Transmission of Monetary Policy and Bank Heterogeneity in Colombia

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Abstract

This study provides evidence of bank heterogeneity in Colombia for the period 2002-2014 and analyzes how bank-specific characteristics determine the bank-lending channel for monetary policy. To analyze bank heterogeneity, this study estimates technical (cost) efficiency using Stochastic Frontier Analysis, which also allows for the measurement of Returns to Scale and a Lerner Index to proxy market power in the loans market. This study also provides measures of capitalization, liquidity, and the commonly used ratios of financial and operational efficiency with bank's balance-sheet data. Furthermore, using a long and unbalanced panel, this study finds evidence of the existence of a bank-lending channel and finds that this transmission mechanism is determined by bank-specific characteristics. The results suggest higher technical and operational efficiency, capitalization, liquidity and market power, increase the sensitivity of loans disbursements to monetary policy shocks, while higher returns to scale lowers this sensitivity.

JEL classification: G21; E52; E59

Key words: monetary policy transmission, bank lending channel, bank heterogeneity, bank efficiency

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1. Introduction

Most central banks follow an inflation targeting strategy and monetary policy is implemented through their main policy instrument, the benchmark interest rate for intervention in the money market. There are different mechanisms in which changes in this rate translate into changes in real economic variables and inflation, that are referred to as the transmission channels of monetary policy. The traditional transmission channel of monetary policy is the interest rate channel (Mishkin, 1996), but the literature has found other mechanisms. One of the alternative mechanisms of transmission of monetary policy through the banking sector is known as the credit channel, which is divided into two different mechanisms. One of them is known as the balance-sheet channel and the other one as the bank lending channel. The former is related to information asymmetries in the capital market and the latter relates directly to the banking sector and the credit market (Gómez-González & Grosz, 2007).

In a very simple manner, the balance-sheet channel (also known as the *flight to quality* channel) results when, because of asymmetries of information between lenders and borrowers, if there is, for example, a contractive monetary policy, the value of borrowers' collateral decreases and so the willingness of lenders to supply loans to these agents is reduced (Black & Rosen, 2007). On the other hand, to understand the bank-lending channel consider a contractive monetary policy where, for example, bank deposits are reduced and capital reserves decrease too. Then, banks face a shortage of funding and must look for alternative resources to keep up with the lending levels. If these other sources of funding are scarce, it is likely that they will be more expensive, so marginal cost of lending will rise and banks will have to reduce their credit supply to the economy (Gómez-González & Grosz, 2007).

Therefore, it becomes clear that the banking sector has an active role in the transmission of monetary policy and the question of how particular characteristics of this sector affect the transmission mechanism of monetary policy is relevant, as has been shown in previous literature (Kashyap & Stein, 1995, 2000; Black & Rosen, 2007; Kishan & Opiela, 2000; Jayaratne & Morgan, 2000; Brissimis & Delis, 2010). Furthermore, if the bank lending channel works by affecting the supply of loans because of changes to the cost of lending, then banks' cost structure (which is related to the efficiency of banks) could determine how this mechanism of transmission of

monetary policy works (Jonas & King, 2008). And, if more efficient banks can translate a contractionary change in the policy instrument faster than inefficient banks can, for example, bank efficiency and its determinants are important on determining the power and efficacy of monetary policy, and policymakers should take this into account when defining regulations that could seem unrelated (such as regulation on bank size, capitalization, market power, risk requirements, etc).

This study assesses if there is evidence of a bank-lending channel for Colombia, and if this mechanism of transmission of monetary policy is heterogeneously determined by bank-specific characteristics, namely efficiency, returns to scale, capitalization, liquidity and market power. First, a theoretical model of industrial organization of the banking sector is presented to motivate how the cost structure of banks could heterogeneously determine the transmission of monetary policy. Then, the empirical approach is in two steps, using monthly balance-sheet data of Colombia's banks from 2002 to 2014, provided by the Financial Supervisor of Colombia, SFC (*Superintendencia Financiera de Colombia*).

In the first step of the empirical methodology, seven measures of bank heterogeneity are calculated. The first measure of heterogeneity is technical (cost) efficiency, using Stochastic Frontier Analysis (SFA). Technical efficiency is related to the ability of banks to produce at their optimal level and particularly cost efficiency, is related to the ability to choose the optimal input quantities given input prices and output quantities (Kumbhakar & Lovell, 2003). With the SFA approach, a trans-log production function for banks is assumed, and a cost function is estimated, so it is possible to calculate returns to scale (RTS) (which is the second measure of heterogeneity) and the marginal cost of loans. With this latter variable and balance-sheet information from banks, this study estimates bank and time-specific Lerner indexes for the loans market (the third measure of heterogeneity). The other four measures of heterogeneity, namely capitalization, liquidity, financial efficiency and operational efficiency, are calculated using balance-sheet data from banks.

In the second step of the empirical approach, the heterogeneity measures are used to model the growth rate of *total* (the sum of commercial, consumer and micro-credits) disbursements, the sum of commercial and consumer disbursements, and commercial and consumer disbursements individually, using changes in the interbank overnight rate (TIB), macroeconomic and other controls, and the interaction of the previously estimated

bank-specific characteristics with changes in the TIB rate. The TIB rate is considered a proxy for monetary policy because it i s highly correlated with the policy rate (TIP).

The findings of this study are twofold. The first is related to heterogeneity in the banking sector in Colombia, and the second, to the heterogeneous transmission of monetary policy through the banking sector. Mainly, there is statistically significant evidence of technical inefficiency in Colombia's banks (around 70.13%) and it depends positively on bank's size, liquidity, capitalization and negatively on credit risk. Also, there is evidence of the existence of a bank-lending channel for Colombia, and of a heterogeneous transmission of monetary policy determined by bank-specific characteristics. Higher more efficient banks (considering the technical efficiency and operational efficiency measures) and banks with higher market power, liquidity, and capitalization, reduce the growth-rate of disbursements faster after a monetary policy shock. On the other hand, higher returns to scale are related to lower sensitivity of disbursements to monetary policy shocks, and financial efficiency does not seem to affect the bank-lending channel (it is not statistically significant).

The results of this study are generally aligned with previous literature on efficiency and heterogeneous transmission of monetary policy through the bank-lending channel, with slight differences. Moreover, some of the heterogeneity measures that were considered had not been broadly studied or included at all in previous literature, particularly for the Colombian case. Then, this study contributes valuable evidence, not only for the literature on monetary policy and the bank-lending channel but also for the efficiency literature and the better understanding of the banking industry in Colombia, for local policymakers.

This study is organized as follows. Sections 2 and 3 of this study include the problem statement and justification for studying this topic and its importance. Section 4 presents the literature review of monetary policy transmission, studies on the bank-lending channel and heterogeneity of banks, the studies that have been done for Colombia in this topic, and the last section dedicated to bank efficiency. Section 5 and 6 present the data and descriptive statistics respectively. Section 7 presents the methodological approach and a motivating theoretical model for the bank-lending channel and bank heterogeneity. Finally, section 8 presents the results and section 9 concludes.

2. Problem Statement

The Board of Directors of Colombia's central bank has a constitutional mandate to *"control inflation, to keep it low and stable, being consistent with a general economic policy"* (Banco de la República, 2018a), which consists of a maximization view of employment and economic growth. To do so, the central bank follows an inflation targeting strategy and monetary policy is implemented through their main policy instrument, the benchmark interest rate for intervention in the money market. Anyhow, there are different mechanisms in which changes in this rate translate into changes in real economic variables and inflation, that are referred to as the transmission channels of monetary policy. Thus, it is of great importance for central banks to understand how these channels work and how their regulatory decisions affect them.

The traditional transmission channel of monetary policy is the interest rate channel. Through the bonds market, changes in the benchmark rate (short-term rate) translate into changes in the long-term rates (along the term structure of interest rates), which in turn impact aggregate demand (Mishkin, 1996). Furthermore, the literature has found that monetary policy also impacts nominal variables, such as loan supply from banks and loan demand, and this amplifies the effect of monetary policy on the real economy. Previous studies have identified two channels in which monetary policy is transmitted to the economy through the banking sector (a mechanism known as the credit channel). One of them is known as the balance-sheet channel and the other one as the bank lending channel. The former is related to information asymmetries in the capital market and the latter relates directly to the banking sector and the credit market (Gómez-González & Grosz, 2007).

In a very simple manner, the balance sheet channel results when, because of asymmetries of information between lenders and borrowers, if there is, for example, a contractive monetary policy, the value of borrowers' collateral decreases and so the willingness of lenders to supply loans to these agents is reduced. Thus, this transmission mechanism is also known as the *"flight to quality"* channel (Black & Rosen, 2007). On the other hand, to understand the bank lending channel consider a contractive monetary policy where, for example, bank deposits are reduced and capital reserves decrease too. Then, banks face a shortage of funding and must look for alternative resources to keep up with the lending levels they have acquired already. If these other sources of funding are scarce, it is likely that they

will be more expensive, so marginal cost of lending will rise and banks will have to reduce their credit supply to the economy (Gómez-González & Grosz, 2007).

Therefore, it becomes clear that the role of the banking sector in the transmission of monetary policy is an active one and the question of how particular characteristics of the banking sector, such as liquidity, capitalization and market power, affect the transmission mechanism of monetary policy is relevant. Furthermore, if the bank lending channel works by affecting the supply of loans because of changes to the cost of lending, then banks' cost structure (which is related to the efficiency of banks) could determine how this mechanism of transmission of monetary policy works. Additionally, if more efficient banks can translate a contractionary change in policy instrument, for example, faster than inefficient banks can, then bank efficiency and its determinants are important on determining the power and efficacy of monetary policy.

Finally, it is important for policymakers to understand the mechanics of monetary policy transmission through the banking sector and consider bank-specific characteristics to propose regulatory changes that could seem unrelated to monetary policy, such as regulation on bank size, capitalization, liquidity or financial conglomerates. Also, central banks should try to understand the mechanism of transmission of monetary policy through financial intermediaries, to align banking regulation so that they can promote financial stability and their main goal (inflation targeting) can be completed in an effective manner.

This study assesses if there is evidence of a bank-lending channel for Colombia, and if this mechanism of transmission of monetary policy is heterogeneously determined by bank-specific characteristics, such as efficiency, returns to scale, capitalization, liquidity and market power.

3. Justification

How monetary policy is transmitted is one of the main concerns of central banks because the effectiveness of their interventions depends on it. Also, banks play a critical role in the economy as matchers of resources through the credit market and the deposit market. If substitutes of loans or deposits through this traditional channel are scarce and costly (so the Modigliani-Miller theorem is not met), then a monetary policy shock could have an

amplified effect on economic variables because of a transmission mechanism through the banking sector. This transmission channel is known as the credit channel, and it is important for policymakers to understand how it works because otherwise, they could be setting policies that have unwanted results on the effectiveness of the monetary policy instruments.

The way the credit channel works must be understood considering two different mechanisms. First, the balance sheet channel works because of the information asymmetries in financial markets, where problems of moral hazard and adverse self-selection are present (Black & Rosen, 2007). Second, the bank lending channel works because of the way a shock to the policy instrument affects the cost of resources that banks use to offer loans to the public. A change in the policy instrument is likely to be transmitted almost immediately to the interbank or money market, which is liquid and where risk is at its lowest (so market rates follow the policy rate very closely). Also, this shock affects the value of bank deposits, so the liquidity a bank has available to commit to loans will be affected. If it is not able to find other loanable resources without incurring higher costs, then loan supply will vary (Gómez-González & Grosz, 2007).

