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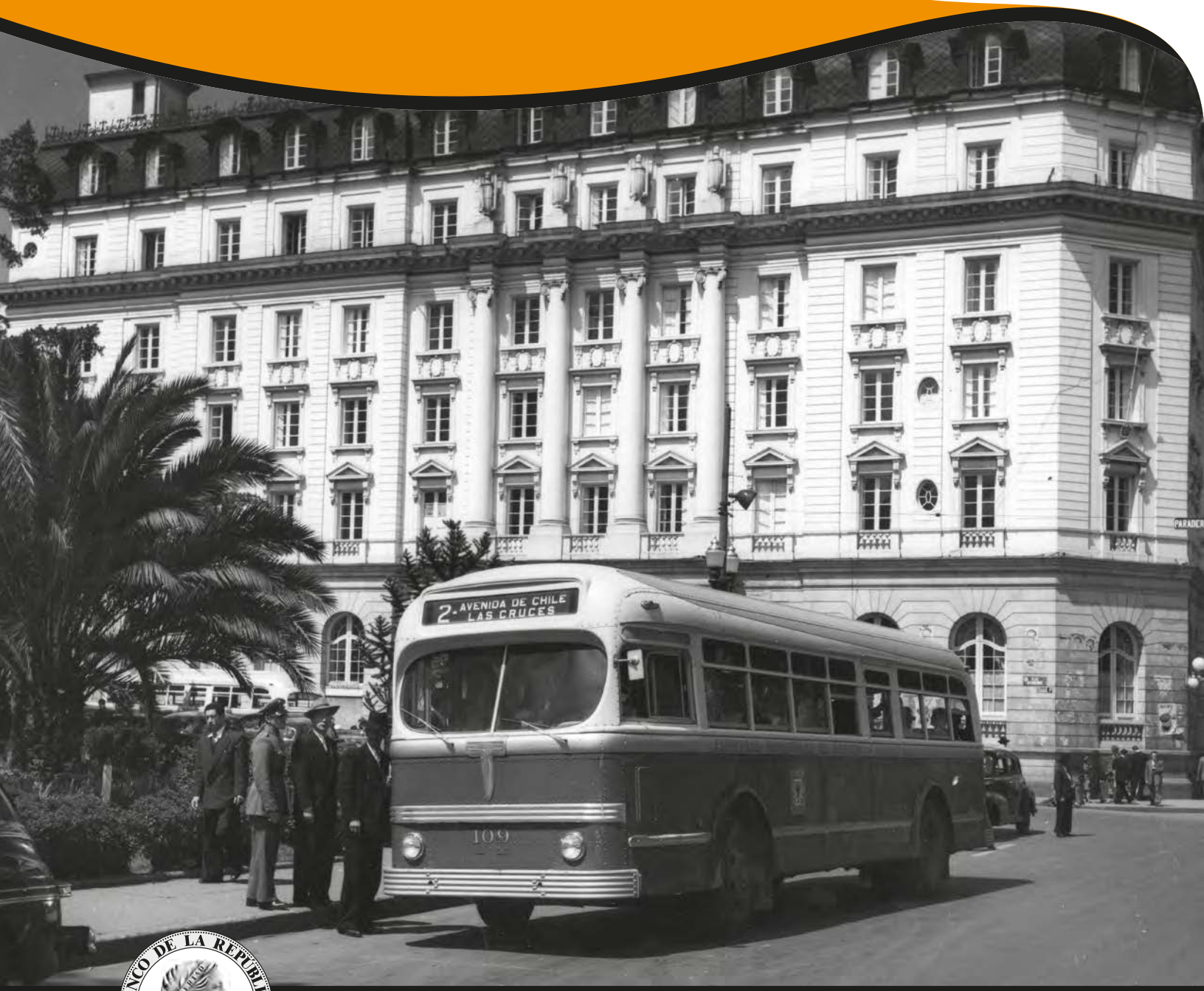

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Asymmetric Interest Rate Transmission in an Inflation Targeting Framework: The Case of Colombia

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Abstract

After adopting an inflation targeting framework for monetary policy at the turn of the century, the Central Bank of Colombia started actively using the monetary policy interest rate as its key policy tool. In this regard, this paper examines the interest rate pass-through from the monetary policy rate to the retail rates in Colombia and explores asymmetries in the adjustment process within the framework of a non-linear version of the ARDL (NARDL) model developed by Shin et al. (2014). Our findings show that the policy rate plays a key role in determining deposit and lending retail rates but the nature of the pass-through varies across different types of lending products. In the case of lending rates, the pass-through is usually a full one, and takes around 12 months to be nearly complete. Our results capture an asymmetric positive pass-through in deposit rates and an upward rigidity in the lending rates of consumer and ordinary corporate loans, key segments of the credit market. These findings imply that most retail lending rates respond more to policy rate cuts than to hikes, indicating that financial intermediaries are more reluctant to raise interest rates than to decrease them following policy adjustments.

JEL classification: E4, E5, G2
Keywords: Monetary policy, Interest rate pass-through, Asymmetry, Nonlinear autoregressive distributed lag (NARDL), Colombia

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Transmisión asimétrica de tasas de interés en un esquema de inflación objetivo: El caso colombiano

Arturo J. Galindo
Roberto Steiner

Abstract

El uso de la tasa de referencia de la política monetaria se convirtió en un elemento central para la formulación de política monetaria por parte del Banco de la República al adoptar un esquema de inflación objetivo a comienzos del siglo. Este trabajo estudia el canal de transmisión de dicha tasa a las tasas que perciben los usuarios del sistema financiero y explora posibles asimetrías utilizando una versión no lineal de los modelos ARDL (NARDL) desarrollada por Shin et al. (2014). Nuestras estimaciones muestran que la tasa de política juega un papel central en la determinación de tasas de interés de depósitos y préstamos y que su transmisión varía entre productos financieros. En el caso de tasas de préstamos, la transmisión es usualmente completa y tarda alrededor de doce meses en completarse. Los resultados sugieren que la mayoría de las tasas de interés de préstamos responden más fuertemente a reducciones en la tasa de política que a incrementos, lo que indica que los intermediarios financieros son menos propensos a subir tasas que a bajarlas tras ajustes de política. Por el contrario, las tasas de interés de los depósitos responden más a las alzas que a las reducciones en la tasa de interés de política.

Clasificación JEL: E4, E5, G2

Palabras Clave: Política monetaria, pass-through de tasas de interés, Asimetría, Rezago distribuido autorregresivo no-lineal (NARDL), Colombia

1. Introduction

The 1991 Constitution granted autonomy to the central bank and entrusted it with "maintaining the purchasing power of money" –i.e. delivering a low and stable rate of inflation. In general terms, since 1991 monetary policy can be viewed as having gone through three distinct phases, all of them characterized by a relatively open capital account:

(i) Until 1994, the central bank targeted the money supply while the exchange rate was fully administered under a "crawling peg" system, with the rate of crawl determined by the difference between Colombian inflation and some notion of international inflation.

(ii) The impossible trinity of targeting both the exchange rate and the money supply while having an open capital account led to the introduction of a crawling exchange rate band in 1994. Allowing the exchange rate to freely float within the band gave the central bank control over the money supply. In 1997, and as a consequence of the headwinds coming from Asia and Russia in the context of a severely deteriorated fiscal stance, the Colombian peso came under pressure. Interest rates significantly increased, and the central bank sold important amounts of international reserves. With pressure against the peso not having subsided, the exchange rate band was depreciated in September 1998 and again in June 1999[2].

(iii) In late 1999 the Colombian government agreed to a stand-by arrangement with the IMF. The program, in addition to fiscal consolidation, called for the flotation of the currency.

