de esto, se realiza un análisis de panel de datos en el que se utilizan como variables explicativas del margen neto de interés la serie de choques, algunas variables macroeconómicas y algunas propias de cada entidad. Mediante una aproximación no lineal, se encuentra una relación cuadrática significativa, la cual indica que una vez se supera el problema de endogeneidad, el margen neto de interés se incrementa ante choques de política monetaria. Ante choques positivos de política monetaria, el aumento en el margen neto de interés obedece al comportamiento asimétrico de los préstamos y los depósitos. Por su parte, ante choques negativos de política monetaria el margen neto de interés incrementa dada la mayor sensibilidad de los costos de fondeo bancarios frente a los ingresos por intereses.

Palabras clave: margen neto de interés, choques de política monetaria, intensidad del crédito, tasas de interés

Clasificación JEL: E43, E44, E52, G21

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Does monetary policy affect the net interest margin of credit institutions? Evidence from Colombia

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Abstract

This paper analyzes empirically the relationship between monetary policy interventions and the net interest margin of Colombian credit institutions for the 2003 – 2019 period. Considering the endogeneity problem that arises when analysing this relationship, we calculate a series of monetary policy shocks as the residuals of regressing the monetary policy rate on a set of quantifiable variables that the Central Bank of Colombia's Board of Directors had at each of its monetary policy meetings. Thereafter, we conduct a panel regression analysis in which we relate these shocks, and a set of macroeconomic and bank-specific variables to the net interest margin. Through a non-linear approach, we find a significant quadratic relationship, which reflects that once the endogeneity problem is overcome, the net interest margin increases to policy shocks. The net interest margin increases to positive policy shocks due to the different dynamics of deposits and loans, and increases to negative policy shocks given the higher sensitivity of banks' funding costs compared to the one of interest income.

Keywords: net interest margin, monetary policy shock, credit intensity, interest rates

JEL Classification: E43, E44, E52, G21

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1 Introduction

The link between the monetary policy rate (MPR) and the profitability of banks has become especially relevant since the global financial crisis given the persistent environment of low interest rates in developed countries (known as "low for long"). For emerging economies, this topic has also been of particular interest given the role that banks and its soundness play on the development of the entire economy.

Several jurisdictions closely monitor the net interest margin (NIM), which is a measure of profitability defined as the difference between lending and deposit rates, to assess the relative efficiency of the financial system, and to foresee a decrease in profitability that could affect financial stability. In this regard, to handle interest rate risk in the short term the Basel Committee on Banking Supervision (2016) has recommended to perform sensitivity analysis of NIM to shocks in interest rates.

There is ample empirical literature abroad that centers on short and long-term effects of an increase of interest rates on NIM. Changes in MPR directly affect income and expenses through interest rates, and indirectly the NIM. In the long run, these changes also impact the present value and timing of future cash flows. However, these effects depend on several factors such as the maturity of assets, the percentage of assets exposed to floating interest rates, and the hedging strategy implemented by credit institutions. Macroeconomic conditions are also relevant to this strand.

The objective of this paper is to shed light on the effects of MPR on credit institutions' NIM in Colombia. While several studies have focused on the determinants of NIM, we chose to evaluate the impact of unexpected changes in the MPR on the intermediation margin. Emphasis is given to the endogeneity problem that arises when analysing the link between NIM and MPR: monetary policy decisions are mainly made considering available macroeconomic information (inflation rate, gross domestic product, lending and deposit behavior) often including NIM.

Our analysis consists of three main components. In the first one, we present several theoretical models that analyze the behavior of NIM. Specifically, we outline the model of Ho and Saunders (1981) and its extensions as a reference point to define the factors that will be considered in our empirical estimation.

Second, we present some stylized facts to give a broad view of the dynamics of NIM, and of lending and deposit rates. In this part, we find that the aggregate NIM has displayed a slightly downward trend over the time-frame (2003 - 2019). Moreover, the behavior of NIM diverges according to the size, business model and the counterparties on the liability side of credit institutions. Altogether, these features are taken into account when defining our econometric model.

Finally, we introduce our identification strategy to get around the endogeneity problem and present the results of a panel regression analysis in which monetary policy shocks (MPS), and a set of macroeconomic and bank-specific variables are related to NIM. To overcome the simultaneity between MPR decisions and NIM we follow Romer and Romer (2004) approach. We estimate an exogenous time series for MPS as the residuals of regressing the MPR on a set of quantifiable variables that the Central Bank of Colombia's Board of Directors had at each of its monetary policy meetings. The resulting series represents policy decisions that cannot be explained in terms of the information available, thus reflecting "surprises" that allow to disentangle the relationship between MPR and NIM.

The chosen strategy offers some advantages over alternative approaches as it assumes the sole channel of transmission between the variables of interest is through the unexpected variations of MPR. Therefore, our work makes an important contribution to the literature as it is the first one to focus on monetary surprises to analyse empirically the effects of monetary policy on NIM.

Our results indicate that a positive quadratic model between MPS and NIM is the one that better fits the data. Therefore, large MPS have statistically significant effects on NIM, and impacts are higher for large credit institutions. Once the endogeneity problem is overcome, NIM increases to positive MPS due to the immediate response on deposits rather than loans. Likewise, NIM increases to negative MPS as the sensitivity of banks' funding costs is higher compared to the one of interest income. The marginal effect of MPS on NIM is small when compared with the one exerted by other variables such as the average costs, the implicit interest payments, and the commercial loans share.

The rest of the paper is organized as follows. The second section reviews the literature. Section three establishes a theoretical framework to analyze the determinants of NIM. Section four shows some stylized facts for the period of analysis (first quarter of 2003 until last quarter of 2019). Section five describes the data, the variables selected for the model and the methodology. Finally, section six and seven discuss the results of the estimations and concludes.

2 Literature Review

Empirical international studies that analyze the relationship between MPR and NIM can be classified into four main approaches: i) descriptive analysis of the determinants of NIM based on profitability decomposition (Ahtik et al. (2016), Covas et al. (2015)); ii) short and long run econometric analysis (Cruz-García et al. (2017), Claessens et al. (2017), Alessandri and Nelson (2015)); iii) empirical assessment of NIM under a low interest rate environment (Borio et al. (2017), Busch and Memmel (2015)), and iv) effects of unexpected changes in MPR on NIM controlling by endogeneity (English et al. (2018)).

As of the descriptive analysis of the determinants of NIM approach, according to Ahtik et al. (2016), the NIM contributes the most to bank profits in Slovenia. Therefore, the authors decompose the different drivers of NIM for a period characterized by a low-interest rate environment (between 2004 and 2016), finding that during this period the drop in NIM could have been offset by a higher volume of loans and changes in banks' business models.

Likewise, Covas et al. (2015) analyze the behavior of the national banks' NIM in the United States by decomposing it into changes in yields, and changes in the composition of assets and liabilities. The authors point out that during the last 5 years of the period of analysis, the NIM decreased due to the environment of low-interest rates, caused by the response of the monetary authorities to the financial crisis. This result was mainly seen across large banks given that the small ones experienced a faster decrease in the cost of deposits.

As of an econometric analysis approach, Cruz-García et al. (2017) study the effect of a prolonged period of reductions in the MPR on NIM in the long run for a sample of commercial banks, savings banks, and other credit institutions of 32 OECD countries between 2003 and 2014. They find a negative relationship that changes to positive as the deposit rate approximates to the zero lower bound. The relationship of short-term interest rates and NIM is found to be non-linear as in Claessens et al. (2017). The latter uses a sample of 3,418 banks from 47 countries for the period 2005 – 2013.

In the same way, Alessandri and Nelson (2015) use a model of a monopolistically competitive bank considering price frictions. Through impulse-response functions of a Bayesian Vector Autoregressive (BVAR) model, they trace the path of NIM and profitability to a positive shock of short term interest rate. All in all, contractionary monetary policy raises short term rates and flattens the yield curve, which at the same time reduces the bank's NIM in the short run. Conversely, in the long run, high yields, and a steep yield curve drive upwards bank's income margin.