Previous literature has extensively documented how the bank lending channel depends on different bank characteristics. Mainly, the literature has showed bank size, capitalization levels and market structure are heterogeneous characteristics of banks that affect monetary policy transmission particularly through the bank lending channel or the balance sheet channel (Ciccarelli, Maddaloni & Peydró, 2013; Baglioni, 2007; Kashyap & Stein, 2000; Kishan & Opiela, 2000; Bluedorn, Bowdler, Koch & others, 2017; Brissimis & Delis, 2010). Anyhow, there are still some features that are at the core of the credit market that have not received enough attention such as bank efficiency (Jonas & King, 2008). The capability of a bank to adapt to changes in the gap between its funding costs and revenues from lending, how their cost structure is affected by a change in the policy rate and how they can transfer these changes through their loans supply, is at the core of the mechanics that work for the bank-lending channel to have an effect. Thus, bank-specific characteristics such as bank efficiency, market structure (and market power), capitalization and liquidity could be affecting the bank-lending channel.

Also, the channels of monetary policy transmission in Colombia have been studied previously, especially since the central bank changed its strategy to inflation targeting and adopted the benchmark interest rate as their main

policy instrument in 2001. Anyhow, there is not a lot of evidence of the role of specific characteristics of banks in the transmission of monetary policy, especially for the efficiency of the banking sector. Furthermore, since there have been changes in banking regulation in recent years, and the industry has been adapting to Basilea III standards (which could have effects on bank-specific characteristics such as capitalization, liquidity and technical efficiency), this topic is worth studying.

4. Literature Review

4.1. Monetary Policy Transmission

In general, Central Banks use monetary policy with different objectives such as controlling inflation, increasing economic growth or decreasing unemployment. Central banks are not able to influence the objective macroeconomic variables directly, so they must rely on different instruments that they can control directly which, through the monetary policy transmission channels, will affect the targeted macroeconomic variables.

As Huertas, Jalil, Olarte, Romero & others (2005) explain, in practice, central banks set different monetary goals (operative and intermediate goals) that are achievable in the short run and will contribute directly to the monetary policy objective. Operative goals must be set on variables that central banks can control directly, that can be measured fast and with precision and that have predictable effects on the main objective, for example, the monetary base or short-run interest rates. On the other hand, intermediate goals are set on variables that they cannot control, but that also affect the objective variables directly, such as a monetary aggregate, long-run interest rates, and loans balances. Finally, policy instruments are variables controlled by the central bank that influence operative goals directly and intermediate goals indirectly, such as limits to interest rates, direct loans, bank reserves and open market operations.

Anyway, how monetary policy (or changes in the operative goals) contribute to achieving the monetary policy objective (impacting macroeconomic variables) is a question that central banks need to answer to ensure their policy decisions are efficient and effective. It is this question that motivates the study of monetary policy transmission channels.

The idea that financial intermediaries' role in the transmission of monetary

policy was an active one, began to strengthen when several authors questioned the application of the Modigliani-Miller theorem after the Great Depression. This theorem asserts that in the presence of perfect capital markets (with complete information), the real economy is sterile to the presence of banks or financial intermediaries. But, as Bernanke & Gertler (1995) explain, if there are frictions in the capitals market, such as incomplete information, the financial market will have significant effects on the real allocation of resources, given that banks enhance available information in that market. Furthermore, these authors show that specific characteristics of the financial intermediaries, such as asset allocation, the risk assumed by banks and costs of monitoring, also affect intermediation (affecting real economic variables eventually).

Bernanke & Blinder (1988) first introduced the idea of a credit channel of monetary policy transmission when they proposed a variation of the IS-LM (Investments-Savings and Liquidity Preferences-Money Supply) model, that let changes in credit supply and demand have independent effects on aggregate demand, so that both bank assets and liabilities had different roles on the transmission of monetary policy. Later, Bernanke & Blinder (1992) also showed that shocks to the Federal Funds rate have significant effects on the real economy through a credit channel, so real macroeconomic variables are not sterile to central bank's decision. When there is a contractive policy, banks reduce their securities holdings and even though they do not reduce current positions on loans, they reduce disbursements of new loans, reducing the supply of loans and affecting aggregate demand. Later, the literature has considered the definition of the credit channel proposed by Bernanke & Gertler (1995). A shock in the monetary policy affects banks' loans allocation through this channel, which at the same time is divided into two channels: the balance sheet channel and the lending channel.

To understand the balance sheet channel, consider the information asymmetries present in the lending market (moral hazards and adverse selection). Banks must rely on information from balance sheets and income statements from their borrowers, but changes in the interest rate levels affect the value of their assets and cash flows, making them attractive or not for banks to be willing to take risks by lending them. Thus, this situation could result in banks changing their supply of loans.

Furthermore, the bank-lending channel is the mechanism by which monetary policy affects aggregate demand through bank loans. To understand this channel, consider a contractionary monetary policy which decreases

the value of banks' liabilities or deposits, so the cost of lending is increased for banks if they cannot replace deposits with other loanable funds without incurring in higher costs. Thus, banks would have to raise interest rates on loans. Moreover, if borrowers are not able to replace loans with other sources of funding also without incurring in higher costs, they will have to reduce consumption and investment, so aggregate demand would be affected and the transmission completed. In summary, when a change in monetary policy reduces deposits, loanable funds are reduced and new loans can only be supplied at a higher rate, resulting in changes in the loans supply that impact the real economy. This is known as the lending channel (Brissimis & Delis, 2010).

The credit channel has been studied widely[1], especially for the case of the United States and the Euro area but also for Colombia. Several studies have shown that the presence of the lending and balance sheet channels amplifies the effect monetary policy on real GDP, and this is an idea that is now widely accepted (Kashyap & Stein, 1995; Ciccarelli et al., 2013; Ciccarelli, Maddaloni & Peydró, 2015; Black & Rosen, 2007; Hülsewig, Mayer & Wollmershäuser, 2006).

4.2. Bank Lending Channel and Bank Heterogeneity

The relationship between bank heterogeneity and the transmission of monetary policy has been studied for different characteristics of banks, mainly size, capitalization, liquidity, market structure and market power. As will be shown, there is little evidence in the literature on the relationship between monetary policy transmission and bank efficiency.

Kashyap & Stein (1995) proposed an extension of Bernanke & Blinder's (1992) theoretical model of bank portfolio behavior. With this model, they support the hypothesis that capital market's imperfections generate a bank lending channel for the transmission of monetary policy. Also, they test their model with cross-sectional predictions that show how these imperfections have heterogeneous effects on banks' allocation of loans and securities, depending on their size in the United States. To do so, they distribute

[1]The literature has identified other channels for the transmission of monetary policy. The traditional transmission mechanism is the interest rate channel, where increases of the monetary policy rate are incorporated by the term structure of real interest rates and aggregate demand is affected. Other channels are the exchange rate channel, the expectations channel and the asset price channel (Gómez, Molano, Campos, Botia & Sanchez, 2016).

banks for each time period by asset size. Then, they regress the variations of net loans of each category, on changes in the monetary policy indicator, the Fed Fund's rate, and other macroeconomic controls, and take the sum of the coefficients of the monetary policy indicator and its lags, as the total impact of monetary policy on net loans. Their results suggest that conditions for the existence of a bank lending channel are met and that a contractionary policy reduces more loan allocation of small banks than larger banks.

A differentiated impact of monetary policy on loans of small and large banks was also studied, more recently, by Black & Rosen (2007). Using data for the United States, they can identify the two mechanisms of the credit channel, the bank-lending, and the balance -sheet channel. Since they can identify totally new loans from new loans allocated with previously committed terms, they use this information to distinguish a change in loans from the supply and demand side. Their results suggest that a contractionary monetary policy generates a reallocation of loans to shorter maturities and increases loan repayment, which eventually reduces total loan supply. Interestingly, they find that the impact is higher for large banks than for small banks, contrary to what other studies have found.

Also, Kashyap & Stein (2000) studied heterogeneous response to monetary policy through the bank-lending channel using a big data set for the United States from 1976 to 1993, and considering not only size but also liquidity of banks (measured as the ratio of securities to assets). In this study, they extend their 1995 paper following a similar empirical strategy. First, they built bank categories according to size, and later, they estimate cross-sectional differences of the response of loan allocation among these classes. To account for heterogeneity due to liquidity differences, they use a two-stage and a direct estimation methodology. In the two-stage estimation, they regress changes in loans for each class of banks on the level of liquidity for each group, and then, they regress the coefficient estimated for liquidity on lags of the monetary policy shocks. The direct estimation regresses changes in loans on liquidity, monetary policy shocks, and interactions between these two. Their results show that the impact of a change in the policy instrument on the growth of loans is higher for the least liquid banks, and especially for small banks.

Capitalization is another specific characteristic that has been shown to be significant for the bank lending channel. Kishan & Opiela (2000) test loan supply shifts due to a monetary policy shock in the United States, segregat-

ing banks by size and the capital leverage ratio, supporting their empirical strategy on a representative bank theoretical model. They use data from banks' balance sheets from 1980 to 1995 and estimate loan equations for the growth rate of different types of loans for each size-capital category of banks. Their results suggest that size and capitalization affect a bank's ability to replace loanable funds when there is a monetary policy shock, so small banks with low levels of capitalizations react more to these shocks. Also, Jayaratne & Morgan (2000) show evidence of the existence of a lending channel because of frictions present in the market for bank debt, so the magnitude of the channel is higher for small under-capitalized banks that are more prone to these frictions.

Brissimis & Delis (2010) argue that the importance of size on explaining the differentiated response of changes in lending, following a monetary policy shock, is not because of size *per se*, but because it is related to market power. Thus, they test if the lending channel works heterogeneously depending on liquidity, capitalization and market power of banks in the United States and the Euro area, using data from 1994 to 2007. For their empirical strategy, they use the local generalized method of moments (LGMM) to estimate a dynamic panel data model, where the specification to test the lending channel is based on an equation for the change of loans, depending on the policy shock and interactions with bank's characteristics. The results of this study provide evidence of the heterogeneity of the bank lending channel depending on liquidity, capitalization and market power, showing that banks with stronger balance sheets and market power take advantage of monetary policy shocks.

Baglioni (2007) not only considers the heterogeneity of the banking sector from capitalization differences, but he also analyses the effect of different market structures on the transmission of monetary policy from a theoretical perspective. In his study, he proposes a theoretical model to analyze the impact of a monetary policy shock (measured by changes on the policy interest rate) on the market for bank loans, where well-capitalized and under-capitalized banks are present. He models the interaction between these types of banks under two market structures, monopolistic competition, and a Cournot oligopoly. The theoretical model suggests that the propagation of a monetary policy shock is dependent on the market structure. Under the monopolistic competition approach, the impact of monetary policy on banks decision is higher, meanwhile, under the oligopoly approach, the impact is weaker. Also, the model suggests that the aggregate impact of monetary policy on loans will be reduced by the presence

of more under-capitalized banks.