The flotation of the currency marks the beginning of a process of gradual adaptation of an inflation targeting framework, although it can be argued that some of its basic features had been in place since the early 1990s (Vargas, 2008). Initially, and having re-established control over monetary aggregates on account of operating under a flexible exchange rate regime, the central bank established a corridor for the monetary base whose rate of growth was subordinated to the inflation target. Using base money as an intermediate target came increasingly under question on account of the lack of stability of money demand.

The initial stages of Colombia´s experience with IT, including a detailed description of the operational issues involved, can be found in Gómez et al (2002) while a comprehensive review of the process of converging to a full-fledged IT monetary framework is provided by López et al (2017). For the purposes of this paper, it is particularly relevant to mention that in 2001 a Transmission Mechanism Model for an open economy was developed, supported by previous work undertaken at the Bank of England. It incorporated an aggregate demand channel, a channel for the direct and indirect influence of the exchange rate, an expectations channel and a costs channel.

Importantly, the main policy instrument chosen for monetary policy, was the interest rate on 1 to 15-day repo and reverse-repo operations conducted by means of auctions[3]. The interbank interest rate fluctuates between the central bank´s rates on loans and deposits and is the first link in the transmission

[2] A fascinating analysis of this process is found in Urrutia and Llano (2011).

[3] Later, the reverse-repo operations were substituted by deposits at the central bank which are not part of bank reserves.

of the central bank´s policy rate of interest to other rates of interest[4]. Through this channel, changes in the monetary policy rate are expected to alter financial sector retail rates and eventually aggregate demand.

Using interest rate data for the Colombian financial sector available since 2002, we explore how this first step in the transmission of monetary policy has worked in Colombia. For such purpose we follow a methodology that allows us to identify relevant and stable long and short-run relationships between the monetary policy rate and relevant retail rates, and that permits the modelling of asymmetries in the transmission mechanism that have been exhibited elsewhere.

In what follows we present the theoretical underpinnings of our paper. In section 3 we describe the data used in our study, and in section 4 the methodology. In section 5 we report our findings and we conclude in section 6.

2. Theoretical underpinnings and literature review

Credit markets play a central role in the transmission of monetary policy. The effectiveness of the credit channel[5] depends on how monetary policy affects the availability of liquidity, the cost of funds, the cost of credit, and on how credit demand reacts to such changes. As noted by de Bondt (2002, 2005) and Borio and Fritz (1995) among others, by steering money market interest rates and altering inflation expectations, monetary policy rate changes can impact economy-wide interest rates and through them aggregate demand. The effectiveness of this mechanism depends critically on the nature and extent of the interest rate pass-through, i.e. how much of an adjustment in the policy rate transmits to retail rates. Literature has shown that the pass-through depends on many factors, including competition considerations in the financial sector, macroeconomic conditions, the nature of credit products, among others[6].

In this paper we explore possible time variation in the pass-through that arises from asymmetries in response to positive or negative movements in the central bank policy rate. Following Greenwood-Nimmo et al (2013) and Rousseas (1985) among others, we pose that financial sector interest rates are defined by a simple mark-up over the cost of funds:

$$r_t = \gamma + \beta\mu_t + e_t \qquad (1)$$

where r_t is the relevant lending interest rate, μ_t is the marginal cost of funds approximated by the central bank policy rate, γ measures the markup over the cost of funds, β is the pass-through coefficient of the

[4] As highlighted by Vargas (2008), the adoption of IT brought about a notorious smoothing of the overnight interbank rate which, in principle, should enhance the ability of the central bank´s repo rate to act as a signaling device of the stance and objectives of monetary policy.

[5] Though important, the interest rate / credit channel is not the only mechanisms through which monetary policy operates. Exchange rate channels, asset price channels, and expectation channels are other ways through which monetary can impact the real economy. For a discussion on transmission mechanisms see Kamin et al. (1998) or Singh et al. (2008). Transmission mechanisms in Colombia are described, among others, in Vargas (2008).

[6] See Gregor et al. (2019) for a thorough review of empirical literature.

cost of funds to the interest rate, and e_t is a disturbance term[7]. In the absence of frictions, there should be a full (or complete) and rapid pass-through of monetary policy rate changes to retail rates (β=1). In practice however, interest rates can be rigid due to the prevalence of implicit contracting in long-term credit relationships, the presence of transaction and menu costs specific to some financial products, and to strategic behavior of financial intermediaries to preserve market share in contestable markets. In such cases the pass-through could be lower than one (or incomplete) and sluggish.[8]

Several studies have found that the differences in the pass-through and the speed of adjustment of retail rates to changes in monetary policy rates is conditional on the direction in which policy rates are adjusted. In terms of equation (1) this means that there could be two pass-through coefficients (β^+ and β^-) each one of them for either a positive or a negative change in μ. Empirical evidence supports such hypothesis. Analyzing data for OECD countries, Borio and Fritz (1995) found that the adjustment of retail interest rates is slower in response to a reduction in money market rates compared to an increase[9]. They argue that this happens because during recessions the elasticity of demand falls, and borrowers become more attached to their traditional lenders. A reduction of the policy rate in that context, leads to a small equilibrium adjustment of the interest rate in the credit market.

On the other hand, the asymmetry of the pass-through could work in the other direction due to the presence of adverse selection problems and asymmetric information in credit markets. In such cases, and to avoid an increase in credit risk (i.e. that the average default risk of clients increases when interest rates rise as in Stiglitz and Weiss(1981)), lenders may be more hesitant to fully transmit an increase in the policy interest rates to clients since this would deteriorate the quality of their pool of risks. This problem materializes when rates rise but not necessarily when they fall. In addition, and as noted by de Bondt (2002, 2005), in contestable markets, increasing the retail rate may risk that a bank may lose clients to its competitors and an upward interest rate rigidity may also appear[10].

In practice both types of asymmetries may be present, and one may dominate the other in either the short-run or the long-run. The empirical literature exploring these asymmetries took a strong turn after the methodological development of Shin et al. (2014) who proposed a method to estimate short and long-run asymmetries within a single empirical cointegration framework: the non-linear autoregressive distributed lag model (NARDL). Using this methodology Greenwood-Nimmo et al. (2013) estimated the pass-through of interest rates in the US and found evidence of asymmetries. Their findings suggest an incomplete pass-through in the US, and a long-run negative asymmetry (a stronger response to rate cuts than to rate increases) and a short-run positive asymmetry (a stronger response to hikes than to cuts).

[7] It is worth noting that this literature focuses on how changes in the policy rate are reflected on financial sector retail rates, regardless of whether they are anticipated or not. This literature points to identifying long-run correlations between the policy rate and relevant retail interest rates. Causality should be interpreted with caution, given that policy changes could be anticipated and reflected in current changes of retail rates. Anticipation, however, does not affect the measurement of the long-run pass-through. While analyzing surprises is key for understanding the impacts of monetary policy as in Christiano et al.(2005), that is beyond the questions posed by this literature.

[8] See de Bondt (2002) for a discussion and Bredin et al. (2002), Gregor et al.(2019), Gregor and Melecky (2017), Heinemann and Schüler (2006), Li and Liu (2019), Sander and Kleimeir (2004), Sahin and Çiçek (2018), Zhang et al. (2017) for examples on empirical evidence.

[9] See for example Mojon(2000), Gropp et al.(2007), and Heineman and Shüler (2002) for papers that confirm this view.

[10] Evidence of this type of asymmetry can be found in Gual(1999), Liu et al.(2008) and Sellon (2002) among others.