As of the third approach, Borio et al. (2017) analyze the effects of monetary policy on banks profitability for a sample of 109 large international banks from 14 advanced economies for the period 1995 – 2012. They find that banks' NIM increases due to higher short-term interest rates and a steeper yield curve. Furthermore, higher interest rates increase loan loss provisions and decrease securities' valuations. These effects are stronger under low-interest rates scenarios.

Busch and Memmel (2015) develop two theoretical models for the German banking system (one for normal times and the other for low-interest rate environments) to differentiate between the short and long-term effects of an increase in the level of interest rates. The effects on NIM are stronger under a low-interest rate environment. Under this scenario, in the short-run, the impact on NIM to an increase in interest rates is negative due to maturity transformation. Contrary, in the medium and long-term, changes in the level of interest rates leads to an increase in banks' NIM. The inflection point, that is, the horizon in which the positive and negative effects offset each other is approximately one and a half years.

In regards to the last approach, English et al. (2018) analyze the impact of changes in interest rates over banks' profitability in the United States between 1997 and 2007. The authors use the instrumental variables approach to overcome the endogeneity problem between profitability and policy rate. The results indicate that positive policy shocks on the level and the slope of the yield curve affect negatively the banks' profitability through changes in the intermediation margin.

In Colombia, one of the first studies to define the NIM was that from Steiner et al. (1997). They propose a theoretical model using banks' monthly information from 1992-1996 to analyze the determinants of NIM. According to them, non-performing loans, reserve requirements, administrative expenses, and deposit interest rate are the main explanatory variables of NIM. Similarly, Estrada et al. (2006) follow a theoretical approach expanding the model propose by Ho and Saunders (1981). They find that credit institutions' inefficiency, risk exposure, and market power are the factors that mostly affect the NIM during the period 1994-2005.

3 Theorical Framework

Several papers have studied the theoretical relationship between MPR and NIM. In this regard, Claessens et al. (2017) propose a model in which the borrowing rate corresponds to a fraction of the lending rate, implying a positive relationship between MPR and NIM. These authors analyze three possible scenarios: one in which the deposit rate is an unchanging proportion of the loan rate, another where the deposit rate is a fixed spread below the loan rate and, one that assumes a proportional growth between the deposit and the loan rate. For the first two scenarios (first derivative equals to a constant), they found a constant change in the intermediation margin as the interest rate changes. In the third case, however, the change on NIM shrinks as the interest rate increases such that the maximum response is obtained at the lowest level of the interest rate. This latter implies that the relationship between these two variables might be non-linear.

Nevertheless, the empirical relationship between policy rate and NIM might differ given the presence of market failures, flattening yield curves and idiosyncratic factors. Market failures might be especially relevant in emerging markets where the size of the financial system is relatively small, and markets are not fully competitive. If that is the case for the deposit market, for instance, changes in MPR might not be fully reflected on NIM. Repricing frictions might have a similar effect as demonstrated by Alessandri and Nelson (2015). Among the idiosyncratic factors, hedging strategies that offset variations linked to interest rate risk, duration and risk profile of the loan portfolio, and the composition of liabilities are the ones that might have a higher influence.

Alessandri and Nelson (2015) use a partial equilibrium model to show that NIM shrinks when market rates increase, even under the presence of non-negligible loan pricing frictions. In contrast, the Monti-Klein model used by Borio et al. (2017) concludes that the derivative of net interest income on MPR is a positive and linear function on MPR itself, which implies that the relationship between both variables is quadratic. This differs from the standard Monti-Klein model due to the presence of three aspects: the cost of maturity transformation, minimum capital requirements and provisions for loans losses.

A different theoretical framework is provided by Ho and Saunders (1981) and their subsequent expansions. In its original model, these authors assume that banks are risk-averse credit intermediaries between suppliers of deposits and demanders of loans. These entities operate under an uncertain scenario and maximize their expected utility over a single period. Subsequently, they set loan and deposit prices by manipulating the size of the fees charged to the costumers. The sum of both intermediation fees is equal to NIM, whose determinants in the model are: market power, risk aversion, size of transactions, and variance of the interest rate on deposits and loans.

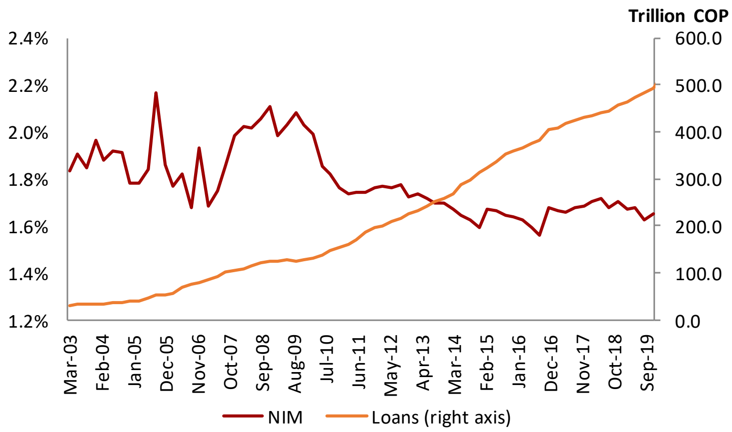
Further extensions of this model introduced by Entrop et al. (2015) include credit risk, interest rate risk, the interaction between both risks and a cost for maturity transformation (loans are assumed to exceed deposit maturity) on their specification model. Under this approach, the determinants of NIM are: i) market power that corresponds to the elasticity of loan demand and deposit supply with respect to the intermediation fees charged; ii) risk exposure which includes credit risk, market risk, and their interaction; iii) the level of interest rates that are affected by the monetary policy rate, and captures the excess holding period returns from risk transformation; iv) operating costs per unit of transaction volume, and v) risk aversion. All in all, we consider these determinants when defining the explanatory variables of NIM in the empirical model presented further down.

4 Stylized Facts

The Colombian credit institutions are classified on four types of entities: banks, financial corporations (FC), corporate financing companies (CFC) and financial cooperatives (cooperatives). At the end of 2019, banks' assets and loans represented 95.0% and 97.0% of the total system, respectively. In contrast, FC did not have any loans due to their market segment: mostly investment bank activities.

For the system as a whole, net interest income (NII), defined as the product of loans and NIM, has been the most important factor in the income statement. The NIM measures the difference between the interest income generated by credit institutions and the amount of interest paid out to their lenders relative to the total amount of loans. During the period of analysis (first quarter of 2003 until last quarter of 2019), the NII has explained an important part of the net income. In fact, during the last quarter, the share of NII on total income was 57.0%. Over time, the NII has grown steadily due to the growth of loans and the downward trend of the NIM. (Figure 1).

Figure 1: **Net interest margin of credit institutions**

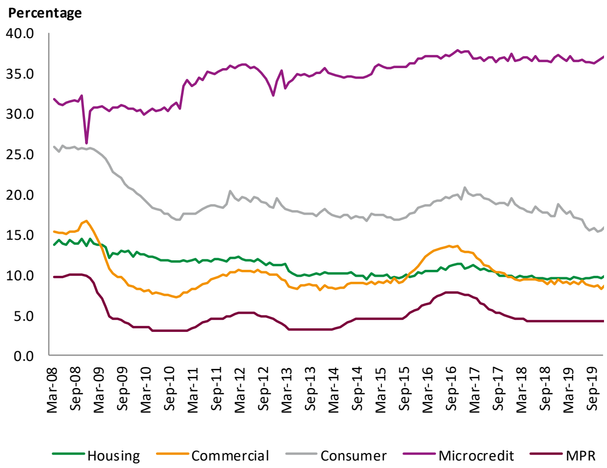


The figure depicts the aggregate NIM of credit institutions included in the dataset used for the econometric model. NIM is defined as the difference between interest income and interest expenses to total loans. Trillions correspond to units of the short numerical scale.
Source: Financial Superintendence of Colombia, authors' own calculations.