Moreover, it is worth noting other studies that have provided evidence of heterogeneous response of banks to monetary policy shocks. Bluedorn et al. (2017) provide evidence of the existence of the lending channel depending on heterogeneous characteristics of banks, and suggest using other measures of monetary policy for the United States, different from the Fed Fund Rate because it could be endogenous. Additionally, there are other studies that extend the work of Kashyap & Stein (1995, 2000). Gambacorta (2005) shows that the results of previous literature on the relationship between the bank lending channel with capitalization and liquidity hold for Italy, but size does not seem to be related. Ehrmann, Gambacorta, Martínez-Pagés, Sevestre & Worms (2001) generalize these results for the Euro area and they are also tested for Germany (Mueller-Spahn & others, 2008). Also, Cetorelli & Goldberg (2012) show that globalization of the banking sector in the United States also matters because internal capital markets of global banks weaken the lending channel. Thus, monetary policy shocks lose impact on loan supply if banks are globalized. Furthermore, Loutskina (2011) shows securitization in the United States weakens the power of monetary policy to affect loan supply.

Finally, the literature on the relationship between monetary policy transmission and bank efficiency has not been studied widely before. To my knowledge, only Jonas & King (2008) have explicitly addressed this issue. In their study, they analyze how the bank lending channel is affected by bank efficiency, specifically, cost efficiency. As they explain, new technology is likely to have reduced cost inefficiencies because of the tools that are now available to reduce information asymmetries in the loans markets, so this may have affected the power of monetary policy. Also, the argument behind their study is that, if a bank is more efficient (considering the costs approach), then the supply of loans of an efficient bank would be less steep than that of an inefficient one because the average costs of increasing loan supply would be lower for the former. Then, if there is a shock derived from a contractionary monetary policy intervention, for example, the cost curve would shift to the left and the efficient bank would show a higher reduction of supply. Furthermore, the efficient bank is likely to be able to reduce risk exposure to risky clients faster.

Using data from 1984 to 2005 from bank's balance sheets in the US, Jonas & King (2008) follow the methodology proposed by Kashyap & Stein (1995). First, they estimate a cost efficiency trans-log function through stochas-

tic frontier analysis. Then, they use this information to segregate banks into efficiency and size categories and estimate the variation of aggregate loans from each group as a function of the policy rate. They find growth rate of net loans responds differently among categories and conclude that more efficient banks, transmit faster to their loan supply a monetary policy shock and the effect is not symmetrical for contractionary and expansionary policies. Thus, they conclude that increases in the policy rate produces a higher decrease in loans than the increase that an expansionary policy shock produces. Anyhow, this study makes simplistic assumptions and does not consider that this differentiated response may also be affected by market structure.

4.3. Monetary Policy Transmission in Colombia

To better understand the transmission of monetary policy in Colombia and what has been studied before, it must be understood first how monetary policy works in Colombia.

The Board of Directors of Colombia's Central Bank (*Banco de la República de Colombia*), has a *"constitutional mandate to keep inflation low and stable, in coordination with a general economic policy"* (Banco de la República, 2018a). To do this, the bank has set an inflation targeting strategy[2], meaning that the main monetary policy objective is to control inflation, also promoting the maximization of employment and economic growth. In 1999 Colombia began to consolidate this strategy by establishing a flexible exchange rate system (leaving behind an exchange rate band regime) and in 2001 the inflation targeting strategy was consolidated. The Central Bank set the long-term inflation objective to 3% and in 2002, it was established that the bank would announce a long-term inflation range target, and since then, it has been set to 2-4%.

In practice, the Board of Directors meets at least once a month on a publicly announced schedule and analyses the most relevant macroeconomic information, such as inflation expectations, economic growth, employment and financial stability, to decide the path of monetary policy. The main policy instrument that is used to implement this policy is the benchmark interest rate for intervention in the money market. The central bank is constantly supplying or withdrawing liquidity from the economy through dif-

[2]The inflation target is set on consumer price inflation, which is measured by the yearly variation of the Consumer Price Index (IPC).

ferent market operations in the money market at the benchmark interest rate so that the interbank overnight interest rate follows the benchmark rate closely.

The transmission channels of monetary policy have been studied for the Colombian case[3]. Gómez-González & Grosz (2007) find evidence of a direct bank-lending channel for Colombia and Argentina. Specifically, for Colombia, they find that a positive shock to the monetary policy instrument has a negative impact on commercial loan's growth rate. Additionally, their results suggest that the effect is heterogeneous across banks, because bank-specific variables such as capitalization and liquidity, heterogeneously affect the cost of funding when the value of core deposits (those that provide stable loanable resources such as current and savings accounts) are affected.

Furthermore, Amaya (2005) finds evidence of a credit channel for Colombia but he considers the effect of monetary policy on interest rates (specifically those of the credit and deposits market) rather than on loans stock or growth. He finds that credit rates have a stronger reaction than deposit rates to a monetary policy shock and concludes loan quality and banks operational costs are relevant determinants of interest rates in the credit market. Other studies support these findings examining the effect of monetary policy on different interest rates of the credit and deposits market in Colombia. For instance, Melo-Velandia & Becerra-Camargo (2006) and Huertas et al. (2005) find evidence of heterogeneous pass-through effect of a monetary policy shock to the DTF and TIB rates footnoteThe DTF rate is the average rate of 90-day time deposits agreed during the previous week in the Colombian market, and the TIB is the interbank rate, that represents the interest rate payable on over-night loans between banks.. Also, another study suggests that the transmission of monetary policy to credit rates is complete after 8 months in Colombia (Chavarro-Sanchez, Cristiano-Botia, Gomez-Gonzalez, González-Molano, Huertas-Campos & others, 2015).

Another transmission mechanism through the banking sector that has been studied for the Colombian case is the risk-taking mechanism, which considers bank's definition of loan supply as a function of the risk they are willing to take. López, Tenjo & Zárate (2011) use a model of hazard function to estimate the effect of a monetary policy change, as measured by

[3]Table 8, in Annex A, summarizes the studies on monetary policy transmission for Colombia that are mentioned in this section.

the inter-bank rate, on commercial loans through the banks' willingness to bear risks. They find larger banks face lower risk in their portfolio and that the more dependent a bank is on the interbank market for loanable funding, the higher the risk rate on their portfolio.

4.4. A deeper look into Bank Efficiency

As it was shown in section 4.2, the literature suggests that the existence of a credit channel, especially the bank lending channel, depends on the existence of differentiated funding costs for banks to constitute new loans and that bank heterogeneity is an important determinant of the way this channel works. Thus, heterogeneous characteristics among banks, and most importantly those that directly affect the cost of lending, may be key determinants of how monetary policy is transmitted to commercial banks and to the real economy. Thus, it is also important to understand how different structures of banks and their use of resources, i.e. efficiency, affect the mechanism that defines banks' loan supply (Jonas & King, 2008) and the setting of spreads (Das & Kumbhakar, 2012).

The efficiency of the banking sector is a topic that has been studied largely. Berger & Humphrey (1997) surveyed 130 studies on the efficiency of the financial sector that comprise 21 countries and that used parametric and non-parametric frontier analysis to measure efficiency. They point out that the purpose of most studies was to test regulatory effects on the banking sector, assess methodological issues or analyze managerial performance, but also that results are not consistent across the literature. Furthermore, Berger & Mester (1997) considered almost 6,000 US banks over the period of 1990-1995 and estimated different measures of efficiency, i.e. cost, standard profit and alternative profit efficiency, using different methodologies, finding average cost efficiency was around 77%. They found that differences across the literature could be due to the differences in the definition of efficiency and its modeling, but that these differences were little when estimating average industry efficiency and firms' rankings. Other studies from the 90's also estimated scale and scope economies and X-efficiency, which is the common term in the literature for the efficient use of inputs (Mester, 1996), and the importance of assumptions on common production functions across firms was established (Altunbaş & Chakravarty, 1998).

More recently, the literature has studied different measures of efficiency depending on the question they are addressing. For instance, many have focused on the effect of banking regulation on the efficiency of the indus-

try. To test if bank size should be regulated, Restrepo-Tobón, Kumbhakar & Sun (2015) use a non-parametric approach that does not make assumptions on the functional form of technology to measure economies of scale in the United States banking industry. They find evidence of substantial economies of scale in large banks (over $1 billion in assets), even though the top one hundred banks seem to have exhausted them. Thus, they suggest bank consolidation and growth should continue in the US.

Also, Badunenko & Kumbhakar (2017) analyze a change in regulation in India (the liberalization of banks ownership) on the returns to scale, technical efficiency and cost efficiency of banks owned by privates, foreigners and the state, using a heteroscedastic four-component model from 1992 to 2009. They find that technology is heterogeneous depending on ownership types and that regulation also affects returns to scale, technical change and efficiency differently. In general, they find publicly owned banks operated closer to their cost frontier than foreign and private banks. Another study tested the same issue in India and found that publicly owned banks operated above their efficient scale from 1996 to 2005 (Das & Kumbhakar, 2012). Additionally, the effect of liberalization on the efficiency of the banking industry in 1996 was also studied for Taiwan using a non-parametric approach (DEA), but in this case, privatization was found to be positive for the efficiency of the industry (Chen & Yeh, 2000). The effect of deregulation on efficiency was also studied for the Spain case from 1986 to 1995, where results showed technical inefficiency was affected at first but productivity growth improved (Kumbhakar, Lozano-Vivas, Lovell & Hasan, 2001).

Furthermore, other changes in regulation have also been studied. For example, the effect of labor regulations on the efficiency of the banking sector was studied by Mamatzakis, Tsionas, Kumbhakar & Koutsomanoli-Filippaki (2015) for the European Union from 2005 to 2010. They find that allocative efficiency is positively affected by labor market liberalization policies, but they are not conclusive regarding technical efficiency.

Moreover, there have been concerns on the effects of heterogeneities across firms on efficiency estimates. Triebs, Saal, Arocena & Kumbhakar (2016) find evidence of the need to consider different technologies across firms when estimating economies of scale and scope. They use a model that allows for flexible technology across firm types and test their theoretical approach with an empirical application to US local government-owned electric utility firms. Additionally, Malikov, Restrepo-Tobon & Kumbhakar (2014) study the presence of economies of scale in Credit Unions of the US

that offer different financial products, and find evidence of technological heterogeneity among firms that must be accounted to reach un biased estimates of efficiency.

Another topic that has been addressed in the literature is the effect of technological change and financial innovations on efficiency. First, Mishkin & Strahan (1999) established that advances on information technologies would affect the structure and efficiency of financial intermediaries because of the reduction of transaction costs and information asymmetries (which result on moral hazard and adverse selection and thus, inefficient selection of product mix of banks). Additionally, recent technological advances and deregulation of the sector have paved the way for different strategies to generate profit, such as off-balance sheet (OBS) activities, which have become more common. On this regard, Lozano-Vivas & Pasiouras (2014) estimate changes in productivity due to OBS activities for 712 banks in 84 countries, from 1999 to 2006. They found OBS is relevant in explaining profit increases, and that profit productivity increases with this financial innovation, especially for advanced countries.