Many papers have used a lineal version of the NARDL, the ARDL (autoregressive distributed lag models) to estimate the pass-through of monetary policy rates both in advanced and emerging market economies. However, fewer have explored the nature of non-linearities particularly in emerging market economies, an issue that is critical to inform how monetary policy changes transmit to the economy under different scenarios. Using the NARDL model, Yu et al. (2013) find evidence of an asymmetric long-run pass-through in Hong Kong, Indonesia, Thailand, and South Korea and of short-run asymmetries in Hong Kong and Singapore. Sahin and Çirçek (2018) analyze the case of Turkey and find evidence of an almost complete asymmetric long-run negative pass-through of money market rates to lending rates.

In the case of Colombia, Holmes et al. (2015) estimate Threshold Autoregressive models (TAR and MTAR) on bank specific data, and find that the pass-through is heterogeneous across banks, and in most cases is incomplete. Their estimation strategy does not allow them to identify if the pass-through varies depending on if movements of the policy rate are positive or negative, but instead allows them to estimate asymmetries in the speed of adjustment to each kind of movement. They find that the speed of adjustment is faster for reductions in the policy rate than to increases. Likewise, Vargas et al (2010) find an asymmetric response, with monetary policy rate drops generating larger responses than policy rate hikes. Gómez et al (2016) report an asymmetric response only in preferential commercial loans and find that the transmission is particularly weak in the case of mortgage loans[11]. Other studies for Colombia that do not address asymmetries, have found that the pass-through is incomplete, though larger for lending than for deposit rates (Cristiano-Botia et al. (2018) and Betancourt et al. (2006)) and of similar magnitude for consumer loans than for commercial loans, although transmission to consumer loans takes longer (Banco de la República, 2020) Finally, there is evidence that the transmission of changes in monetary policy rates is enhanced with the ability of the government to issue treasuries at longer maturities (Vargas et al, 2012), when changes in policy rates are complemented with changes in reserve requirements (Vargas et al 2010) and when the participation of foreigners in the local bond market increases (Romero et al 2020).[12]

This paper adds to the literature that explores asymmetries in the pass-through of monetary policy rate changes to deposit and lending interest rates, by estimating NARDL pass-through models for different types of deposit and lending interest rates in Colombia. We first estimate models for deposit and lending rates of the financial sector and for banks exclusively, that as of September of 2020 account for 95% of total credit[13]. Then we focus on different segments of bank credit (consumer, commercial, microcredit and housing loans). Both the choice of methodology and the segmentations chosen for analysis are novel to the exploration of this key element of the transmission of monetary policy in Colombia and in emerging markets in general. As in Holmes et al. (2015), we also provide evidence of possible differences in the speed of adjustment using dynamic simulations of our estimated models, and in addition we provide estimates of asymmetric pass-throughs for different types of loans.

[11] González et al (2010) find evidence of a 50-60 bps drop in the interest rate differential between mortgage rates and treasuries for every 100 bps drop in the monetary policy rate.

[12] Using quarterly data for the pre-IT period and imposing the restriction of symmetry, Gómez et al (2002) found evidence of a complete pass-through of the policy rate to the rate on 90-day CDs after only 2 quarters.

[13] The remaining 5% of the financial sector is made up of quasi-banks. The largest of these are commercial financing companies and cooperative banks. Results similar to those reported in this paper are available upon request.

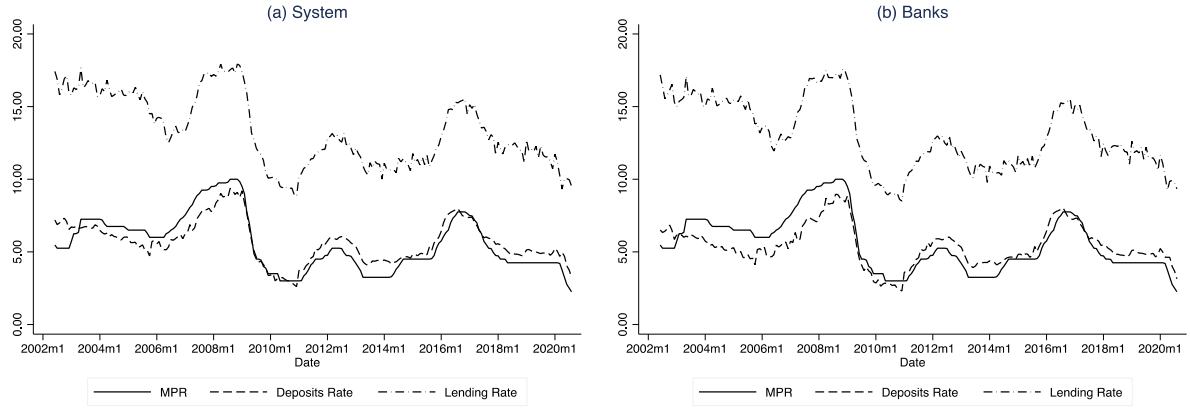
3. Data

Our study uses the monetary policy rate reported by Banco de la República and financial sector interest rates reported by the Financial Superintendency of Colombia based on financial intermediary data reported weekly by each financial intermediary to the supervisor. All data used in the study is available in the web page of the Banco de la República. Our sample is restricted by data availability, and our dataset spans from May of 2002 to August 2020. We use monthly weighted averages of weekly reported interest rates.

The monetary policy rate (MPR) is the interest rate set by the Board of Directors of the Central Bank for expansionary overnight open market operations. Through it, the Central Bank aims at altering liquidity within its inflation targeting framework. We explore the pass-through of changes to the MPR to deposit and lending rates of the financial sector. We first analyze the pass-through of monetary policy rates to the deposit and lending rates for the financial sector as a whole and for the banking sector specifically.

For deposit rates we use the weighted average of the interest rates of term deposits ranging from a one-day term to over a 360-day term. Our deposit interest rate data does not account for interests paid on savings accounts, since marginal rates on these are not required in the financial supervisor's reports. Our data accounts for nearly 40% of deposits in the financial system. The lending rates used are also weighted averages of financial intermediary specific data of the main types of loans: consumer and commercial loans (ordinary and preferential)[14]. Figure 1 plots the interest monetary policy rate, and the deposit and lending rates of the financial system and for banks.

Figure 1: Interest rates – System and Banks



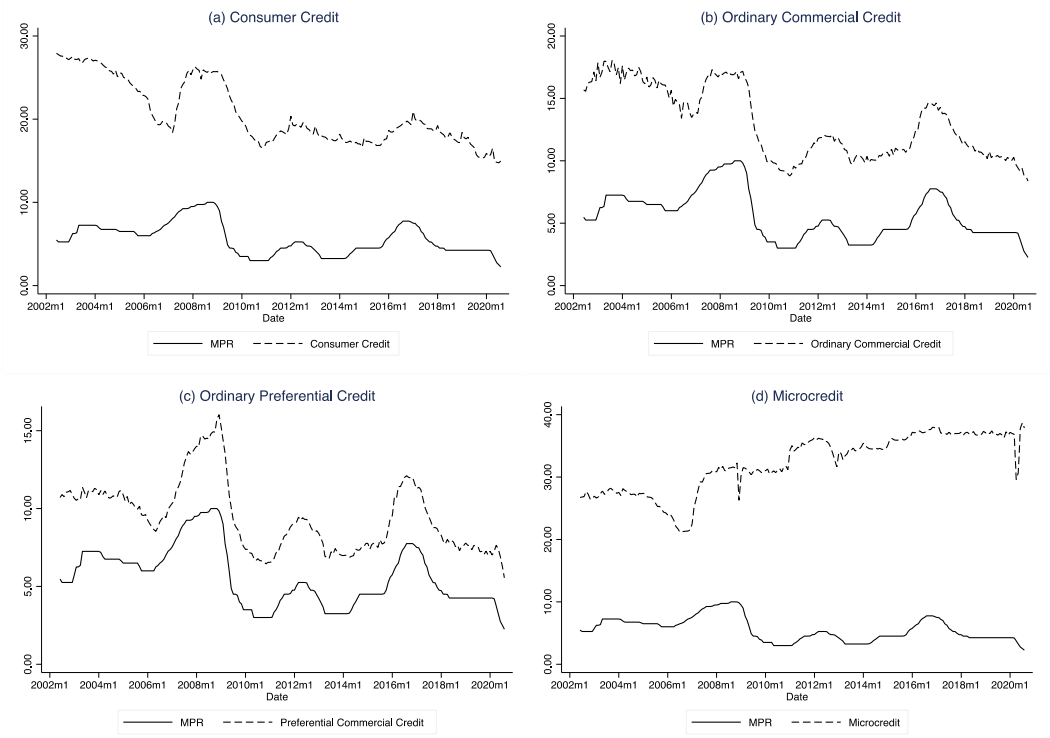
Source: Banco de la República and Financial Superintendency of Colombia. Data available at: http://www.banrep.gov.co