The sources of interest income vary among the different types of intermediaries because of their loan portfolio composition. While banks' portfolio is mainly allocated to commercial loans (52.5%), the other types of intermediaries are concentrated on consumer loans (68.8% and 64.2% for CFC and cooperatives, in its order). The same occurs for housing loans, which have a higher share on banks, and for microcredit loans, which are more relevant for cooperatives.

The interest rate pass-through from the MPR to the retail rates in Colombia varies across different types of lending products. Indeed, Galindo and Steiner (2020) find that there exists an upward rigidity in the lending rates of consumer and ordinary corporate loans. Likewise, they determine that in some cases these rates respond more to MPR cuts than to hikes. Figure 2 presents historical data of MPR and marginal rate charged on loans disbursed at each moment in time. In broad terms, a relatively strong co-movement is seen for commercial rates. This happens as well for the other rates but to a lesser extent, especially in the case of microcredit.

Figure 2: Marginal interest rate by bank credit modalities



The figure depicts historical data of monetary policy rate and marginal rate charged on loans disbursed by credit modality at each moment in time.
Source: Financial Superintendence of Colombia, authors' own calculations.

Regarding deposit rates a similar pattern is found. The interest rates paid on saving and current accounts fluctuate less to changes in the MPR than those remunerating term deposits. This observation can be extended to saving accounts by counterparty: business and public sector customers rates follow more tightly changes in the MPR than retail customer rates do [1]. The funding strategies of banks rely more on saving and current accounts (44.0% of total liabilities), while CFC and cooperatives focus on term deposits (61.1% and 62.3% of total liabilities, respectively). This differentiation can also be seen when comparing the counterparties of saving accounts: for banks the most important counterparties are businesses (54.4%), while for CFC and cooperatives are retail customers (65.5% and 65.9%).

Covas et al. (2015) suggest that the transmission channels might vary according to the size of the entities. In fact, this might be the case for Colombian credit institutions as shown in Figure 3[2]. Large entities rates display a strong pattern of co-movement with policy rate in comparison with the one observed for small and medium ones[3].

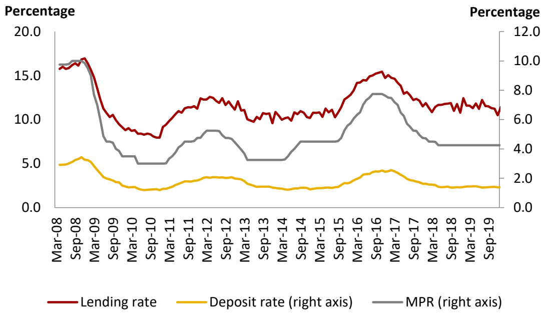
[1] The correlation coefficient between MPR and saving accounts rate for businesses is 98.0%; between MPR and the rate for public sector customers is 94.0%, and 60.6% between MPR and the rate for retail customers.

[2] The information concerning general patterns for each type and size of intermediary is only available since 2008. However, in the empirical analysis it is included since 2003 through proxy variables.

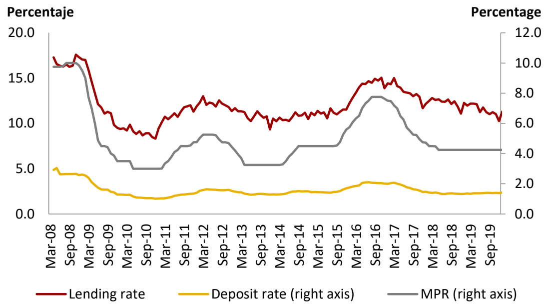
[3] The share over total assets for small credit institutions is less than 1%. For medium credit institutions range between 1% and 9%, and for the large ones it is greater than 9%.

Figure 3: Deposit and lending retail rates of credit institutions

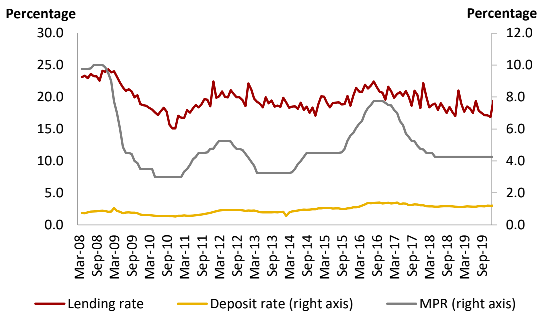
(a) **Large entities**



(b) **Medium entities**



(c) **Small entities**

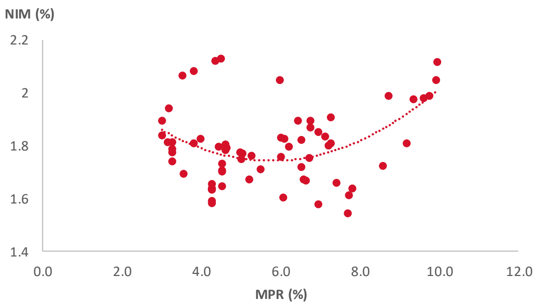


The figure depicts monetary policy rate, deposit retail rate and lending retail rate of small, medium and large credit institutions. Monthly average information.
Source: Financial Superintendence of Colombia, authors' own calculations.

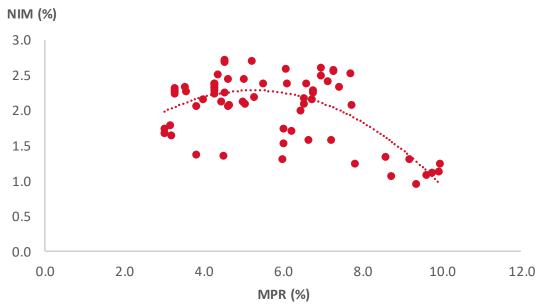
All in all, these particular features mentioned above translate into different relationship between MPR and NIM depending on the type of institution. In this regard, Figure 4 depicts the observed behavior of MPR and NIM for banks, CFC and cooperatives. Each observation corresponds to a cross section average value by quarter between 2003 and 2019. At first sight, the relationship between these two variables seems to be non-linear. Specifically, a polynomial adjustment suggests that for banks the relationship might be quadratic and convex, while for CFC quadratic and concave.

Figure 4: Empirical relationship between MPR and NIM

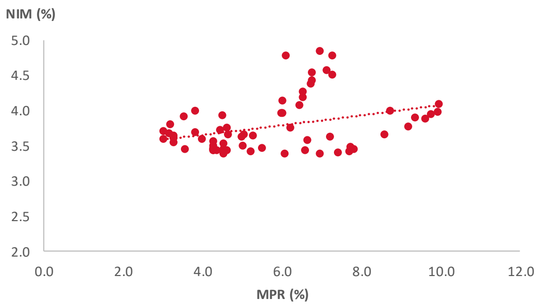
(a) **Banks**



(b) **CFC**



(c) **Cooperatives**



The figure depicts quarterly cross-sectional averages of the sample (2003q1-2019q4) for each type of intermediary. The dotted lines correspond to trend-lines fitted with polynomials of degree 2.
Source: Financial Superintendence of Colombia, authors' own calculations.