The efficiency of the Colombian banking industry has also been studied. Herrera, Bernal & others (1983) where the first to estimate a cost function derived from a Cobb-Douglas production function (using OLS), for commercial banks in Colombia in 1981. They found evidence of economies of scale and a decreasing cost function. Later, Ferrufino & others (1991) included other financial intermediaries (financial corporations – FC - and corporations for savings and mortgages - CAV) in the estimation of a translogarithmic cost function using OLS. She found that CAV also had decreasing cost functions and showed scale economies, but the FC's showed constant average costs, suggesting the level of production was optimal. Furthermore, technical efficiency and X-efficiency was estimated for Colombia for the first time by Suescún, Misas & others (1996). They also estimated scale economies for the Colombian bank industry between 1989 and 1995 and found that average inefficiency was 30.8% of total operative costs, of which 85% was due to X-inefficiency, although it should be noted that they did not include financial costs, which accounts for about 66% of total costs (Janna Gandur, 2004).

Up until 2003, all other studies for efficiency for the Colombian banking industry only estimated efficiency in relation to other banks (Castro, 2001; Badel, 2002) meaning there was the assumption that one bank was indeed efficient (Janna Gandur, 2004). Subsequent studies tried to overcome this

weakness and estimated absolute efficiency using parametric methodologies. Janna Gandur (2003) used stochastic frontier analysis to measure cost efficiency for the banking sector in Colombia, from 1992 to 2002. He found that average cost inefficiency was around 34% but that, over time, efficiency rose 17 percentage points. Estrada (2004) also estimated absolute efficiency for Colombia's banks from 1989 to 2003 using stochastic frontier analysis and a trans-log function, but found average inefficiency was lower, 28%.

The most recent literature on efficiency for the Colombian case has extended methodological rigor, the use of both parametric and non-parametric techniques, and the inclusion of heterogeneous information of banks. Almanza-Ramírez (2012) estimates cost efficiency (including scale, technical and allocative efficiency) of 15 banks in Colombia between 1997 and 2007, using a non-parametric technique (Data Envelopment Analysis – DEA). He found average cost efficiency was around 75.9% and inefficiency was mostly due to allocative inefficiency (19.3%).

Also, Fernández & Estrada (2013) estimated X-efficiency of credit establishments in Colombia from 2002 to 2014, estimating a Cost Stochastic Frontier with a trans-log function of 2 outputs and 3 inputs (they also implement a semi-parametric approach, *Order-m*, to test for robustness). Their study suggests technical efficiency has increased over time in Colombia's banking sector, except for a decrease in efficiency observed between 2008 and 2010, due to macro-prudential policies set in 2007. They find an average efficiency level of 51.6% and a level of 60.3% in June 2012. They explain that their estimates may be biased downward around 10% because of missing variables for some banks. Furthermore, they analyze the relationship between efficiency and market structure conditions, and they find that market concentration is negatively related to efficiency, so it is possible that the most concentrated banks have fewer incentives to reduce costs since their market power lets them obtain satisfactory profits (compared with the rest of the market).

More recently, Sarmiento, Cepeda, Mutis & Pérez (2014) estimated different measures of efficiency using the non-parametric DEA approach for commercial banks in Colombia, from 2000 to 2009, which let them study the effects of the financial crisis of 2008. They found that technical efficiency improved gradually (except in 2008 due to external forces). Average technical efficiency for the period of study was 79.03% but it showed high heterogeneity among banks. Anyway, the literature's agenda on efficiency for the Colombian sector seems to be focused on the effect of merg-

ers and acquisitions (M&A), due to the high number of foreign banks entering the industry. For instance, Sarmiento & Galan (2014) use stochastic frontier analysis to estimate efficiency and identify the effects of risk-taking on bank's performance for Colombia for the period 2002-2012, specifically considering the role of bank's size and if it has been involved in a M&A process. They find that higher capitalization leads to greater profit and cost efficiency and that foreign large banks, involved in M&A processes, profit more from credit risk than local, small banks, which do so from market risk.

5. Data

The data used in this study consists of an unbalanced panel, with monthly data from 2002 to 2014, for 34 banks (of which 13 are present for the whole time-period). Banks' data on balance-sheets and disbursements is taken from the *Superintendencia Financiera de Colombia*, SFC, which is the public supervisor of the financial sector. The time period is limited because of three reasons. First, as the Inflation Targeting policy was adopted in 2001, the dynamics of monetary policy transmission would have to be studied with a different approach before this date. Second, banks are required to report their balance-sheet information to the supervisor under a different accounting rule since 2015 [4], so data after 2015 is not comparable directly. Third, the SFC only reports monthly information on total disbursements by banks since May 2002.

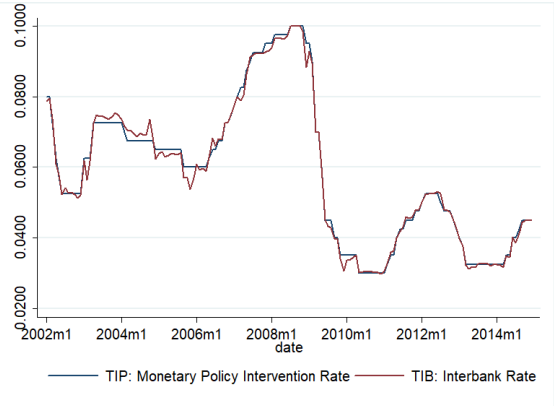
Also, the panel includes data from 34 banks that operated from 2002 to 2014 but not necessarily throughout the whole time-frame. 13 banks begun to operate before 2002 and were still functioning in 2014, 7 banks that were still open in 2014, begun to operate between 2009 and 2011. Also, 8 banks that were operating in 2002, were liquidated or absorbed in 2005 or 2006, and 3 more also stopped operating between 2013 and 2014. The bank with fewer observations in the panel, *Granbanco S.A.*, operated from 2005 to 2007. 6 banks were removed from the database because they had little information available (due to the quality of information reported or time operating). This information was complemented with SFC reports of all bank events (mergers, acquisitions, liquidations, change of names, among others). Also using this data, a dummy variable to report when a bank ac-

[4] Before 2015, accounting information had to be reported under PUC (*Plan Único de Cuentas*) standards. Since 2015, the SFC adopted the International Financial Reporting Standards (IFRS).

quired or merged with other was built.

Additionally, to calculate the price of labor using personnel expenses reported in the financial statements, the number of employees was taken from the SFC. Anyhow, it should be noticed that this information had to be complemented with data from the Central Bank and it is reported quarterly, so monthly time-series were built interpolating. Also, the series of total employees resulted from adding reported employees to 80% of reported sub-employees, to account for the fact that many sub-employees do not work full-time (neither do they always work half-time).

Figure 1. Monetary Policy Rates



Note: The figure plots the policy intervention rate (TIP) and interbank overnight rate (TIB), effective on the last day of each month.

Source: Author's calculation using data from Colombia's Central Bank.

Other variables were obtained from the Central Bank. These variables include monthly and annual Inflation, measured as percentage variation of the Consumer Price Index, CPI; the Industrial Price Index, IPI, as a proxy for GDP (which is only available in a quarterly basis); the Intervention Rate of the Central Bank [5], TIP; and the Interbank overnight rate [6], TIB. It should be noted that these last two variables are reported daily, so the last observation of each month was taken as the month's rate. The TIB is used as

[5]The Monetary Policy Intervention Rate is the minimum rate of expansionary auctions of overnight loans from the Central Bank, which are awarded in Open Market Operations (Banco de la República, 2018b).

[6]The Interbank Overnight Rate, TIB, is the weighted average rate of overnight interbank loans that do not have collateral (Banco de la República, 2018c).

a proxy for monetary policy because it is highly correlated with the TIP rate (99,65%), although it shows daily variations because it also reflects liquidity and credit risk conditions in the interbank market (see figure 1). This rate is commonly used in the literature to proxy monetary policy (see (Gómez-González & Grosz, 2007; Amaya, 2005; López et al., 2011; Huertas et al., 2005)).

Variables regarding nominal or monetary amounts, such as disbursements and all variables taken from banks' financial statements, where deflated using the CPI. Also, although balance-sheet data are stocks, information from income statements is reported to the SFC as accumulated income, expenses and profits. Thus, to identify *monthly income statements* (expenses, income, and profit generated in each month) income, expenses and profit accounts from the same year were differentiated and then, the values were deflated. This transformation of the data presents some challenges, since income statements are reported using the accrual principle, so it is possible to find decreases in accumulated income and expenses. This issue was avoided as possible, using accumulated data when calculating ratios with data from income statements.

Furthermore, to analyze the bank-lending channel, this study uses total disbursements. Every bank or credit establishment is required to report total loan disbursements by type of loans and the weighted average interest rates set on these loans [7] The definition of each loan category considered in this study, according to the SFC, Superintendencia Financiera de Colombia (2018), is as follows [8]:

- **Micro-credits**: Loans of an amount not over 25 minimum monthly legal salaries (as established by law) granted to a small business [9].
- **Consumer Loans**: These are loans granted to natural persons, to finance the acquisition of consumer goods or services that do not have a commercial purpose.

[7] This data is available since May 2002, which constraints the time period considered in this study.

[8] Current account overdrafts and credit limits authorized on credit cards are also reported as disbursements by the SFC, but they are not considered in this study.

[9] A small business is a natural or legal person that produces some economic activity e.g. agriculture, industry, commerce or services, that has at most 10 employees and assets less than 501 minimum monthly legal salaries.

- **Commercial Loans**: All loans different from Mortgage Loans[10], Consumer Loans or Micro-credits. This category includes:
  - **Preferential or Corporate Loans**: Loans, with maturities higher than 30 days, granted to clients that are eligible to negotiate an interest rate.
  - **Treasury Loans**: Loans, with maturities under 30 days, granted to clients that are eligible to negotiate an interest rate for their short-term liquidity needs.
  - **Ordinary Loans**: Commercial loans that cannot be classified as treasury loans or corporate or preferential loans.

It is worth noting that data on disbursements excludes disbursements related to restructuring processes and only includes loans that are funded by the bank's own resources (not by special lines of credit (rediscount). Also, this study focuses on analyzing the bank lending channel using data on disbursements of Micro-credit, Consumer, and Commercial Loans. For this, this study refers from now on to *total disbursements* or *disbursement of total loans*, talking about the sum of disbursements on micro-credit, consumer, and commercial loans. When referring to Total Loans, it is referring to loans as the amount of assets in loans on balance-sheets.

6. Descriptive Statistics

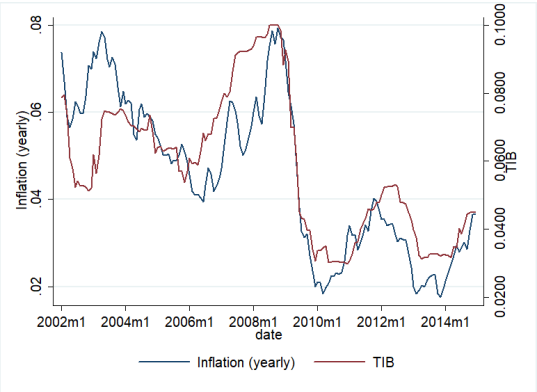
Since 1991, Colombia's Central Bank took on a constitutional mandate to control inflation, also putting into consideration the maximization of production and employment. To do this, it adopted different policies (from controlling the exchange-rate with bands, to defining reference levels for the monetary base). Anyway, inflation and the Interbank rate (TIB) showed great levels of volatility, the country went through one of its worse crises in 1999 with GDP falling 4.2%, real interest rates as high as 24% (annually) and a credit crunch (Flórez, Posada & Escobar-R., 2004).