A first visual inspection suggests a close relationship between the MPR and relevant interest rates that seems to hold. Non-surprisingly, given their relative size, the patterns observed in the banks seem to be reflected in the aggregate system. We also explore the pass-through for different bank lending rates. We focus on five relevant rates: consumer lending rates, ordinary commercial credit rates, preferential

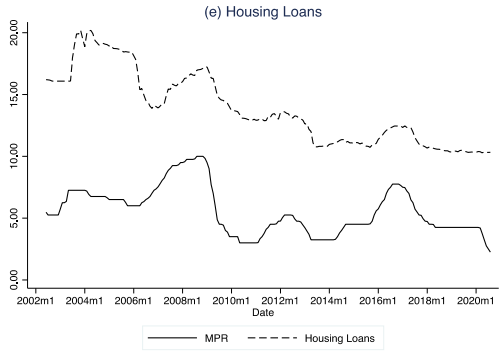
[14] The data used exclude financial intermediary treasury operations.

commercial credit rates, microcredit rates and housing credit rates[15]. As of August 2020, commercial credit accounted for 55% of the total stock of bank credit, consumer lending for 29%, housing loans for 14%, and microcredit for 2%. With respect to commercial credit, ordinary and preferential have a very similar share. Figure 2 reports the MPR and the interest rates charged by banks by type of credit. For all types of credit except microcredit, the lending interest rate seems to follow closely the policy rate.

Figure 2: Interest rates by bank credit modality



[15] Consumer loans are loans to individuals used to finance the purchase of goods and services for non-commercial purposes. Commercial credits are all loans different than consumer, microcredit or housing loans and are divided into ordinary and preferential. Preferential commercial loans are those loans exceeding a 30-day term, and that are given to clients that have the ability to negotiate an interest rate with the supplying bank. Ordinary commercial loans are a more standard product traditionally supplied to smaller firms. Microcredit loans are small loans supplied to small firms (with up to 10 workers and with a restriction on asset size). Microloans can be used for leasing operations or for the purchase of goods and services. For the purpose of this study, we focus on the latter. Finally, housing loans, are loans provided to households to purchase or build their dwelling. There are several modalities of housing loans, depending on if the loan is used to purchase or to build, it the loan is in pesos or inflation indexed units, and if the loan is to acquire social interest housing or non-social interest housing. In this study we use the interest rate of the non-social interest housing, peso denominated, dwelling purchase loan, the largest in this segment for banks.



Source: Banco de la República and Financial Superintendency of Colombia. Data available at: http://www.banrep.gov.co

Table 1 reports some basic descriptive statistics of the data plotted in figures 1 and 2.

Table 1: Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Minimum	Maximim
MPR	213	5.60	1.94	2.25	10.00
Deposit Rates					
System	213	5.67	1.44	2.61	9.38
Banks	213	5.38	1.39	2.30	8.97
Lending Rates					
System	213	13.26	2.42	8.83	17.93
Banks	213	12.95	2.33	8.49	17.59
Bank Lending Rates					
Consumer loans	213	20.43	3.66	14.75	27.53
Ordinary commercial loans	213	12.93	2.86	8.38	18.05
Preferential commercial loans	213	9.41	2.29	5.55	16.03
Microcredit loans	213	32.34	4.58	21.15	38.70
Housing loans	213	13.76	2.95	10.28	20.19

4. Empirical Methods

We employ the nonlinear autoregressive distributed lag model, the NARDL, developed by Shin et al. (2014) to estimate in a coherent manner the asymmetric responses of financial sector rates to positive or negative changes of the policy rate. The model is an asymmetric extension of the Autoregressive Distributed Lag (ARDL) cointegration approach developed by Pesaran and Shin (1999) and Pesaran et al. (2001). The empirical analysis starts by posing the following asymmetric cointegration relationship:

$$r_t = \theta^+ MPR_t^+ + \theta^- MPR_t^- + \varepsilon_t \qquad (2)$$

where r_t is the relevant financial sector interest rate we seek to analyze, MPR_t is the monetary policy rate, and ε_t is an error term. MPR_t is a vector of regressors that follows:

$$MPR_t = MPR_0 + MPR_t^+ + MPR_t^- \qquad (3)$$

with MPR_0, the initial value of the time series, and MPR^+ and MPR^- are partial sums defined by:

$$MPR_t^+ = \sum_{i=1}^{t} \Delta MPR_i^+ = \sum_{i=1}^{t} max(\Delta MPR_i, 0) \qquad (4)$$

$$MPR_t^- = \sum_{i=1}^{t} \Delta MPR_i^- = \sum_{i=1}^{t} min(\Delta MPR_i, 0) \qquad (5)$$

θ^+ and θ^- are the associated positive and negative asymmetric long-run parameters and Δ is the first difference operator. Shin et al. (2014) show that (2) can be reparametrized as an ARDL(p,q) model of the form:

$$\Delta r_t = c + \alpha r_{t-1} + \beta^+ MPR_{t-1}^+ + \beta^- MPR_{t-1}^- + \sum_{i=1}^{p-1} \psi_i \Delta r_{t-i} + \sum_{i=0}^{q-1} \varphi_i^+ \Delta MPR_{t-i}^+ + \sum_{i=0}^{q-1} \varphi_i^- \Delta MPR_{t-i}^- + \varepsilon_t \qquad (6)$$

Equation (6) is the NARDL(p,q) specification. In it, α measures the speed of adjustment, while the long-run pass-through positive and negative coefficients can be computed as: $\hat{\theta}^+ = -\hat{\beta}^+/\hat{\alpha}$ and $\hat{\theta}^- = -\hat{\beta}^-/\hat{\alpha}$ respectively. If θ is equal to one, the long-run pass-through would be complete, if θ is lower than one it would be incomplete, and if θ is greater than one, there would be evidence of an adjustment of the interest rate greater than that of the policy rate. The ψ_i and φ_i coefficients capture the short-run dynamics.

Pesaran et al. (2001) develop a bounds test procedure to test for cointegration, that Shin et al. (2014) show can be extended directly to the NARDL model. They propose an F-statistic to test the null joint hypothesis that α=0 and $\beta^+ = \beta^- = 0$. The rejection of the null hypothesis provides statistical evidence of cointegration. The bounds test allows the comparison of the F-statistic with critical values for I(0) and I(1) variables[16].