To understand the transmission channel between MPR and NIM, the decomposition proposed by Ahtik et al. (2016)) is used. This method seeks to determine how is the pass-through of changes in the MPR to NII by isolating the quarterly change of NII into quantity and price effects [4]. Our approach differs from the one mentioned above as we analyze interest income (II) and interest expenses (IE) separately, seeking to identify which one is more affected to changes in the MPR. Therefore, equations (2) and (3) stand for quarterly variations of interest income due to price ($\Delta IIP_{i,t}$) and quantity ($\Delta IIQ_{i,t}$), in its order. Similarly, equations (4) and (5) stand for quarterly variations of interest expenses due to price ($\Delta IEP_{i,t}$) and quantity ($\Delta IEQ_{i,t}$).

$$\Delta IIP_{i,t} = (\frac{II_{i,t}}{L_{i,t}} - \frac{II_{i,t-1}}{L_{i,t-1}})L_{i,t-1} \tag{1}$$

$$\Delta IIQ_{i,t} = (L_{i,t} - L_{i,t-1})\frac{II_{i,t}}{L_{i,t}} \tag{2}$$

$$\Delta IEP_{i,t} = (\frac{IE_{i,t}}{D_{i,t}} - \frac{IE_{i,t-1}}{D_{i,t-1}})D_{i,t-1} \tag{3}$$

$$\Delta IEQ_{i,t} = (D_{i,t} - D_{i,t-1})\frac{IE_{i,t}}{D_{i,t}} \tag{4}$$

Where $L_{i,t}$ corresponds to the total amount of loans, $D_{i,t}$ to the level of deposits, $II_{i,t}$ to the flow of income, and $IE_{i,t}$ to the payment of interests to deposits held by entity i

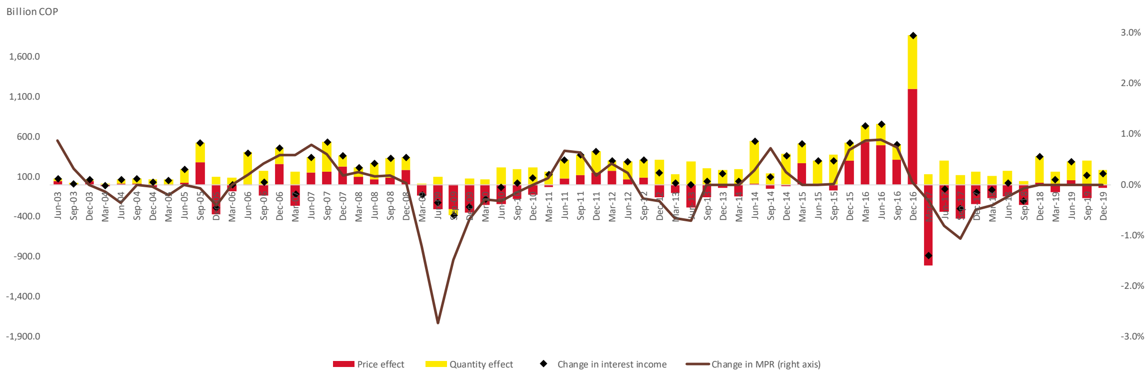
[4]NII is equal to interest income minus interest expense.

during quarter t.

As Figure 5 and 6 show, during the period 2003-2019 aggregate variations in II and IE occurred simultaneously to changes in the policy rate. This becomes more evident in periods of relatively large variations such as those observed during 2009 and 2017. During these periods, price effects dominated quantity effects, which might indicate that rates (active and passive) co-moved in a timely manner to changes in the MPR. These price effects were larger for II than for IE, possibly due to the zero lower bound constrain that prevent large drops in passive rates. As a consequence, price effects on NII tend to be negative (without controlling for other variables), under a scenario of large changes in the MPR [5].

Certainly the feature of large and dominant price effects during periods of stress is coherent with the idea that MPR and NIM might be related in a nonlinear way, as large variations of the former generate an outsized response of the latter. This might be explained by the fact that credit institutions are not willing to modify their rates to small variations of the MPR given that their proportion of assets and liabilities linked to fixed rates is relatively large (52.8% and 49.6%, in its order). Likewise, it may be related to sudden shifts in the expectations of credit institutions about the future path of interest rates when observing large changes in the MPR.

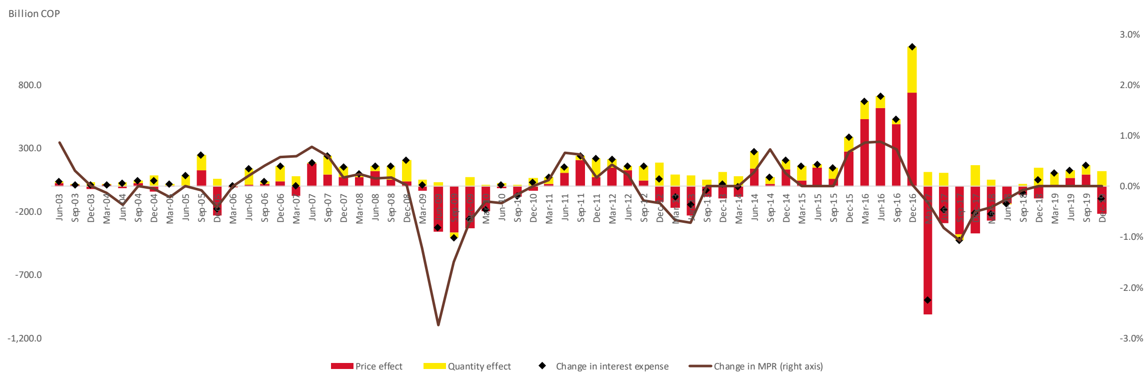
Figure 5: Price and quantity contributions to changes in interest income



The figure depicts the decomposition of changes in interest income into price effects (interest rates) and quantity effects.
Source: Financial Superintendence of Colombia, authors' own calculations.

[5] In this analysis, valuation effects of the loan portfolio are negligible given that this balance sheet item is not value at market prices.

Figure 6: Price and quantity contributions to changes in interest expenses



The figure depicts the decomposition of changes in interest expenses into price effects (interest rates) and quantity effects.
Source: Financial Superintendence of Colombia, authors' own calculations.

5 Data, Variables and Methodology

5.1 Data

The data used for the empirical analysis contains information of Colombian credit institutions' balance sheet from 2003 to 2019. The sample includes banks, CFC, and financial cooperatives; 40 entities in total. Therefore, the panel data is made up of 1,939 observations.

5.2 Variables

The dependent variable is the NIM which is defined as the difference between interest income and interest expenses to total loans. Although there are several definitions of NIM, this one was chosen due to the fact that is the most widely used in economic literature, and also because some of the theoretical models presented above are based on this definition. For its part, considering the necessity to overcome the endogeneity problem, the independent variable of interest is the monetary policy shock series rather than the MPR.

As is well known, when estimating the causal response of interest rates and NIM to changes in the MPR one face an endogeneity problem, given the simultaneity between these variables. To address this identification problem, we construct a series of exogenous policy shocks (MPS) following the methodology of Romer and Romer (2004). Under this approach, MPS are calculated as the residuals of regressing the MPR on a set of quantifiable variables that the Central Bank of Colombia's board of directors had at each of its monetary policy meeting. The information set includes the current level of the policy rate (MPR), the inflation rate (π) and GDP observed in the current quarter and during the previous one, as well as the forecasts for two quarters ($\tilde{x}_{t,t+2}$) of inflation rate and GDP provided by the technical staff at the meeting, and the changes in the forecasts ($\Delta\tilde{x}_{t,t+2}$) since the previous meeting.

Moreover, considering that our goal is to analyze the effect of changes in the MPR on NIM, a measure of credit intensity (defined as credit growth over GDP) was included in the set of information used to calculate the policy shocks series. This was done seeking to control for the endogenous relationship between changes in the policy rate and the financial context. As demonstrated by Clavijo-Ramírez et al. (2016), this indicator is a good predictor of the credit cycle and the financial conditions for the Colombian case.

The following equation was estimated using quarterly data from 2003 to 2019.

$$\Delta MPR_t = \beta_0 + \beta_1 MPR_{t-1} + \beta_2 GDP_{t-1} + \beta_3 \pi_{t-1} + \beta_4 \tilde{\pi}_{t,t+2} + \beta_5 G\tilde{D}P_{t,t+2} + \beta_6 \Delta\tilde{\pi}_{t,t+2} + \beta_7 \Delta G\tilde{D}P_{t,t+2} + \beta_8 CreditIntensity_t + \epsilon_t \quad (5)$$

The estimated residuals $\hat{\epsilon}_t$ represent policy decisions that cannot be explained based on the information available, and therefore reflect "surprises" or exogenous policy shocks. In this way, the endogenous relationship between the MPR and the NIM is eliminated.