Then, in 2001, expansionary and contractionary auctions became the main monetary policy of the Central Bank, and it gradually reduced the volatility of the interbank rate (TIB) and brought inflation down to one digit levels and to the target level (3%). As can be seen in figure 2 and figure 3, the

[10]Mortgage Loans are loans of any amount granted to natural persons, whose purpose is to buy a home (under construction, new or used). They are not included in this study.

TIB, which follows closely the monetary policy instrument (TIP), has varied according to inflation and production (approximated by the Industrial Production Index). In periods of high inflation, the bank has implemented contractionary policies (increasing the TIP and thus, the TIB), and when it can implement expansionary policies to promote economic growth, without losing control of inflation, it does.

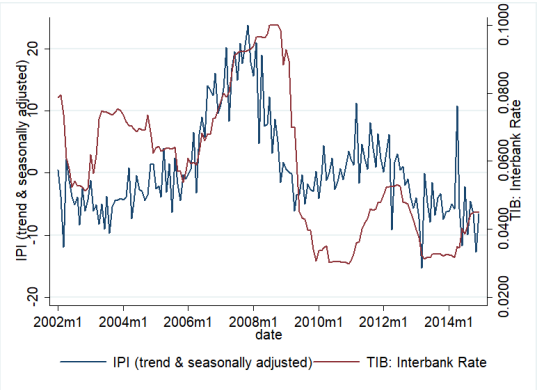
Figure 2. Inflation and Interbank Rate



Note: The figure plots the interbank overnight rate, TIB, effective on the last day of each month. Inflation is the yearly variation of the Consumer Price Index.

Source: Author's calculation using data from Colombia's Central Bank.

Figure 3. Production and Interbank Rate

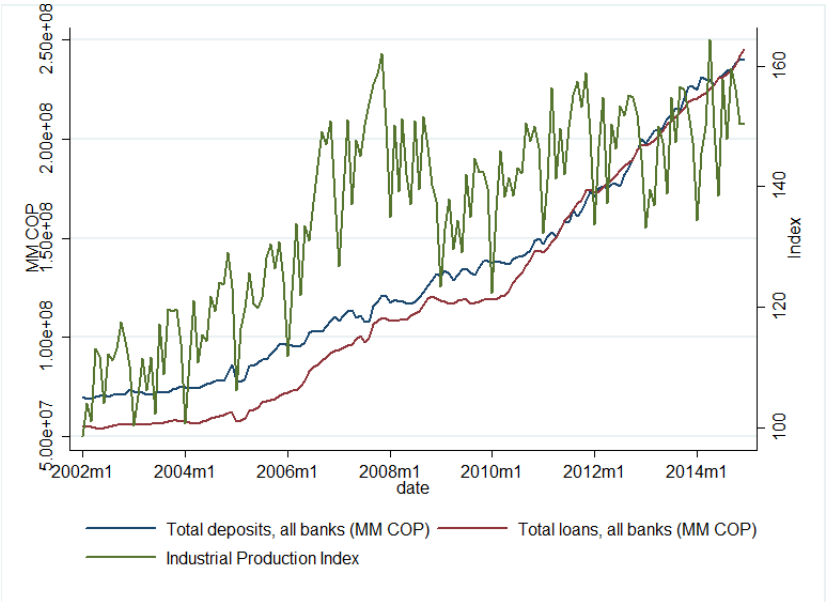


Note: The figure plots the Industrial Production Index, adjusted to remove the time-trend and seasonality effects. The TIB rate is the effective rate on the last day of each month.

Source: Author's calculation using data from Colombia's Central Bank.

Looking at monetary policy cycles from 2002 to 2015, one can identify four periods of contraction, accompanied by four periods of expansion. The most pronounced cycle was around the 2008 global crisis, where yearly inflation rose to its maximum (7.94%) in October 2010, and production was high. Because of the crisis, inflation fell to one of its lowest points (1.84%) and production also fell, so the central bank went into an expansionary period, reducing the TIB to a minimum of 2.97% in December 2010, to promote economic growth. From 2002 to 2014, Colombia went through a period of economic expansion, except for the period of 2008 where it was affected by the global crisis. Since the implementation of an effective inflation targeting strategy for monetary policy after 2001, inflation and interest rates were controlled and there has been an expansion of the banking sector and the loans and deposits market. Figure 4 shows total real deposits and loans in the banking sector have experienced a positive trend, only showing a slow in its growth rate around 2008.

Figure 4. Loans, Deposits and Production



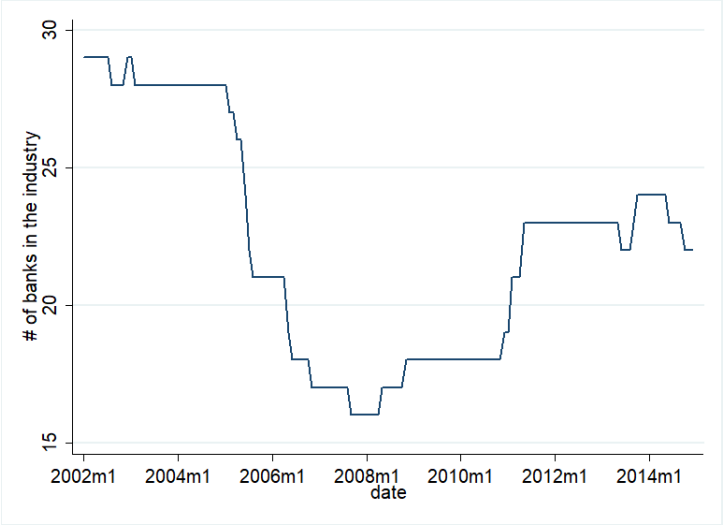
Note: The figure plots the Industrial Production Index without any transformations, the sum of total deposits and loans in millions COP, as reported on balance-sheets for all the credit establish ments considered in this study.

Source: Author's calculation.

On the other hand, in 2002 Colombia's banking sector was also coming out of a transitional period of deregulation and globalization, after the

1991 crisis. Figure 5 shows the number of operating credit establishments or banks registered in Colombia according to the SFC reports, showing a process of concentration at the beginning of the century, followed by the entrance of new establishments. At the beginning of 2002, there were 29 registered credit establishments in the SFC. From 2002 to 2004, there was one acquisition event and two banks where dissolved. In 2005, there were several events: one new bank was registered, 3 banks were canceled or liquidated, and there were 5 mergers. Also, between 2006 and 2008 there were 6 mergers/acquisitions, the license of one bank was canceled and 2 new banks began to operate. From 2009 to 2014, although there were 9 events of mergers/acquisitions, 6 new banks began operations.

Figure 5. Number of banks in Colombia



Note: The figure plots the number of registered and active credit establishments before the financial supervisor (*Superintendencia Financiera de Colombia - SFC*).

Source: Author's calculation using data from the SFC.

Table 1 shows summary statistics of data from bank's balance sheets, for three groups of banks depending on their asset size. Group *big* contains the 11 banks with higher average assets in the sample, *small* includes banks whose average assets were in the lower third, and *medium* includes the rest of the banks. The average size of big banks is 16.5 billion COP, the average size of banks in the middle group is about 1/3 of big banks' size, 5.2 billion COP, and small banks are 0.9 billion, about 5% of the big banks' average size.

Table 1. Descriptive Statistics by Bank's Asset Size

	count	mean	sd	min	median	max
Big						
Total Assets	1,467	16,500,000	14,000,000	3,131,930	11,500,000	84,600,000
Total Loans	1,467	10,200,000	9,609,498	1,226,592	6,345,938	56,700,000
Securities&Money Market	1,467	3,911,542	2,722,778	541,058.9	3,213,458	14,500,000
OBS	1,466	0.245	0.127	0.034	0.223	0.870
Price of deposits	1,467	0.0033	0.00132	0.00055	0.00326	0.0113
Price of labor	1,425	4,734.4	2,172.7	686.7	4,206.3	26,341.2
Price of physical capital	1,467	0.143	0.121	0.0344	0.106	1.427
Credit Risk	1,467	0.0666	0.0485	0.00798	0.0473	0.287
Liquidity	1,467	0.331	0.115	0.137	0.310	0.611
Capitalization	1,467	0.112	0.0312	0.0251	0.109	0.233
Total Costs	1,454	298,921.7	446,031.9	21,120.16	162,827.1	10,600,000
Profit	1,467	30,770.61	38,356.6	-116,529.8	22,413.04	640,215.3
Medium						
Total Assets	1,052	5,244,801	2,743,519	952,505.6	5,057,692	14,900,000
Total Loans	1,052	3,175,476	1,650,355	539,333.4	2,961,612	8,536,229
Securities&Money Market	1,052	1,391,342	1,094,369	36,351.64	1,274,953	7,615,079
OBS	1,049	0.199	0.128	0.00378	0.159	0.744
Price of deposits	1,052	0.00385	0.00133	0.00134	0.00373	0.0193
Price of labor	992	4,560.7	1,725.02	1,800.6	4,320.9	18,711.9
Price of physical capital	1,051	0.107	0.101	0.0184	0.0842	1.134
Credit Risk	1,052	0.0738	0.0762	0.00993	0.0425	0.357
Liquidity	1,052	0.302	0.104	0.0725	0.292	0.583
Capitalization	1,052	0.108	0.0329	0.0446	0.111	0.203
Total Costs	1,045	100,854.9	237,945.9	765.4	72,735.4	7,374,050
Profit	1,052	7,674.6	8,124.97	-70,301.8	6,378.8	59,484.1
Small						
Total Assets	769	933,827.6	488,205.3	62,032.9	929,669.8	2,782,182
Total Loans	769	622,880.7	365,192.5	15,202.27	630,087.5	1,470,649
Securities&Money Market	769	170,849.7	168,717.5	254.7259	112,637.4	1,312,377
OBS	750	0.257	0.216	0.00279	0.191	0.874
Price of deposits	769	0.00493	0.00179	0.00064	0.00473	0.0144
Price of labor	719	6,698.7	6,086.5	917.4	4,628.325	75,362.3
Price of physical capital	768	0.220	0.233	0.0171	0.167	1.493
Credit Risk	769	0.0406	0.0331	0	0.0410	0.242
Liquidity	769	0.265	0.213	0.0165	0.191	0.897
Capitalization	769	0.181	0.107	0.0391	0.143	0.782
Total Costs	762	27,559.6	35,357.5	2,261.7	21,664.7	512,232.7
Profit	769	570.87	3,471.2	-30,286.3	979.2	13,228.7

Note: The table shows descriptive statistics for bank categories according to total assets. The textitBig category, includes the 33% banks with the highest average total assets, the *Small* category, includes the 33% banks with the lowest average total assets and the *Medium* category includes the rest. All nominal amounts were deflated using the CPI. Amounts in millions of pesos (COP).

Source: Author's calculation.