Based on (6), one can test the existence of long and short-run asymmetries in the pass-through. Standard Wald tests under the null hypotheses that $\sum_{j=0}^{q} \beta_j^+ = \sum_{j=0}^{q} \beta_j^-$ and that $\sum_{j=0}^{q-1} \varphi_j^+ = \sum_{j=0}^{q-1} \varphi_j^-$, respectively, can be used. If the null hypotheses are not rejected, equation (6) reduces to standard ARDL cointegration representation. If the nulls are rejected there is evidence of long-run or short-run asymmetric effects, or both. In the case of long-run asymmetries, if $\theta^+ < \theta^-$ the asymmetry means that the pass-through of a reduction of the policy rate is greater than that of an increase. This is referred to as a negative long-run asymmetry. The opposite is referred to as a positive long-run asymmetry. The analogous holds for short-run asymmetries. In the case of lending rates, a negative long-run asymmetry means that the financial system reacts stronger to a reduction in the policy rate than to an increase of the same magnitude.

5. Results

We explore the pass-through to deposit and lending rates of changes in the monetary policy rate. A key step towards a correct model specification is identifying the presence of non-linearities or asymmetries described in the previous section[17]. We follow Shin et al. (2014) and use a Wald test to detect if there are asymmetries in the long and short-run coefficients of a properly specified NARDL model. We first estimate the lag lengths of a NARDL(p,q) model for each of the relevant variables. We use the Bayes

[16] In this sense the estimated model can include either I(0) or I(1) variables, or a combination of both.

[17] To implement the methodology described in the previous section a key starting point is that the variables analyzed are either I(0) or I(1). The ARDL model is not suitable under the presence of integrated stochastic processes of order 2. Appendix table 1 confirms that all of the relevant variables in this study are either I(0) or I(1).

information criteria (BIC) to choose the appropriate lag structure for each independent variable.[18] Wald tests under the null hypothesis of the equality of long-run coefficients and the equality of short-run ones are conducted. If the null hypothesis is rejected, a NARDL model is the preferred specification; if not rejected the correct specification is an ARDL.

Table 2 reports the Wald tests on long and short-run asymmetries and their p-value. The Wald tests reported suggest that there are long-run asymmetries in the models of deposit interest rates for the aggregate financial system and for banks, and symmetry in the lending interest rate.

Table 2: Asymmetry Specification Tests

	Long-run Asymmetry		Short-run Asymmetry	
Dependent Variable	Wald Stat.	P-value	Wald Stat.	P-Value
Deposits Rate				
System	19.55	0.00	0.02	0.89
Banks	38.23	0.00	0.05	0.83
Lending Rate				
System	0.51	0.47	0.00	0.99
Banks	0.01	0.92	0.00	0.98

Table 3 reports the results of estimating the ARDL and NARDL models suggested by the above specification tests for each relevant interest rate. Each pair of columns reports the results of deposits and lending interest rates as the dependent variables. Columns (1) and (2) report results for the whole financial system, and (3) and (4) for the banking sector. The lower part of the table reports additional information including the cointegration bounds test[19]. Cointegration is not rejected in any case, indicating the existence of stable long-run relationships between the interest rates explored and the monetary policy rate. Appendix 2 reports CUSUM tests that show that these coefficients are stable through time. These tests support the parsimonious specifications used throughout this paper by suggesting no need of additional controls to ensure parameter stability.

The first row in table 3 reports the adjustment coefficient. As seen, there are no significant differences between the adjustment speed of deposit and lending rates in the financial system as a whole as in the banking sector. Most likely the estimates for the financial system are driven by the comparatively large size of the banking sector. In the lower part of the table we use the estimated adjustment coefficient to compute the number of months that would be needed to absorb 50 and 90 percent of a long-run equilibrium deviation[20]. For deposit rates of both banks and the financial system, half of a shock would be absorbed in less than 4 months and 90% of it within a year. For lending rates, in the case of banks, half of the shock would be absorbed in about 4 months and 90% of it in 14 months. The numbers for the financial system are slightly different, suggesting that quasi-banks are more sluggish in their adjustment.

[18] Once a lag structure is identified using the BIC we verify its appropriateness analyzing if serial correlation is properly dealt with. We use Cumby-Huizinga autocorrelations tests up to the 12th order to ensure no autocorrelation remains. Eliminating serial correlation is crucial for the implementation of the cointegration bounds test. The resulting structure of the models used is reported in the bottom part of tables 3 and 5.

[19] The table reports the F-test and its statistical based on critical values computed by Kripfganz and Schneider (2018).

[20] The α coefficient indicates how much of a long-run deviation is absorbed in one period. In the table we report the number of months that it would take to absorb 50% and 90% of the shock, in the latter case this is obtained as: $n = \log_{1-\alpha}(0.1) = \ln(0.1)/\ln(1-\alpha)$ where ln is the natural logarithm.

Regarding the pass-through coefficients (θ's derived from equation 6), we find that in the case of loans in the whole financial system and in the banking sector, the passthrough is complete. The estimated coefficients are close to 1. For deposits we find a slightly lower pass through and asymmetries are present. Our estimations suggest that the interest rate adjusts less to a negative MPR fluctuation than to a positive one. A possible explanation for this positive asymmetry of downward rigidity is that reducing deposit rates may lead to a migration of deposits to other intermediaries or other savings vehicles. The fact that we find an asymmetry in deposits' responses to changes in the MPR but not in loans indicates that when monetary policy is loosened, at the margin the interest rate spread falls, and the contrary could happen during monetary expansions[21].

Table 3: Estimation result by type of institution

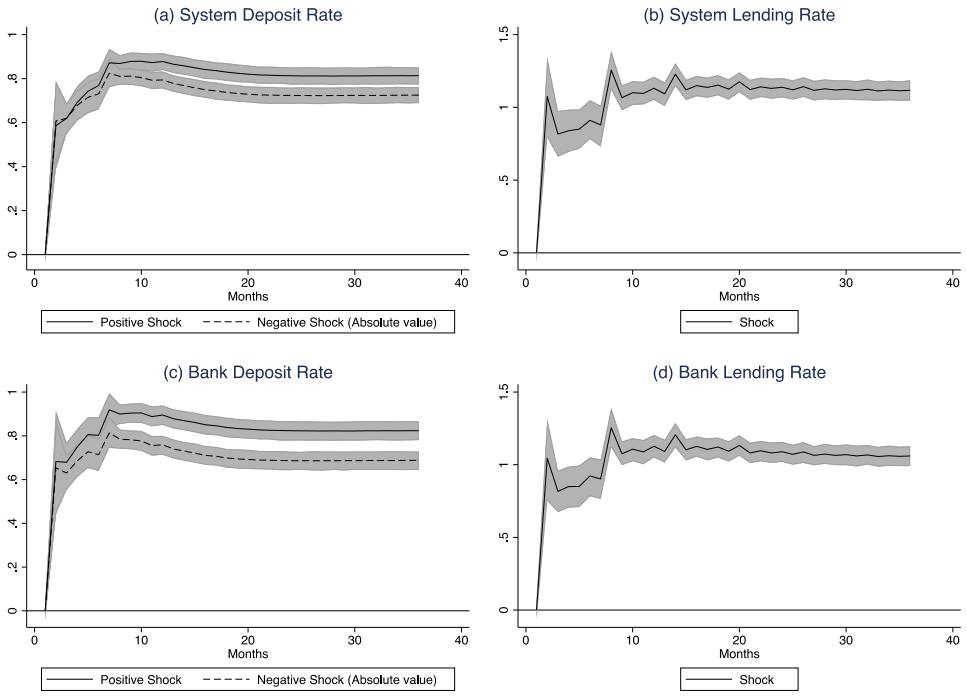
	System		Banks	
Interest rate:	**(1) Deposits**	**(2) Loans**	**(3) Deposits**	**(4) Loans**
Adjustment coefficient (α)	-0.185 ***	-0.127 ***	-0.179 ***	-0.148 ***
	0.030	*0.029*	*0.038*	*0.033*
Long-run relationship (θ)				
MPR (t-1)		1.113 ***		1.063 ***
		0.113		*0.097*
MPR + (t-1)	0.812 ***		0.826 ***	
	0.059		*0.081*	
MPR - (t-1)	0.724 ***		0.685 ***	
	0.047		*0.064*	
Short-run Dynamics				
D.interest rate(t-1)	-0.015	-0.242 ***	-0.043	-0.222 ***
	0.051	*0.065*	*0.062*	*0.064*
D.interest rate(t-2)	0.064	-0.069	0.065	-0.052
	0.065	*0.060*	*0.058*	*0.060*
D.interest rate(t-3)	0.048	-0.033	0.069	-0.029
	0.067	*0.050*	*0.061*	*0.052*
D.interest rate(t-4)	0.012	0.025	-0.011	0.034
	0.052	*0.049*	*0.068*	*0.051*
D.interest rate(t-5)	0.152 ***	-0.033	0.150 **	-0.017
	0.052	*0.058*	*0.062*	*0.060*
D.interest rate(t-6)		0.310 ***		0.311 ***
		0.051		*0.051*
D.MPR		1.071 ***		1.047 ***
		0.162		*0.167*
D.MPR+	0.587 ***		0.685 ***	
	0.115		*0.141*	
D.MPR-	0.606 ***		0.653 ***	
	0.066		*0.094*	
Constant	0.979 ***	0.872 ***	0.821 ***	1.021 ***
	0.162	*0.230*	*0.198*	*0.250*
Number of Observations	213	213	213	213
R-Squared	0.42	0.41	0.38	0.41
Bound F test	13.74 ***	9.38 ***	9.52 ***	10.19 ***
P-Value of Long-run Symmetry	0.00		0.00	
P-Value of Short-run Symmetry	0.89		0.86	
Speed of 50% adjustment	3.40	5.10	3.52	4.32
Speed of 90% adjustment	11.3	16.9	11.7	14.4
Model Specification	NARDL(6,1)	ARDL(7,1)	NARDL(6,1)	ARDL(7,1)