To carry out the empirical analysis, we also chose control variables considering the model of Ho and Saunders (1981) and their subsequent extensions previously described in section 3. In that way, for the econometric specification we include the following time-variant and bank-level variables:

Bank Size
Following Borio et al. (2017) we include the logarithm of total assets considering that potential losses might be proportional to the size of credit institutions. Moreover, we analyze the effects over NIM differentiating by large, medium and small credit institutions[6].

Risk Aversion
To measure risk aversion we include a proxy defined as equity over total assets. This was done since the degree of risk aversion can affect the NIM given that more risk-averse credit institutions might require higher margins to cover the higher cost of equity financing compared to debt financing.

Credit Risk
credit institutions include an implicit risk premium in their interest rates concerning the possibility of default on loans. Credit risk is approximated by the Nonperforming Loan Ratio (NPL), which is calculated as the ratio of non-performing loans[7] to outstanding loans.

Average Cost
Since NIM should cover, at least, the operating costs, the ratio between total operating costs (administrative expenses, wages, commissions and depreciation) to total assets is included.

Implicit Interest Payments
Operating expenses net of non interest revenues to total assets ratio is also included considering that implicit payments affect transaction costs which, at the same time, requires a wider NIM to compensate entities (Angbazo, 1997).

[6]As mentioned in Section 4, large entities are the ones with a share over total assets greater than 9%, for medium entities range between 1% and 9% and for the small ones is less than 1%.

[7]In Colombia, loans are considered nonperforming if the debtor has made zero payments of interest or principal within 30 days

Commercial loans share
Concerning the pertinence of the composition of loan portfolio for the transmission of MPR among lending rates (see Section 4), we include the share of commercial loans over total loans.

Market power
As an indicator of market power, we include two types of Herfindahl–Hirschman Index: one to approximate the concentration in the loan market and the other in the deposit market. This is done taking into account that some studies found a positive statistical relationship between profitability and either concentration or market share (Cruz-García et al., 2017).

Furthermore, operating costs to total assets ratio is included as a measure of efficient management, like so cash over deposits as a measure of liquidity, and the slope of the yield curve as a measure of interest rate risk. As time dependent variables we use the quarterly GDP growth and inflation rate to control for the possible influence of the economic cycle on the NIM.

5.3 Methodology

The analysis is based on an estimation of a fixed-effects panel data model with clustered standard errors. We also include the lag of NIM as an explanatory variable to capture the inertia in its evolution.

The reduced form regression equation of the model is given by:

$$NIM_{it} = \omega NIM_{i,t-1} + \alpha_1 MPS_t + \alpha_2 MPS_t^2 + X'_{it}\theta + Z'_t\phi + \gamma_i + \delta_t T_t + u_t \qquad (6)$$

for $t = 1, \ldots, T$, indicating the period, and $i = 1, \ldots, N$ the number of entities in the sample. NIM_{it} is the NIM of each CI, while X'_{it} refers to a matrix of CI-specific control variables. Z'_t represents macroeconomic variables (GDP growth and inflation rate), γ_i captures entity fixed effects, and T_t time fixed effects. Finally, MPS_t corresponds to policy shocks measured as the residuals of the regression described in Subsection 1 of Section 5. As this latter is the variable of interest, we focus on α_1 and α_2. First, we analyse the direct effect of MPS on NIM: fitted values for different levels of MPS keeping the other explanatory variables at their means, so we focus on $\hat{\alpha}_1 MPS_t + \hat{\alpha}_2 MPS_t^2$. Second, we analyse marginal effect of changes in MPS over NIM through the estimated partial derivative $\frac{\delta \hat{NIM}}{\delta MPS} = \hat{\alpha}_1 + 2\hat{\alpha}_2$.

6 Results

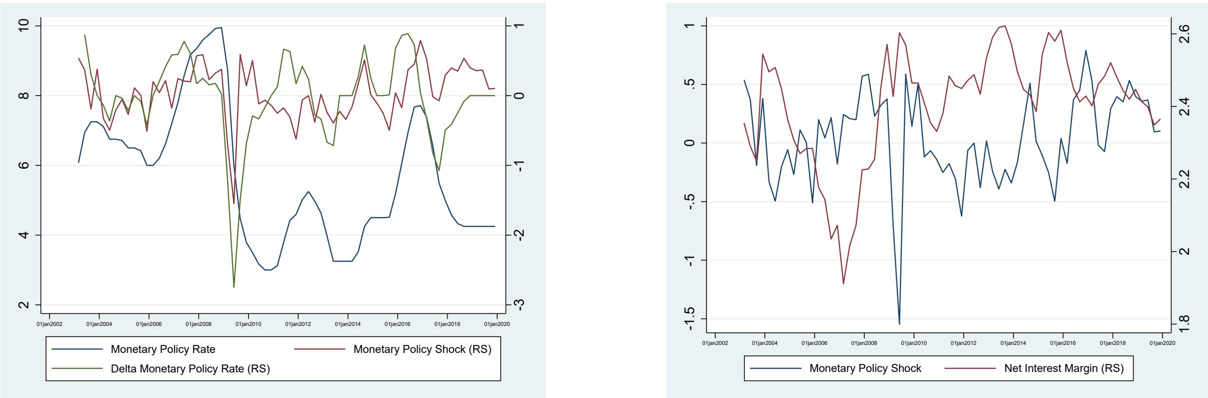
6.1 Measure of Monetary Policy Shocks

In Figure 7 we plot MPS series that is defined as the estimated residuals from the regression specified in equation (6). The estimates are reported in Appendix A. As it is shown, the effect of credit intensity is significant, which supports our identification strategy.

This series eliminates much of the endogenous movement between monetary policy rate and macroeconomic, and financial market conditions. By conditioning on real-time forecasts of macroeconomic variables which are formed using a multitude of economic variables, this monetary surprises are also independent of current expectations of future economic conditions.

Figure 7. Monetary Policy Shocks

(a) **Levels and changes in MPR** (b) **Net Interest Margin**



The figure shows negative values of monetary policy shocks coincide with periods of reductions in monetary policy rate. Moreover, net interest margin leaps ahead movements of monetary policy shocks at least until the first quarter of 2019. Panel A depicts monetary policy rate behavior (level and changes between 2003q1-2019q4) and monetary policy shocks series calculated following Romer and Romer (2004) approach and panel B depicts monetary policy shocks series and aggregate net interest margin (*interest income-interest expenses/total loans*) of credit institutions included in the dataset used for the econometric model. Y-axis units in percentage.
Source: Financial Superintendence of Colombia, authors' own calculations.

Panel A shows MPS series, and level and changes in MPR throughout years. Negative (positive) values in monetary policy surprises coincide with periods of reductions (increases) in policy rate. In fact, during 2009 policy shock was negative and the intervention interest rate decreased by 600 basis points as a way to reactivate the economic activity given the decline in national output.

Regarding the relationship between MPS and NIM, in Panel B both series are presented. NIM leaps ahead the movements of MPS at least until the first quarter of 2019, which means NIM increases (decreases) few periods before a positive (negative) shock. However, during a short period in 2009 it is possible to identify a co-movement between both series: negative policy shock and decreases in NIM. This is perhaps due to the fact that during the second semester of 2009 implicit lending rates decreased more than implicit deposit rates.

6.2 Net Interest Margin and Monetary Policy Shocks

Table 1 presents the results of the estimation of equation (7). In the first column a linear relationship between NIM and MPS was assumed. As can be seen, the effect of these shocks is not statistically significant. This might be due to the empirical nonlinear relationship between NIM and MPR mentioned in section 4. Therefore, in columns (2) to (4) this feature is explored, finding this specification is the one that better fits data.