Total loans are, on average, 10 billion COP for the bigger banks, but the average for the lower 34% is not even 1% of this number. Thus, there is some indication of concentration in the lending market. This relationship also holds for average securities and assets as positions in the money market (which includes public and private debt). Also, the Off-Balance Sheet

variable was named as this, because it gives information on income generated by the bank by activities that are not related directly to its assets. Then, OBS is defined as the ratio of non-interest income to total income, where non-interest income, said roughly, gathers income from bank operations that are not related to loans, securities or money-market positions. This ratio seems to be around 20% for all bank sizes, although it shows a high standard deviation.

Price of deposits, which is the ratio of interest expenses on deposits to total deposits reported as liabilities, are around 0.35% (monthly) for big and mid-size banks, but this cost is a lot higher for small banks (around 0.5% monthly). The smaller banks also exhibit the higher price of labor, which is the ratio of personnel and honorary expenses to total employees (including sub-employees). Finally, the price of physical capital is calculated as operating expenses (non-interest operating expenses minus personnel expenses) over total fixed assets, is on average 14.3% for big banks, 10.7% for mid-size banks, but again, it is a lot higher for smaller banks, 22%.

Also, there are other variables regarding the bank's balance-sheet composition. Credit risk is the percentage of total loans that are classified (a priori) by the bank as highly risky (of appreciable risk, significant risk or risk of un-collectability). This variable does not vary a lot across categories and does not seem high. Smaller banks are the ones with less credit risk, 4% on average, while mid-size banks have the higher average credit risk, of 7.3%. Liquidity (liquid assets over total assets) is also similar across categories, around 30%. Smaller banks show lower levels of liquidity, although it is possible that with regulation in Colombia following Basilea III policies in the last year, there could be less volatility in this variable. Capitalization, measured as total equity over total assets, is close to 11% for big and mid-size banks. Small banks are more capitalized, 18% on average.

Finally, average costs for big banks are almost 300 thousand million COP, while they are a bit over one-third of this number for mid-size banks. Total costs for small banks are 27.5 thousand million COP. On the other hand, the differences in profit are more notable for smaller banks. When looking at the average ratio of profit over costs, only considering observations with positive revenue, it is almost 14% and 12% for big and mid-size banks, and a lower 10% for small banks, so intuitively, one might think bigger banks could be more profit efficient.

Table 2 shows monthly real disbursements by banks in millions (COP),

as reported to the SFC and following the definition presented in section 6. Total disbursements, which is a variable calculated as the sum of consumer, commercial and micro-credit disbursements, is on average 1.05 billion COP. As seen in the balance-sheet data presented before, average total disbursements for mid-size banks is about 1/3 of this number (3 hundred thousand million COP), but for the small banks, this number falls to less than 65 thousand million COP.

Table 2. Descriptive Statistics, Disbursements by Bank's Asset Size

	count	mean	sd	min	p50	max
Big						
Total Disb.	1,427	1,049,799	1,032,202	7,186.1	762,733.6	6,795,095
Consumer&Commercial Disb.	1,427	1,045,929	1,029,328	5,100.2	762,733.6	6,774,177
Consumer Disb.	1,427	124,573.8	118,486.3	1,657.1	90,356	645,172.5
Commercial Disb.	1,427	921,355.0	973,446.3	462.5	665,581.1	6,398,547
Ordinary Disb.	1,399	285,499.1	444,601.2	38.4	76,369.45	2,936,868
Preferential Disb.	1,289	410,944.5	457,003.4	139.5	277,321.4	3,186,405
Treasury Disb.	1,347	286,305.0	330,304	7.075	174,681.3	3,012,448
Micro-credit Disb.	798	6,920.0	8,616.2	0.978	2,845.9	65,995
Medium						
Total Disb.	1,016	295,236.6	282,682.4	7,760.7	205,197.9	1,755,879
Consumer&Commercial Disb.	1,016	291,053.1	283,996.7	7,180.7	195,307.8	1,755,879
Consumer Disb.	1,016	66,797.2	53,516.7	854.48	55,195.75	233,680.1
Commercial Disb.	1,016	224,256.0	267,594.1	1,400	116,506.3	1,706,716
Ordinary Disb.	953	66,173.2	100,543.2	241.95	29,997.6	692,747.4
Preferential Disb.	785	114,599.0	132,520.8	28.6	62,409.7	633,919.1
Treasury Disb.	777	96,294.5	157,807.2	26.5	38,138.2	1,224,227
Micro-credit Disb.	389	10,926.5	14,579.4	2.429	3,473.3	68,530.6
Small						
Total Disb.	739	64,453.7	59,774.4	429.8	55,013	476,601.5
Consumer&Commercial Disb.	739	56,524.8	63,595	176.24	45,529.6	476,601.5
Consumer Disb.	423	18,820.2	17,147.9	0.886	13,355.03	161,643.6
Commercial Disb.	694	48,718.8	64,255.97	176.24	27,733.09	476,601.5
Ordinary Disb.	407	8,565.2	7,906	37.38	6,887.9	62,110.2
Preferential Disb.	461	242,405.7	24,191.6	87.767	18,000	139,863
Treasury Disb.	415	45,960.9	61,053.37	65.764	30,393.7	457,986.5
Micro-credit Disb.	255	22,978.5	28,346.2	6.27	2,687.03	94,039.04

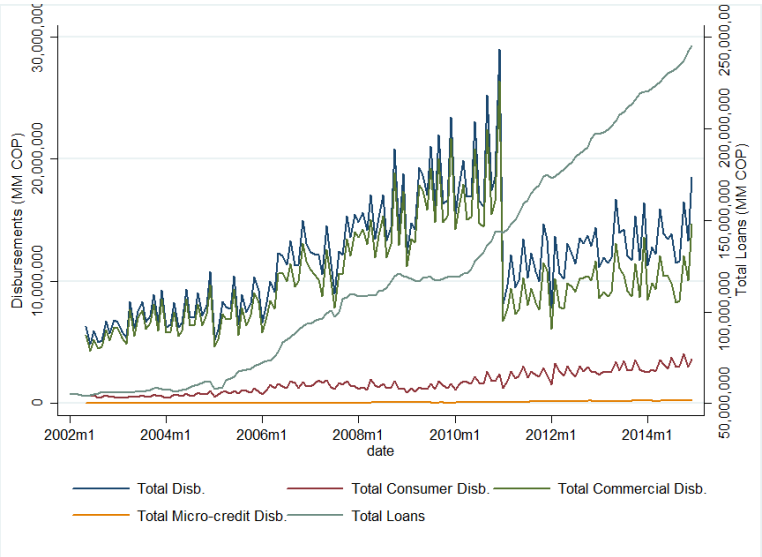
Note: The table shows descriptive statistics of monthly disbursements for bank categories according to total assets. The textitBig category, includes the 33% banks with the highest average total assets, the *Small* category, includes the 33% banks with the lowest average total assets and the *Medium* category includes the rest. *Total disbursements* is the sum of commercial, consumer and micro-credit disbursements. All nominal amounts were deflated using the CPI. Amounts in millions of pesos (COP).

Source: Author's calculation.

Furthermore, for all groups of banks by size, consumer, and commercial loans represent the biggest portion of total loans, and micro-credit is most important for small banks. Smaller banks seem to be more intensive in consumer lending and micro-credit, considering average micro-credit

disbursements are a much smaller fraction of total disbursements for big and mid-size banks than for small banks. Also, average preferential loans are proportionally higher for big and small banks than for small banks.

Figure 6. Loans and Disbursements



Note: The figure plots *total* disbursements (i.e. the sum of commercial, consumer and micro-credit disbursements), consumer disbursements, commercial disbursements, micro-credit disbursements and total loans (as reported in balance-sheet data). All the variables are the sum of disbursements and loans from all the credit establishments considered in this study. All nominal amounts were deflated using the CPI. Amounts in millions of pesos (COP).

To complement the data presented on table 2, figure 6 shows total disbursements and loans (as assets in banks' balance-sheet) for all credit establishments (as reported by the SFC). The dynamics of total disbursements are driven by that of commercial loans, which represent the biggest portion of total loans. Also, disbursements on commercial loans exhibit higher volatility than commercial or micro-credit disbursements, and this last category is extremely small, compared to the others. Considering the proportion of disbursements on commercial loans to consumer or micro-credits, intuitively one might expect that the bank-lending channel works mainly through this line of credit, although credit demand might be equally affected for commercial and consumer loans.

Also, it is clear that there is a structural change in disbursements from December 2010 to January 2011. Total disbursements fell 72%, driven by a fall

in commercial loans of 74.4%, and keeping a lower level from that moment on. This decrease in disbursements of commercial loans was driven by a 73.3% fall in ordinary loans, a 74.3% decrease of disbursements of preferential loans and 76.4% fall in disbursements of treasury loans. This variation was due to a demand shock (not a supply shock) because of a regulatory change.

Before January 2011 and the implementation of a tax reform (*Ley 1430 de 2010*, (Congreso, 2010)), the tax to financial transactions (GMF), which is a tax proportional to the amount of any financial transaction, was not applicable to disbursements to third parties and disbursements that were settled on the same day. This regulatory reform included as part of the taxable basis, disbursements to third parties unless they were mortgage loans or destined to buy cars or fixed assets [11]. Thus, disbursements or payments to third parties for different concepts such as the payment of payrolls, services, vendors, or of any liability, became taxable (Congreso, 2010). Then, the use of disbursements as a mechanism to make payments avoiding the GMF, that would be applicable to payments via current accounts, for example, b ecame unattractive when costs were driven up by the tax. This explains why disbursements showed a peak right before the application of this law and a high and sustained drop afterward, but the growth rate of total loans in the banking industry was not significantly altered.

On the other hand, previous data gives a hint of market concentration in Colombia's banking sector. To analyze this, a concentration index for the industry, the Herfindahl-Hirschman Index[12] was calculated, particularly for the loans market. Figure 7 shows the evolution of the HHI calculated with banks' participation in two different variables: total disbursements in the industry and total loans. The HHI for total disbursements is much more volatile than the HHI for total loans.

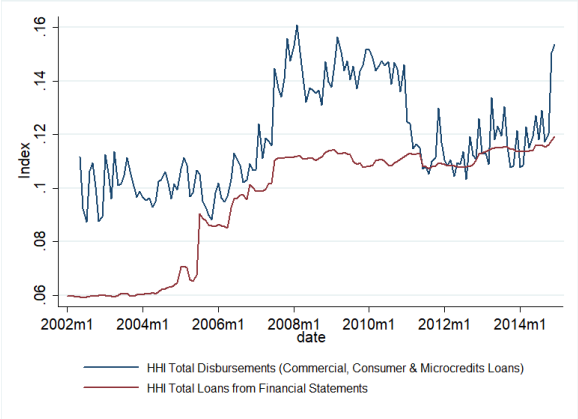
Figure 7 clearly indicates that market concentration increased from 2005 to 2008 (going from 0.06 to 0.11) after several merger events, but it stayed relatively stable afterward, a bit under 0.12. Also, figure 8 shows how market share of the 6 biggest banks (by average asset size in the sample) evolved over time. These banks went through processes of mergers or acquisitions where their market share shows sudden rises. Market participation stays

[11] Article 6, Law 1430 of 2010

[12] The Herfindahl-Hirschman Index (HHI) is a measure of market concentration that is calculated as the sum of the squares of the participation of each individual in the industry (Ortiz, Zuleta, Misas, Jaramillo & others, 2016).

high after these peaks, which drives up market concentration and probably increases the market power of these banks.