Notes: Newey-West standard errors in italics. *** significant at 1%, ** significant at 5%

[21] The impact of profits depends of course on the interest rate elasticity of loan and deposit demands.

In order to provide a visual representation of the adjustment of relevant rates to changes in the monetary policy rate, we follow Jordan and Philips (2018) and Philips (2018) and dynamically simulate the NARDL and ARDL models estimated and reported in table 3. Figure 3 reports the effect of a counterfactual change of the MPR (in the case of a NARDL a change to the MPR^{+} and the absolute value of the change of the MPR^{-}) of 1 percentage point on the relevant financial sector interest-rate[22].

Figure 3: Dynamic Simulation of 1 a percentage point change in the MPR by type of institution



Notes: 95% confidence intervals are plotted.

The results of the dynamic simulations show a relatively fast adjustment of deposit and lending rates to monetary policy changes. There is a strong short-term adjustment following a monetary policy change of both deposit and lending rates. In the case of deposits, the rates stabilize at different long-run levels depending on the sign of the MPR movement. As estimated in table 3, the long run pass-through is higher after positive changes in the MPR in the case of deposit rates.

In summary, we find evidence of asymmetries in the response of different rates to monetary policy changes. It is worth mentioning that the key estimated parameters are not significantly different

[22] The dynamic simulation starts with an OLS estimation of the model. It then takes 1000 draws of the vector of parameters from a multivariate normal distribution with means equal to the estimated parameters of the model and the estimated variance covariance matrix of the parameters. To create predicted values of the dependent variable, uncertainty is introduced by simulating the standard error of residuals taking draws of an inverse chi-squared distribution, scaled by the degrees of freedom of the model and the estimated standard errors of the residuals of the regression. Simulations of the dependent variable are produced by setting all variables except the MPR to their means. The average of the simulations is the predicted value and percentile confidence intervals are also produced.

from those estimated in other emerging market economies[23]. In order to further investigate the transmission mechanism of monetary policy, and to identify if asymmetries are present in macroeconomically relevant segments of credit markets. we carry out similar exercises to those performed above, but for different categories of bank credit. In table 4 we report Wald tests under the null hypotheses of long and short-run symmetries. In the case of consumer, ordinary commercial and microcredit loans, the long-run symmetry hypothesis is rejected, suggesting the appropriateness of estimating a NARDL model.

Table 4: Asymmetry Specification Tests by Type of Bank Loan

	Long-run Asymmetry		Short-run Asymmetry	
Dependent Variable	Wald Stat.	P-value	Wald Stat.	P-Value
Consumer loans	5.32	0.02	0.65	0.42
Ordinary commercial loans	12.23	0.00	0.46	0.50
Preferential commercial loans	0.11	0.74	0.38	0.54
Microcredit loans	44.80	0.00	1.93	0.17
Housing loans	2.03	0.15	0.42	0.52

The results of estimating the appropriate ARDL and NARDL models are reported in table 5. The first relevant aspect to note is that we are not able to identify a long-run relationship between the policy rate and the microcredit and housing loans rate[24]. As shown in the lower segment of the table, we are not able to reject the null hypothesis of no cointegration for these. This means that there is no evidence of a stable pass-through of the monetary policy rate to the lending rates of these segments, which means that lending retail rate determination in these segments is mostly driven by other considerations. We concentrate the rest of our analysis in our results of consumer, ordinary commercial, and preferential commercial loans[25]. These three segments account for nearly 85% of bank credit, which in turn is close to 80% of total financial sector credit.

We find evidence of long-term asymmetries in the pass-through of policy rates for consumer and ordinary commercial credit. In both cases the asymmetries estimated suggest that the pass-through is higher when policy rates are reduced than when they increase. This finding implies that monetary policy may be more effective when it is expansionary than when it is contractionary. However, given that this is just a first stage of monetary policy, the true and complete transmission will depend on how this translates to credit demand.

In the case of consumer credit and preferential commercial credit the long-run pass-through is greater than one, meaning that lending rates are adjusted more than the change in the policy rate. This is particularly noticeable in the case of consumer loans. In the case of ordinary commercial credit, the negative passthrough is greater than one, and the positive pass-through is incomplete. These findings may be interpreted as evidence of contestable markets in those credit segments, and potential adverse

[23] See for example: see Gregor at al. (2019), Li and Liu (2019), Sahin and Çirçek (2018), Yu et al. (2013) and Zhang et al. (2017) for emerging market studies. Results are also in line with those of Gambacorta et al. (2015) for UK, Italy and Spain and in the ballpark of those of Holmes et al. (2015) for Colombian banks.

[24] This is consistent with Gonzalez et al.(2010) who find that mortgage rates are more strongly correlated with long -term public debt bond rates than with short-term rates.

[25] Appendix 3 reports CUSUM tests on the stability of the estimated parameters.

selection effects that reduce incentives to increase lending rates significantly following a rise in the monetary policy rate.