The detailed results reported in the second column of Table 1 show the estimate of α_2, which corresponds to the coefficient associated to the quadratic term of MPS, is positive and statistically significant. This means that once the endogeneity problem is overcome, the NIM increases to contractionary (postive) and expansionary (negative) policy shocks.

In columns (3) and (4) a variation of the model is included. First, considering that there might be a different response of NIM to MPS depending on the type of credit institutions, an interaction between banks, financing cooperatives, financing companies and MPS was included. For the first two types of credit institutions, the estimate of the coefficient associated to the interaction term is positive and statistically significant. In the same way, considering that the effect can also depend on the size of credit institutions, an interaction between size and MPS was included. The result is the same: there is a positive quadratic statistically significant effect[8], which means that NIM of small, medium and large credit institutions also increases to contractionary and expansionary policy shocks.

The results for the bank-specific variables are broadly consistent between each different specification model. For instance, average cost has a positive and significant effect over NIM, as the intermediation margin should cover at least the operating costs. In the same way, the sign of implicit interest rate is positive and statistically significant, which means that higher implicit payments demand wider margins to compensate entities for the increase in transaction costs. The coefficient for the Herfindahl-Hirschman Index (HHI) is also positive and statistically significant since entities with greater market power can set higher margins. Finally, a higher concentration on commercial loans reduces the intermediation margin.

[8]These results are robust to different measures of monetary policy shocks. Robustness exercises are in Appendix B.

Table 1: Determinants of Net Interest Margin: 2003–2019

VARIABLES	(1) Fixed Effects	(2) Fixed Effects	(3) Fixed Effects	(4) Fixed Effects
NIM_{t-1}	0.802***	0.802***	0.801***	0.802***
	(0.0263)	(0.0265)	(0.0273)	(0.0271)
Size	0.0235	0.0251	0.0255	
	(0.0304)	(0.0304)	(0.0305)	
Average Cost	0.0633*	0.0639*	0.0648*	0.0624*
	(0.0338)	(0.0340)	(0.0337)	(0.0347)
Implicit Interest Payments	0.0729**	0.0722**	0.0719**	0.0721**
	(0.0277)	(0.0278)	(0.0280)	(0.0276)
Commercial Loans Share	-0.00372***	-0.00370***	-0.00374***	-0.00382***
	(0.000619)	(0.000617)	(0.000617)	(0.000597)
Efficiency	-0.00454	-0.00436	-0.00434	-0.00561
	(0.0315)	(0.0316)	(0.0312)	(0.0316)
Inflation Rate	-0.0285***	-0.0260***	-0.0262***	-0.0269***
	(0.00748)	(0.00762)	(0.00755)	(0.00742)
GDP Growth	-0.0120**	-0.0102*	-0.0103*	-0.0111*
	(0.00586)	(0.00584)	(0.00587)	(0.00581)
HHI Loans	4.39e-06	1.94e-06	3.61e-06	7.30e-06
	(1.83e-05)	(1.83e-05)	(2.01e-05)	(1.79e-05)
HHI Deposits	3.03e-05*	3.38e-05**	3.56e-05**	2.63e-05
	(1.54e-05)	(1.55e-05)	(1.73e-05)	(1.59e-05)
Risk Aversion	0.00119	0.00118	0.00126	0.000968
	(0.00146)	(0.00144)	(0.00144)	(0.00150)
Non-Performing Loan Ratio	0.00103	0.000949	0.000803	0.000909
	(0.00169)	(0.00168)	(0.00166)	(0.00174)
Liquidity to Total Assets	-0.00119	-0.00104	-0.00100	-0.00120
	(0.00282)	(0.00282)	(0.00280)	(0.00275)
Yield Curve (Slope)	-0.00316	-9.07e-05	7.75e-05	-0.00148
	(0.00425)	(0.00427)	(0.00430)	(0.00419)
Monetary Policy Shock	-0.00814	0.0149		
	(0.0156)	(0.0152)		
Monetary Policy Shock^2		0.0732***		
		(0.0222)		
Banks · Monetary Policy Shock			0.00940	
			(0.0180)	
Financing Companies · Monetary Policy Shock			0.0311	
			(0.0319)	
Cooperatives · Monetary Policy Shock			0.0141	
			(0.0227)	
Banks · Monetary Policy Shock^2			0.0685***	
			(0.0175)	
Financing Companies · Monetary Policy Shock^2			0.117	
			(0.0837)	
Cooperatives · Monetary Policy Shock^2			0.0548**	
			(0.0225)	
Size · Monetary Policy Shock				0.000276
				(0.000310)
Size · Monetary Policy Shock^2				0.00142***
				(0.000365)
Observations	1,939	1,939	1,939	1,939
R-squared	0.873	0.874	0.875	0.874
Credit Institutions	40	40	40	40
Time Fixed Effects	YES	YES	YES	YES

The sample includes 40 credit institutions from 2003q1 to 2019q4. Estimates are from dynamic fixed effects regression. Robust standard errors in parentheses. Variables are defined in Section 5.2. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level respectively.

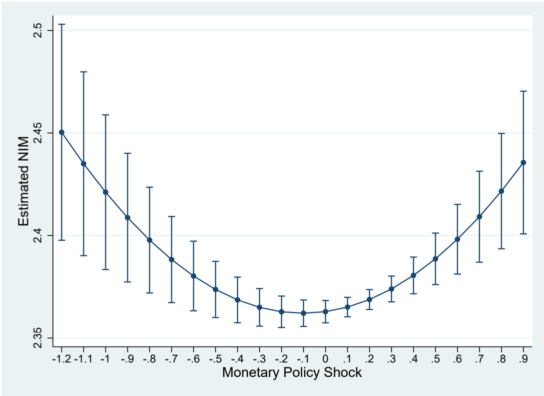
Figure 8 presents the fitted values of NIM for different levels of policy shocks ($\hat{\alpha}_1 MPS_t + \hat{\alpha}_2 MPS_t^2$). As the nonlinear relationship between these two variables is the one that better fits data, and the coefficient associated to this term is positive and statistically significant, there is evidence that NIM increases as policy shocks are bigger (negative or positive). The effect over NIM is greater for large entities, and is statistically equal between banks and financial cooperatives. Figure 9 shows the marginal effect of NIM for different levels of MPS ($\frac{\delta N\hat{I}M}{\delta MPS} = \hat{\alpha}_1 + 2\hat{\alpha}_2$). There are significant marginal effects as MPS moves away from zero, which implies the intermediation margin only responds to large and unanticipated changes in policy rate.

These two features: positive and statistically significant quadratic relationship between NIM and MPS, and significant marginal effects as policy shocks are bigger, might be due to the role of credit market imperfections. According to Bernanke and Blinder (1992) and Kashyap and Stein (1995), who examined the effects of monetary policy shocks on banks' deposits, securities and loans, policy surprises work by affecting the composition of bank assets. A change in MPS leads to an immediate response on deposits rather than loans, as the latter are commitments whose stock is difficult to change quickly.

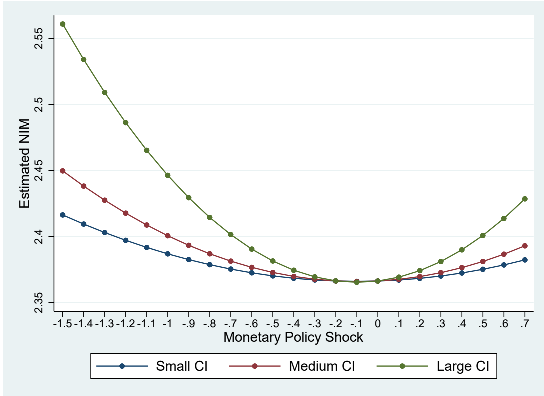
For instance, contractionary MPS leads to a short-run sell-off of banks' securities holdings, which means a decline in the volume of banks' deposits as well as a decline in banks' assets. The decrease in both banks' deposits and banks' assets increases NIM. Over time, the effect will also be reflected in loans, given the liquidity conditions that will lead banks to refuse to make new loans. On the contrary, expansionary MPS exerts a positive effect on NIM due to the higher sensitivity of banks' funding costs, which usually tend to fall more quickly than interest income under this scenario.