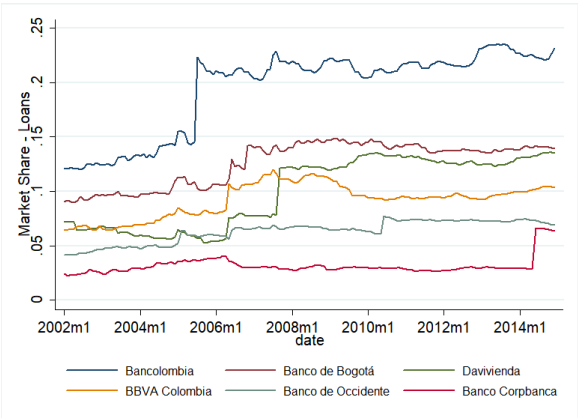
Figure 7. Herfindahl-Hirschman Index for Loans



Note: The figure plots the calculated HHI for the loans market. HHI of Total Disbursements is calculated using participation with data on *total* disbursements (i.e. commercial, consumer, and micro-credit), and the HHI for Total Loans, using participation with data from bank's balance-sheets, for the banks considered in this study.

Source: Author's calculation using data from the SFC.

Figure 8. Market Share, Loans Market



Note: The figure plots the participation or market share of the 6 biggest banks in the loans market, considering total loans reported on balance-sheets.

Source: Author's calculation using data from the SFC.

7. Methodology

7.1. Theoretical Model

Consider banks as rational agents that take maximizing decisions in an environment of imperfect competition (Baglioni, 2007). To understand the dynamics of the banking industry and the mechanisms that determine interest rates and loan supply, a simple and motivating oligopoly model, the Klein-Monti model, is presented following Freixas & Rochet (2008) and Jonas & King (2008). In a simplifying manner, banks are considered financial intermediaries that buy loans and sell deposits with a given technology, thus incurring in costs. Also, banks are supposed to be of equal size and market power, but their cost structures may differ. This motivating model assumes a Cournot oligopoly, where banks' competition is on quantities, as opposed to a Bertrand oligopoly, where competition is on prices[13].

Suppose there are i=1,2,...N banks, and they are all supposed to have only two assets, one liability, and for simplicity, assume that they have not received money from investors, meaning equity equals zero. These banks get liquidity from their clients in the form of deposits D, they settle loans L and must keep liquid reserves R. They do not hold capital or fixed assets, so there is no investment and the risk-taking behavior of banks (and the cost of capital that these risks entail) are not included or modeled, as a simplifying assumption. Thus, because of the balance-sheet constraint, it must be that assets equal the bank's liabilities.

$$D_i = R_i + L_i \tag{1}$$

Furthermore, these banks may choose to leave banking reserves in cash C, or take a (net) position in the interbank market (better known as the money market) M. To simplify, it is fine to assume that operations in this market are short-term settlements and entail minimum risk, so that the price of the market, the interest rate, is exogenous and equals the monetary policy rate, r.

$$R_i = C_i + M_i \tag{2}$$

[13]This model could be extended to consider other market structures, such as Perfect Competition, Monopolistic Competition or a Bertrand oligopoly. Considering the scope of this study, only the Cournot oligopoly case is presented, as a motivation to consider heterogeneous characteristics of banks as determinants of a differentiated reaction to monetary policy shocks.

On the other hand, cash does not yield any interest rate. Then, it is reasonable to assume that banks would only want to leave reserves in cash to the minimum amount required by the regulator. Thus, consider α as the percentage of deposits from clients that the bank must leave as cash reserves according to the central bank.

$$C_i = \alpha D_i \tag{3}$$

Furthermore, this model entails a simplistic assumption that there are three agents in the real sector, the government, firms, and households. Households have savings and banks are intermediaries for firms to access these resources, so they can finance investment. The government deficit is financed issuing securities (ΔB) and changing the monetary base, that consists of all cash reserves held by banks (C). Therefore, households are assumed to have zero cash holdings, the monetary base equals total cash reserves in the bank system and households' money equals total deposits in the economy.

Continuing with the analysis of the banking sector, from equation (3), we could describe the position of each bank in the money market as $M_i > 0$, if the bank has enough reserves (surpassing the cash requirements from the central bank). Intuitively, the bank only takes to the money market those resources that it does not have to leave as cash reserves and that it does not use as funding to lend in the credit market.

$$\begin{aligned} R_i &= \alpha D_i + M_i \\ D_i - L_i &= \alpha D_i + M_i \\ M_i &= (1-\alpha) D_i - L_i \end{aligned} \tag{4}$$

Notice that banks face a demand for loans, whose inverse function is $r_L(L)$, where $L = L_1 + \cdots + L_n$; $L_i = L/n$ and $\delta r_L(L)/\delta L < 0$, $\delta^2 r_L(L)/\delta L^2 < 0$ (assuming convexity and a continuously differentiable function). Moreover, they face a supply of deposits, whose inverse function is assumed to be $r_D(D)$, where $D = D_1 + \cdots + D_n$; $D_i = D/n$ and $\delta r_D(D)/\delta D > 0$. Also, consider that to be able to lend and receive deposits, banks must spend physical and human capital that must be compensated, so there are costs involved in the production of the bank's outputs. Consider these administrative costs as given by $TC_i = f(D_i, L_i)$, such that $\delta TC_i(D_i, L_i)/\delta L_i > 0$; $\delta TC_i(D_i, L_i)/\delta D_i > 0$ and $\delta^2 TC_i(D_i, L_i)/\delta L_i^2 = \gamma_i > 0$.

Then, without loss of generality, it is possible to assume that each bank

acts as a rational agent that must choose the level of D_i and L_i, maximizing their profit or utility function, considering strategically what would be the decision of other participating agents. Then, the following profit function is proposed.

$$\begin{aligned}\pi_i(L_i, D_i) &= r_L(L)L_i + rM_i - r_D(D)D_i - TC_i(L_i, D_i) \\ &= r_L(L)L_i + r[(1-\alpha)D_i - L_i] - r_D(D)D_i - TC_i(L_i, D_i) \\ &= [r_L(L) - r]L_i + [r(1-\alpha) - r_D(D)]D_i - TC_i(L_i, D_i)\end{aligned} \tag{5}$$

Thus, the bank's maximizer behavior follows the first order conditions given by the following equations.

$$\begin{aligned}\frac{\delta\pi_i(L_i, D_i)}{\delta L_i} &= \frac{\delta r_L(L)}{\delta L}\frac{\delta L}{\delta L_i}L_i + r_L(L) - r - \frac{\delta TC_i(L_i, D_i)}{\delta L_i} = 0 \\ &\rightarrow \frac{\delta TC_i(L_i, D_i)}{\delta L_i} = \frac{\delta r_L(L)}{\delta L}L_i + r_L(L) - r\end{aligned} \tag{6}$$

$$\begin{aligned}\frac{\delta\pi_i(L_i, D_i)}{\delta D_i} &= r(1-\alpha) - r_D(D) - \frac{\delta r_D(D)}{\delta D}\frac{\delta D}{\delta D_i}D_i - \frac{\delta TC_i(L_i, D_i)}{\delta D_i} = 0 \\ &\rightarrow \frac{\delta TC_i(L_i, D_i)}{\delta D_i} = r(1-\alpha) - r_D(D) - \frac{\delta r_D(D)}{\delta D}D_i\end{aligned} \tag{7}$$

Applying the Implicit Function Theorem to equation (6), the reaction function of bank i to a change in the monetary policy rate can be can be derived.

$$\begin{aligned}1 &= [\frac{\delta^2 r_L(L)}{\delta L^2}L_i + 2\frac{\delta r_L(L)}{\delta L} - \frac{\delta^2 TC_i(L_i, D_i)}{\delta L_i^2}]\frac{\delta L_i}{\delta r} + \sum_{j\neq i}^{n}[\frac{\delta^2 r_L(L)}{\delta L^2}L_i + \frac{\delta r_L(L)}{\delta L}]\frac{\delta L_j}{\delta r} \\ &= [r_L^{''}(L)L_i + 2r_L^{'}(L) - \gamma_i]\frac{\delta L_i}{\delta r} + \sum_{j\neq i}^{n}[r_L^{''}(L)L_i + r_L^{'}(L)]\frac{\delta L_j}{\delta r}\end{aligned} \tag{8}$$

However, consider the Cournot oligopoly case with just two banks, and define L^* as the equilibrium level of the loans market. Then, one could solve equation (8) for each bank and find the following reaction function for bank i, as shown in Jonas & King (2008).

$$\frac{\delta L_i}{\delta r} = \frac{r_L^{'} - \gamma_j}{3(r_L^{'})^2 + r_L^{'}r_L^{''}L^* - (2r_L^{'} + r_L^{''}L_i)\gamma_j - (2r_L^{'} + r_L^{''}L_j - \gamma_j)\gamma_i} < 0 \tag{9}$$

$$\frac{\delta(\delta L_i/\delta r)}{\delta \gamma_i} = \frac{(r_L^{'} - \gamma_j)(2r_L^{'} + r_L^{''} L_j - \gamma_j)}{[3(r_L^{'})^2 + r_L^{'} r_L^{''} L^* - (2r_L^{'} + r_L^{''} L_i)\gamma_j - (2r_L^{'} + r_L^{''} L_j - \gamma_j)\gamma_i]^2} > 0 \tag{10}$$

As follows from equation (9), the denominator is positive and the nominator is negative, so the reaction of loan supply from each bank to a contractionary monetary policy is negative, meaning that loan supply should fall when the policy rate rises. Also, equation (10) is positive (both the denominator and the nominator are positive) meaning that a bank's reaction to an increase in the monetary policy interest rate (which is negative) becomes *less negative* as γ_i increases. Because γ_i is the slope of the marginal cost function of bank i to produce loans, an increase in this parameter means that the bank becomes less efficient. Then, if defining a parameter for cost efficiency $\rho = 1/\gamma$, where an increase in ρ means a bank becomes more cost efficient, it is possible to say that the more efficient a bank is, the negative reaction of loans to an increase in the monetary policy rate will be greater (more negative) or faster.

7.2. Heterogeneity and Bank Efficiency

As it was shown in section 4.2 and proposed in section 7.1 using a theoretical model, the transmission of monetary policy through the bank-lending channel seems to be dependable on specific characteristics of banks. This study considers different sources of heterogeneity according to what has been done previously in the literature, and it extends the work of Jonas & King (2008) to the Colombian banking industry.

The basic sources of heterogeneity in the banking sector can be obtained from relationships of variables from bank's balance-sheet data. These variables are capitalization, liquidity, and operational and financial efficiency. Capitalization is measured as the ratio of equity over total assets. Liquidity is measured as liquid assets over total assets, where liquid assets include cash holdings, negotiable and available to sell public and private debt, and active positions in the money market (including posted collateral). Operational and financial efficiency are measured as the commonly used ratios of total operating expenses over total assets and total operating expenses net of interests over total income, accordingly.