Table 5: Estimation result by type of bank loan

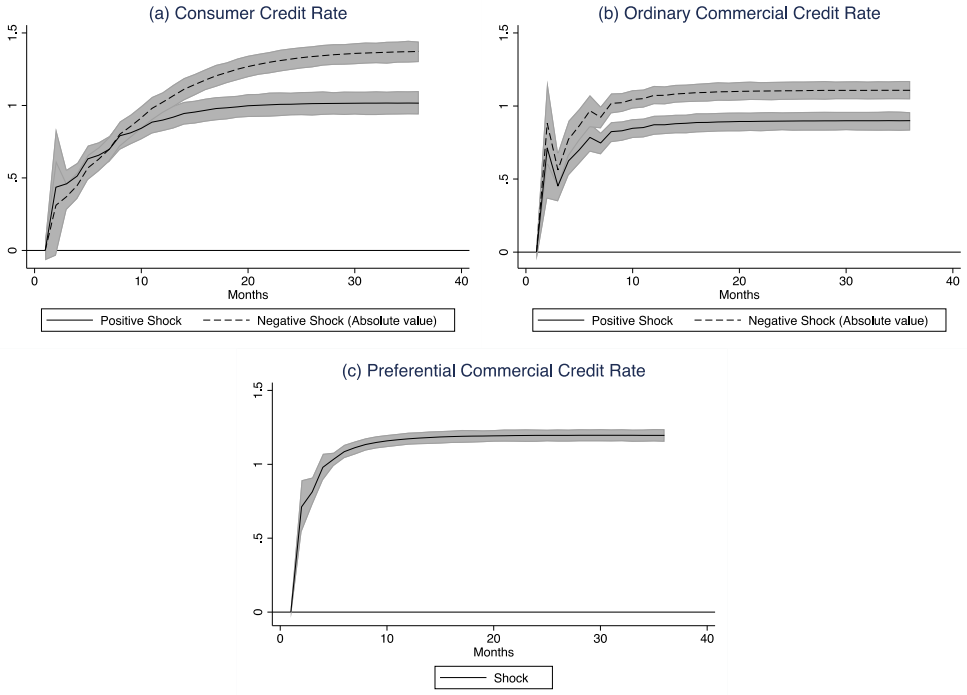
interest rate:	Consumer Credit	Commercial Ordinary	Commercial Preferential	Micro	Housing
Adjustment coefficient	-0.066 **	-0.096 ***	-0.157 ***	-0.134 *	-0.012
	0.027	*0.018*	*0.035*	*0.081*	*0.008*
Long-run relationship					
MPR			1.199 ***		1.485 **
			0.067		*0.663*
MPR +	1.032 ***	0.892 ***		0.776 **	
	0.303	*0.135*		*0.309*	
MPR -	1.376 ***	1.104 ***		-0.242	
	0.204	*0.111*		*0.241*	
Short-run Dynamics					
D.interest rate(t-1)	-0.032	-0.391 ***	0.039	-0.002	0.302 ***
	0.117	*0.108*	*0.062*	*0.124*	*0.088*
D.interest rate(t-2)	0.038	0.037	0.144 *		
	0.091	*0.066*	*0.080*		
D.interest rate(t-3)	0.198 ***	0.177 ***			
	0.042	*0.059*			
D.interest rate(t-4)	-0.009	0.187 ***			
	0.064	*0.064*			
D.interest rate(t-5)	0.009				
	0.053				
D.interest rate(t-6)	0.113 *				
	0.069				
D.MPR			0.709 ***		0.123
			0.087		*0.141*
D.MPR(t-1)					-0.074
					0.173
D.MPR(t-1)					0.332
					0.245
D.MPR+	0.421 ***	0.716 ***		0.635 **	
	0.136	*0.183*		*0.278*	
D.MPR-	0.314 ***	0.878 ***		0.103	
	0.089	*0.154*		*0.258*	
Constant	1.507 **	1.423 ***	0.410 ***	3.332	0.050
	0.688	*0.284*	*0.115*	*2.107*	*0.072*
Number of Observations	213	213	213	213	213
R-Squared	0.21	0.36	0.53	0.07	0.26
Bound F test	4.88 **	9.13 ***	10.31 ***	1.37	2.62
P-Value of Long-run Symmetry	0.02	0.00		0.00	
P-Value of Short-run Symmetry	0.42	0.50		0.17	
Speed of 50% adjustment	10.2	6.8	4.1	4.8	58.1
Speed of 90% adjustment	33.9	22.7	13.5	16.0	193.0
Model Specification	NARDL(7,1)	NARDL(5,1)	ARDL(3,1)	NARDL(2,1)	ARDL(2,3)

Notes: Newey-West standard errors in italics. *** significant at 1%, ** significant at 5%, *significant at 10%

In figure 4 we provide dynamic simulations of a 1-point increase in the policy rate. Our results suggest a fast adjustment of commercial credit rates, both ordinary and preferential, compared to consumer lending. While a significant part of the adjustment on commercial loans happens in the first six months following a policy rate change, consumer lending rates take longer to converge to their long-run values. It is worthwhile noting that our results suggest that asymmetries in the pass-through of monetary

policy rate changes are present in what accounts for nearly 57% of banking sector credit, or nearly 55% of financial sector loans.

Figure 4: Dynamic Simulation of 1 a percentage point change in the MPR by type of institution by type of bank loan



Notes: 95% confidence intervals are plotted.

6. Concluding remarks

Since having adopted an inflation targeting framework at the turn of the century, the Central Bank of Colombia started using the overnight repo rate as its key policy tool. While monetary policy operates through several channels –including asset prices, the exchange rate and expectations—the interest rate / credit channel is deemed to be the most important. Its effectiveness hinges on how monetary policy affects liquidity and the cost of funds and of credit, and on how credit demand reacts to these changes. An important component of the credit channel is, of course, the interest rate pass-through –i.e. how much and how fast a change in the central bank´s policy rate affects retail rates.

The pass-through can be incomplete and sluggish on account of implicit contracting in long-term credit relationships, transaction costs and strategic behaviors by financial intermediaries to preserve their market share. Moreover, several studies have found that the direction in which policy rates are adjusted may affect the degree of pass-through and the speed of adjustment of retail rates to changes in policy rates. Some studies have provided evidence that during recessions the elasticity of credit demand declines, borrowers becoming more attached to their traditional lenders. In that case, the adjustment of retail interest rates in response to a reduction in policy rates is lower, compared to an increase. On the other hand, on account of adverse selection and asymmetric information, the asymmetry of the pass-through could work in the opposite direction –i.e. to avoid an increase in credit risk, lenders may be more hesitant to fully transmit a change in the policy rate to clients, a problem that materializes when policy

rates rise but not necessarily when they fall. An upward rigidity in loan rates may also be the consequence of contestable markets in specific lending or deposit segments. In practice, both types of asymmetries may be present, an issue that can only be solved empirically.

Using monthly weighted averages of weekly interest rates for the May 2002 to August 2020 period, we have examined the interest rate pass-through from the monetary policy rate to retail rates in Colombia and identified asymmetries in the adjustment process. We first analyzed the pass-through to deposit and lending rates of the financial system and of banks specifically and we then focused on lending rates of banks for different types of loans.

We found that in the case of loans both in the aggregate financial system and in the banking sector, the pass-through is complete. For deposits we find a slightly lower pass-through, with important asymmetries. In particular, the deposit interest rate adjusts less to a negative policy rate movement than to a positive one. A possible explanation is that reducing deposit rates may lead to a migration of deposits to other intermediaries, a sign of high competition in this market. Importantly, finding an asymmetry in deposits' responses to changes in the policy rate but not in the rate on loans indicates that when policy is tightened the interest rate spread falls, while the opposite could happen when monetary policy is loosened.

For the financial system as a whole we show that for deposit interest rates, 50% of a change in the policy rate is absorbed in less than 4 months, 90% being absorbed within a year. The adjustment is slightly more sluggish in lending rates. We then undertook a similar exercise for different categories of bank credit. Not being able to identify a long-run relationship between the policy rate and the microcredit and housing loans rate, we focus on consumer, ordinary commercial, and preferential commercial loans. These three segments account for nearly 85% of bank credit, which in turn is close to 80% of total financial sector credit. We found evidence of long-run asymmetries in the pass-through of policy rates for consumer and ordinary commercial credit. In both cases the pass-through is higher when policy rates are reduced than when they are increased. This finding suggests that, with regard to the credit channel, monetary policy may be more effective when it is expansionary than when it is contractionary. However, it is important to note that the macroeconomically relevant transmission will ultimately depend on how these changes in commercial bank interest rates affect credit demand.