Figure 8. Fitted values of the NIM to different levels of MPS

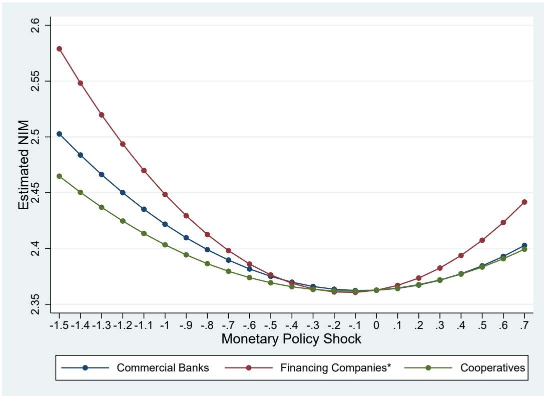
(a) Non-linear relationship



(b) By size



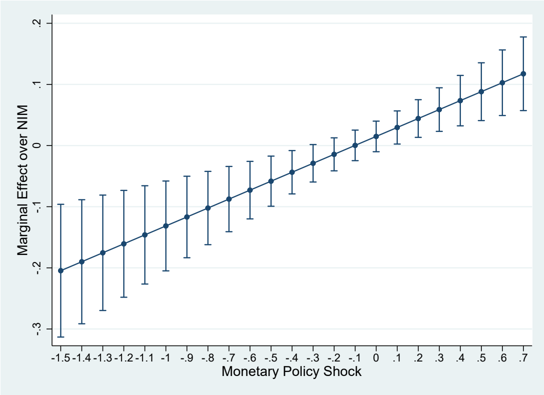
(c) By type of entity



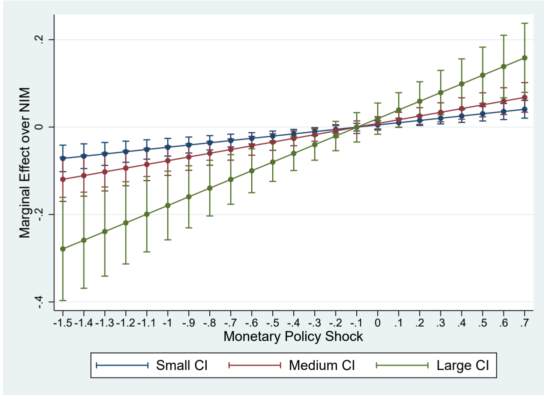
The figure plots fitted values of net interest margin to different levels of monetary policy shocks considering the quadratic relationship better fits the data. Panel (a) shows fitted values calculated using the estimated coefficients reported in Table 1 column 2, panel (b) shows fitted values calculated using the estimated coefficients reported in Table 1 column 3, and panel (c) shows fitted values calculated using the estimated coefficients reported in Table 1 column 4. In general, net interest margin increases as monetary policy shocks are bigger (negative or positive). X-axis and Y-axis units in percentage.
Source: Authors' own calculations.

Figue 9. Marginal effects - Effect of changes in MPS over NIM

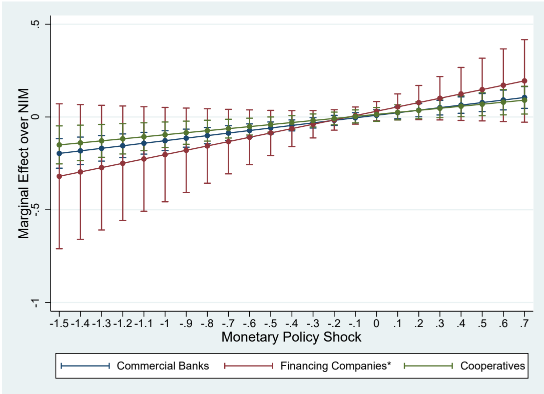
(a) Non-linear relationship



(b) By size



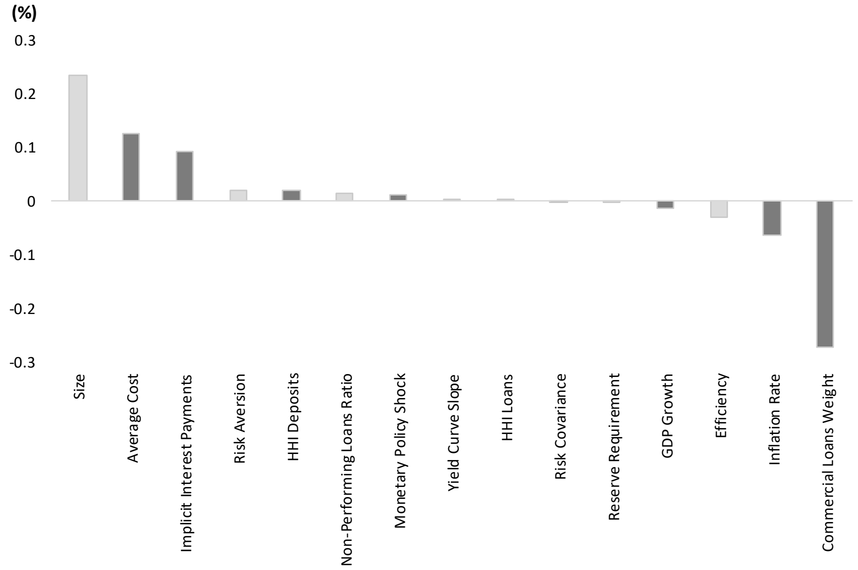
(c) By type of entity



The figure plots marginal effects of net interest margin to changes in monetary policy shocks. Panel (a) shows marginal effects calculated using the estimated coefficients reported in Table 1 column 2, panel (b) shows marginal effects calculated using the estimated coefficients reported in Table 1 column 3, and panel (c) shows marginal effects calculated using the estimated coefficients reported in Table 1 column 4. In general, there is a significant effect over net interest marginal only when monetary policy shocks are large enough. X-axis and Y-axis units in percentage.
* Marginal effects are not statistically significant for financing companies.
Source: Authors' own calculations.

Finally, as mentioned before, the coefficients for average costs, implicit interest payments and market power (captured by Herfindahl-Hirschman Index) are statistically significant and positive, while for commercial loans share, inflation rate and GDP growth coefficients are statistically significant and negative. To assess how the variation of each explanatory variable affects NIM, Figure 10 quantifies the impact of an interquartile variation in each of the explanatory variables considering the estimates reported in column (2). The variables are ordered from highest to lowest impact, and the dark gray bars correspond to variables whose effect is statistically significant. For the time frame analyzed the most important determinants of NIM are: average costs, implicit interest payments, and commercial loans share.

Figure 10: Economic impact of the net interest margin determinants



The figure shows the effect on net interest income of a variation of 25–75 percentile of the distribution in each of the explanatory variables. The dark gray bars correspond to variables whose effect is statistically significant.
Source: Authors' own calculations.

7 Conclusions

Analyzing the link between MPR and NIM is relevant to capture the transmission of macroeconomic shocks to the balance sheet of credit institutions. Several studies have found a concave relationship between these two variables, implying NIM decreases to an expansionary MPR. However, as monetary policy decisions are mainly made based on the macroeconomic information available at the time, these results might be biased due to endogeneity. To overcome this problem and to get unbiased estimators that relate MPR to NIM is desirable to capture the response of the intermediation margin to exogenous policy shocks. Therefore, we analyze the relationship between NIM and monetary policy surprises, which correspond to unexpected variation (policy shocks are orthogonal to unexpected changes in economic activity, financial conditions and inflation) in the policy rate path.