An important result of our estimations is that in the case of consumer credit and preferential commercial credit, the long-run pass-through is greater than one. In the case of ordinary commercial credit, the negative pass-through is greater than one while the positive pass-through is incomplete. These asymmetries may be interpreted as evidence for contestable behaviors in those credit segments and potential adverse selection effects that reduce incentives to increase lending rates significantly following a rise in the policy rate.

Finally, we found evidence that interest rates on commercial loans, both ordinary and preferential, adjust faster than rates for consumer lending. While a significant part of the adjustment on commercial loans happens in the first six months following a policy rate change, consumer lending rates take longer to converge to their long-run values.

On account of the COVID-19 pandemic, the central bank reduced its policy rate from 4.25% in March 2020 to 1.75% in September, this after having held the rate steady for almost 2 years. During the same 6-month period, the weighted average rate of interest on CDs declined 200 bps. As to the interest

rate on loans, it declined 81 bps for consumer credit, 233 bps for preferential commercial credit and 152 bps for ordinary commercial loans. This pattern conforms reasonably well to the findings in this paper.

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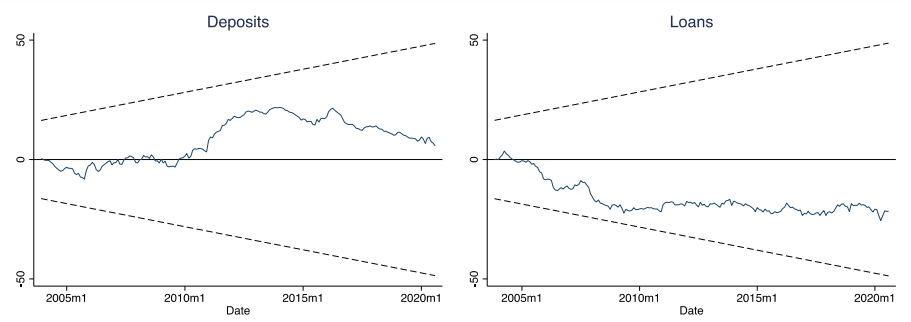
Appendixes

Appendix 1: Stationarity tests

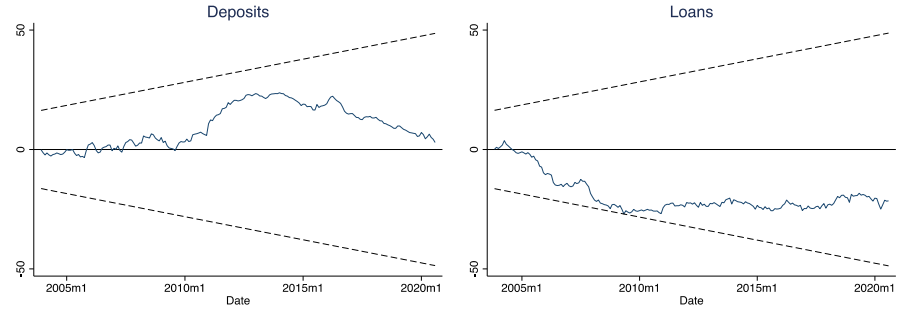
Null Hypothesis:	Time series has a unit root						Time series is stationary					
	Level			First difference			Level			First difference		
Variable	ADF test stat.	5% Critical Value	Reject H0	ADF test stat.	5% Critical Value	Reject H0	KPSS test stat.	5% Critical Value	Reject H0	KPSS test stat.	5% Critical Value	Reject H0
MPR	-2.205	-3.435	No	-6.358	-2.883	Yes	0.641	0.463	Yes	0.100	0.463	No
Deposit Rates												
System	-2.440	-2.883	No	-5.064	-2.883	Yes	0.247	0.463	No	0.057	0.463	No
Banks	-2.564	-2.883	No	-5.401	-2.883	Yes	0.100	0.463	No	0.057	0.463	No
Lending Rates												
System	-3.717	-3.436	Yes	-3.256	-2.883	Yes	0.159	0.146	Yes	0.044	0.463	No
Banks	-3.753	-3.436	Yes	-3.274	-2.883	Yes	0.148	0.146	Yes	0.045	0.463	No
Bank Lending Rates												
Consumer loans	-3.290	-3.436	No	-3.995	-2.883	Yes	0.153	0.146	Yes	0.047	0.463	No
Ordinary commercial loans	-3.437	-3.437	No	-3.241	-2.883	Yes	0.210	0.146	Yes	0.052	0.463	No
Preferential commercial loans	-3.300	-3.437	No	-3.550	-2.883	Yes	0.086	0.146	No	0.058	0.463	No
Microcredit loans	-1.306	-2.883	No	-5.184	-2.883	Yes	0.159	0.146	Yes	0.042	0.463	No
Housing loans	-4.002	-3.436	Yes	-4.385	-2.883	Yes	0.160	0.146	Yes	0.060	0.463	No

Appendix 2. CUSUM Tests

(a) System

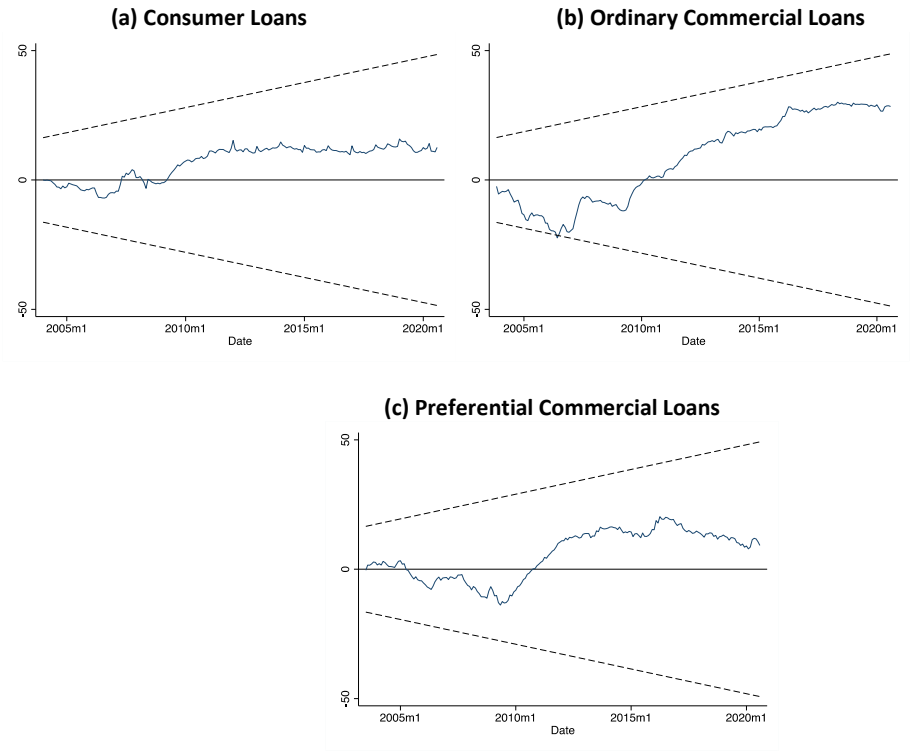


(b) Banks



Notes: 5% confidence intervals are plotted.

Appendix 3. CUSUM Tests by type of banking sector loan



Notes: 5% confidence intervals are plotted.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