The results obtained in this study for a large sample of banks in Colombia for the period 2003–2019 are derived from a non-linear approach, which is suitable to describe the dynamics of the link between policy surprises and NIM. We find that a positive quadratic model between MPS and NIM is the one that better fits the data. Once the endogeneity problem is overcome, NIM increases to positive (contractionary) and negative (expansionary) MPS.

A contractionary MPS increases NIM as in the short-run there is a sell-off of banks' securities holdings,which means a decline in the volume of banks' deposits as well as a decline in banks' assets. In the case of expansionary MPS, the mechanism that increases NIM occurs through a higher sensitivity of banks' funding costs, which usually tend to fall more quickly than interest income. The results for large credit institutions are explained by the weight of its commercial loans and its deposit structure.

Finally, the marginal effect of MPS on NIM shrinks when compare with the one exerts by other variables such as the average costs, the implicit interest payments, and the commercial loans share. These results are robust to variations in the measurement of MPS.

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Appendix A: Construction of Monetary Policy Shocks

Table A.1. Romer and Romer (2004) approach - Regression results

	Δ Monetary Policy Rate$_t$	
	(1)	(2)
Monetary Policy Rate$_{t-1}$	-0.261^{***}	-0.252^{***}
	(0.043)	(0.041)
GDP Growth$_{t-1}$	0.152^{***}	0.107^{**}
	(0.049)	(0.050)
Inflation$_{t-1}$	0.139	0.102
	(0.086)	(0.083)
F.GDP Growth$_{(h=2)}$	0.147^{*}	0.131
	(0.084)	(0.081)
F.Inflation$_{(h=2)}$	0.209^{**}	0.266^{***}
	(0.084)	(0.083)
ΔF.GDP Growth$_{(h=2)}$	-0.128^{**}	-0.101^{*}
	(0.052)	(0.051)
ΔF.Inflation$_{(h=2)}$	-0.135	-0.210^{*}
	(0.108)	(0.107)
Credit Intensity$_t$		0.093^{***}
		(0.034)
Observations	75	75
R^2	0.621	0.659
Adjusted R^2	0.582	0.618

Coefficients are reported in percentage. The sample is from 2003q1 to 2019q4. We exclude 2020 as the technical staff did not provide forecast for 2020q1 given the COVID-19 pandemic. ***, **, and * denote statistical significance at the 1, 5, and 10 percent level respectively.

Appendix B: Robustness exercises

Table B.1 presents the results of the estimation of equation (7) using a different measure for policy shocks from the one presented in the main text. MPS is defined as the difference between policy rate expectations of financial intermediaries and their subsequent realizations for each date analyzed: a level different from zero indicates a "surprise". In Table B.2 MPS is measured as the residuals of Romer and Romer (2004) original specification model (i.e. credit intensity variable is not included).

In Figure B.1 the three different measures of policy shocks are compared. In general terms, the dynamics are the same along the three different series presented.

Table B.1. Robustness - Monetary Policy Shock (Bloomberg)

VARIABLES	(1) Fixed Effects	(2) Fixed Effects	(3) Fixed Effects	(4) Fixed Effects
NIM_{t-1}	0.794***	0.794***	0.794***	0.795***
	(0.0262)	(0.0262)	(0.0262)	(0.0274)
Monetary Policy Shock	-0.0857**	-0.0429		
	(0.0366)	(0.0481)		
Monetary Policy Shock^2		0.145		
		(0.137)		
Banks · Monetary Policy Shock			-0.0278	
			(0.0630)	
Financing Companies · Monetary Policy Shock			-0.0860	
			(0.0867)	
Cooperatives · Monetary Policy Shock			-0.0518	
			(0.101)	
Banks · Monetary Policy Shock^2			0.313*	
			(0.178)	
Financing Companies · Monetary Policy Shock^2			-0.202	
			(0.300)	
Cooperatives · Monetary Policy Shock^2			-0.0945	
			(0.278)	
Size · Monetary Policy Shock				0.000195
				(0.00117)
Size · Monetary Policy Shock^2				0.00742**
				(0.00318)
Observations	1,880	1,880	1,880	1,880
R-squared	0.867	0.867	0.867	0.867
Credit Institutions	40	40	40	40
Time Fixed Effects	YES	YES	YES	YES

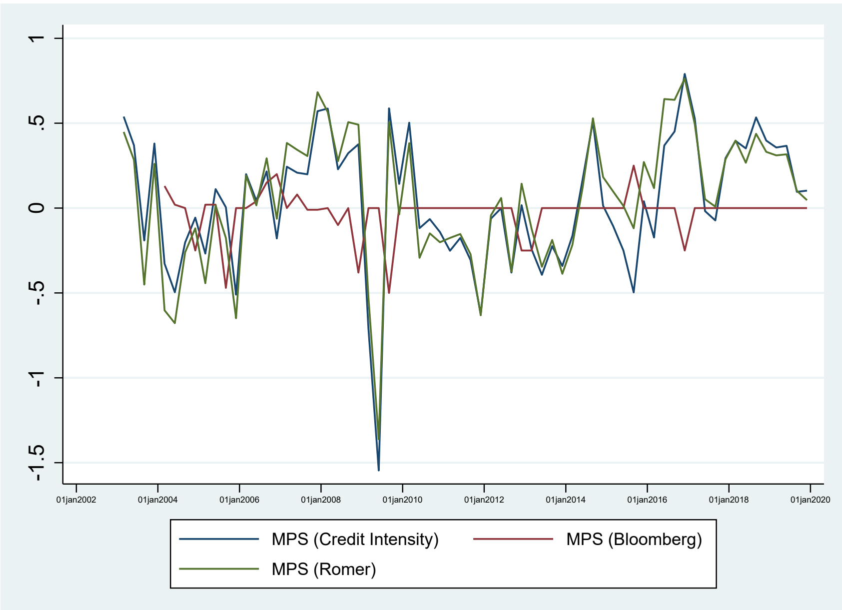
***, **, and * denote statistical significance at the 1, 5, and 10 percent level respectively.

Table B.2. Robustness - Monetary Policy Shock (Romer & Romer)

VARIABLES	(1) Fixed Effects	(2) Fixed Effects	(3) Fixed Effects	(4) Fixed Effects
NIM(-1)	0.802***	0.802***	0.801***	0.802***
	(0.0262)	(0.0265)	(0.0275)	(0.0270)
Monetary Policy Shock	0.000717	0.0243		
	(0.0176)	(0.0167)		
Monetary Policy Shock^2		0.0920***		
		(0.0245)		
Banks · Monetary Policy Shock			0.0199	
			(0.0202)	
Financing Companies · Monetary Policy Shock			0.0392	
			(0.0319)	
Cooperatives · Monetary Policy Shock			0.0223	
			(0.0247)	
Banks · Monetary Policy Shock^2			0.0922***	
			(0.0190)	
Financing Companies · Monetary Policy Shock^2			0.113	
			(0.102)	
Cooperatives · Monetary Policy Shock^2			0.0747***	
			(0.0237)	
Size · Monetary Policy Shock				0.000438
				(0.000366)
Size · Monetary Policy Shock^2				0.00191***
				(0.000389)
Observations	1,939	1,939	1,939	1,939
R-squared	0.873	0.875	0.875	0.874
Credit Institutions	40	40	40	40
Time Fixed Effects	YES	YES	YES	YES

***, **, and * denote statistical significance at the 1, 5, and 10 percent level respectively.

Figure B.1. Three different measures of monetary policy shocks



The figure plots the monetary policy shocks derived from each approach described in the text. MPS (Credit Intensity) corresponds to policy shocks calculated as the residuals of Romer and Romer (2004) original specification model but including credit intensity variable to control for financial conditions. MPS (Romer) corresponds to policy shocks calculated following Romer and Romer (2004) original specification model. MPS (Bloomberg) corresponds to policy shocks measured as the difference between policy rate expectations of financial intermediaries and their subsequent realizations for each date analyzed.
Source: Authors' own calculations.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