Anyhow, financial and operational efficiency are balance-sheet ratios that do not show the complete picture of the cost structure of each bank, so it

may not represent well the cost function of each bank. To achieve a better measure of efficiency, this study estimates the optimal cost function and cost efficiency of each bank, according to the theory of firm efficiency.

To begin, consider there are two different types of efficiency of any production firm: technical efficiency and allocative efficiency. Technical efficiency is related to the ability to produce at the optimal level or achieve the maximum level of production possible given the level of inputs (output-oriented efficiency), or, the ability to use the minimum level of inputs to produce a certain level of production (input-oriented efficiency) (Kumbhakar & Lovell, 2003). Allocative efficiency consists of choosing the best combination of inputs, given a certain level of output and input prices, or choosing the best combination of outputs, given a combination of inputs and their prices (Kumbhakar, Wang & Horncastle, 2015).

Technical efficiency and allocative efficiency form together the concept of economic efficiency, a concept that is related to the economic behavior of the decision-making agent. Considering a cost maximizing agent, economic efficiency is studied in the form of cost efficiency (choosing the optimal input quantities given input prices and output quantities). Considering a profit-maximizing agent, economic efficiency is approached in the way of profit efficiency (choosing the optimal output quantities - or prices - given output prices - or quantities - and input prices) [14] (Kumbhakar & Lovell, 2003). As Estrada (2004) explains, in the presence of perfect competition, cost and profit efficiency should be identical with a fixed level of output, but if there is market power involved, a firm may be profit efficient but cost inefficient or vice-versa.

Also, some studies relate efficiency to scale and scope economies. An industry shows scale economies when it has a production function such that when inputs are increased by a proportion λ, then outputs increase by a proportion equal to or greater than λ (Kumbhakar et al., 2015). On the other hand, scope economies exist among outputs when the production functions of two different outputs, are such that the cost of producing them separately is greater than it would be if they were produced together (Mester, 1996).

[14] The product of technical efficiency and allocative efficiency is sometimes referred to in the literature as X-efficiency.

This study estimates cost efficiency [15] of the banking sector in Colombia following the previous work of Estrada (2004) and Sarmiento & Galán (2017), and the theoretical development of Kumbhakar et al. (2015) for the Stochastic Frontier approach (SFA).

Suppose banks are technically inefficient firms, whose objective is to define a level of output y that minimizes costs. If $e^{-\eta} \leq 1$ is the technical inefficiency factor, the minimum cost function of each bank, with j inputs and input prices w, can be written as in equation (11). The actual costs function can be written as in equation (12).

$$C^*(\mathbf{w}, \mathbf{y}) = \sum_j \mathbf{w}_j \mathbf{x}_j \exp(-\eta) \tag{11}$$

$$\begin{aligned} C^a &= \sum_j \mathbf{w}_j \mathbf{x}_j = C^* \exp(\eta) \\ \rightarrow \ln C^a &= \ln C^*(\mathbf{w}, \mathbf{y}) + \eta \end{aligned} \tag{12}$$

To estimate equation (12), suppose a trans-log specification for $\ln C^*$ with 3 inputs and 3 outputs and add a noise term to make the function stochastic. The outputs are total loans y_1, securities y_2 (which includes total investments and active positions in the money market), and off-balance sheet activities y_3, which is defined as the ratio of non-interest income (income that is not related to loans or securities) to total income. The input prices are the price of deposits w_1, the price of labor w_2 and the price of physical capital w_3. Then, for bank i, at time t, the equation to be estimated is as follows.

$$\begin{aligned} \ln C^a_{it} &= \ln C^*(\mathbf{w}_{it}, \mathbf{y}_{it}) + v_{it} + \eta_{it} \\ &= \beta_0 + \sum_{j=1}^{3} \beta^w_j \ln w_{j,it} + \sum_{j=1}^{3} \beta^y_j \ln y_{j,it} + \frac{1}{2} \sum_{j=1}^{3} \sum_{k=1}^{3} \beta^w_{jk} \ln w_{j,it} \ln w_{k,it} \\ &+ \frac{1}{2} \sum_{j=1}^{3} \sum_{k=1}^{3} \beta^y_{jk} \ln y_{j,it} \ln y_{k,it} + \sum_{j=1}^{3} \sum_{k=1}^{3} \beta_{jk} \ln w_{j,it} \ln y_{k,it} + v_{it} + \eta_{it} \end{aligned} \tag{13}$$

[15] For further studies, considering the banking sector in Colombia exhibits a certain level of market concentration and market power (it is not perfectly competitive as shown in section 6), profit efficiency should also be estimated, since a cost-efficient bank is not necessarily profit-efficient and vice-versa.

Furthermore, the following restrictions must be imposed to ensure linear homogeneity of degree 1 in input prices and symmetry.

$$\begin{aligned}
\beta^w_{jk} &= \beta^w_{kj} \\
\beta^y_{jk} &= \beta^y_{kj} \\
\sum_{j=1}^{3} \beta^w_j &= 1 \\
\sum_{j=1}^{3} \beta^w_{jk} &= 0, \forall k \\
\sum_{j=1}^{3} \beta_{jk} &= 0
\end{aligned} \tag{14}$$

These restrictions are included in the estimation of equation (13), by normalizing total costs and input prices with one of the other input prices, w_3, so the new equation to be estimated is as in (15). Also, a time trend is included in the estimated equation to allow for technological progress (Sarmiento & Galán, 2017).

$$\begin{aligned}
\ln(\frac{C^a_{it}}{w_{3,it}}) = \theta & \\
&+ \sum_{j=1}^{2} \beta^w_j \ln \frac{w_{j,it}}{w_{3,it}} + \sum_{j=1}^{2} \beta^w_{jj} (\ln \frac{w_{j,it}}{w_{3,it}})^2 + \beta^w_{12} \ln \frac{w_{1,it}}{w_{3,it}} \ln \frac{w_{2,it}}{w_{3,it}} + \sum_{j=1}^{3} \beta^y_j \ln y_{j,it} \\
&+ \sum_{j=1}^{3} \beta^y_{jj} (\ln y_{j,it})^2 + \sum_{j \neq k} \beta^y_{jk} \ln y_{j,it} \ln y_{k,it} + \sum_{j=1}^{2} \sum_{k=1}^{3} \beta_{jk} \ln \frac{w_{j,it}}{w_{3,it}} \ln y_{k,it} \\
&+ \gamma_1 t + \gamma_2 t^2 + \sum_{j=1}^{3} \gamma_{3,j} \ln y_{j,t} t + \sum_{j=1}^{2} \gamma_{4,j} \ln \frac{w_{j,it}}{w_{3,it}} t + v_{it} + \eta_{it}
\end{aligned} \tag{15}$$

This equation is estimated by Maximum Likelihood estimation, imposing distributional assumptions on η and v. The assumption on the error term is $v \overset{iid}{\sim} N(0, \sigma^2_v)$. Also, heteroscedasticity is assumed because the inefficiency term may depend on bank-specific characteristics, so the assumption on η is that it follows a half-normal distribution $\eta \sim N^+(0, \sigma^2_{\eta,i})$, and the variance of η is modeled. The variance of technical inefficiency is modeled as in equation (16).

$$\sigma^2_{\eta,i} = \exp(\mathbf{z}_{it}\delta) \tag{16}$$

The bank-specific characteristics used to model the inefficiency term are the natural logarithm of size or total assets (z_1) ; credit risk (z_2), measured as the percentage of risky loans[16] to total loans; liquidity (z_3) and capitalization (z_4), as defined previously; and a time trend to allow time effects on the efficiency estimates.[17]

The estimated measure of inefficiency for each bank in each time period is given by equation (17). Then, this measure of inefficiency can only take positive values equal to or higher than one, so that when $E_{it} = 1$ all deviations from the optimal cost functions are due to random error, and when $E_{it} > 1$, deviations are due in part to random errors but also to inefficiency of the bank, conditional on outputs and inputs prices. The measure $TE_{it} = 1/E_{it}$ is bounded between 0 and 1 and can be interpreted as the percentage of actual costs that equal optimal costs, so the higher TE, the more cost efficient is the bank.

$$E_{it} = E[\exp(v_{it})|v_{it} + \eta_{it}] \tag{17}$$

Finally, the estimation of equation (15) is used to calculate returns to scale (RTS) for each bank at each point in time and a Lerner Index to proxy market power. The measure of RTS is the reciprocal of cost elasticity with respect to output, which is, in turn, the derivative of equation (15) with respect to y (Kumbhakar et al., 2015). On the other hand, the Lerner Index is measured as in equation 18, where the price of loans P^{loans} is measured as interest income from loans over total loans, and the marginal cost of loans MC^{loans} is measured as in equation (19), where EC^y_{it} is total cost elasticity for loans (from the stochastic frontier estimation).

$$L^{loans}_{it} = \frac{P^{loans}_{it} - MC^{loans}_{it}}{P^{loans}_{it}} \tag{18}$$

$$MC^{loans}_{it} = \frac{C^a_{it}}{y_{it}} EC^y_{it} \tag{19}$$

[16]Risky loans are those reported to the SFC classified as loans with appreciable risk, significant risk, and risk of un-collectibility .

[17]It is worth noting that market risk exposure (the ratio of securities to total assets) is not included because it is highly correlated with credit risk, and the importance of foreign ownership to model bank efficiency was tested, but this variable was not significant.

7.3. Monetary Policy Transmission

The empirical approach to analyzing if bank-specific characteristics affect the way monetary policy is transmitted through the allocation of loans is a dynamic panel model. This methodology considers the seminal work of Kashyap & Stein (1995) and the work of Jonas & King (2008), which use time series analysis. Furthermore, given that the data used for Colombia has a small number of individuals but considerably long time-series, the approach is a long panel data, like Gómez-González & Grosz (2007) does.

Therefore, this study models the growth-rate of loans disbursements, y_{it} (specifically disbursements of consumer loans, commercial loans and micro-credits), with changes in the TIB rate, Δr_t, and the interaction of bank specific characteristics lagged one period (B_{it-1}) with changes in the TIB rate, to evaluate if the transmission mechanism of the shock is not direct but may be heterogeneously transmitted because of these characteristics. Also, the model includes dummies for each quarter to control for seasonality Q^j (omitting the dummy for the first quarter), a lagged dummy to control for mergers and acquisitions, MA, that takes the value of 1 if the bank merged or acquired another bank, and a dummy that takes the value of 1 on January 2011, Tax, to account for the Tax Reform that was implemented on this date. As macroeconomic variables to control for demand effects, inflation, π is included and the growth of the Industrial Production Index, IPI, to proxy GDP growth (which is only available in quarterly data).

All non-stationary variables are included in differences and the natural logarithm of disbursements is used to smooth variance. Also, 5 lags of the endogenous variable were included after analyzing the autocorrelation behavior of the variable, and 6 lags of Δr_t and the IPI growth were also included, considering this is a good time-frame to account for lags in the decision making process of banks, avoiding over-identification of the model and considering the transmission of monetary policy, that at least through the interest rate channel, may take up to 8 months (Gómez et al., 2016).

As bank-specific characteristics, 7 different measures are considered. These variables are technical efficiency, measured by the SFA approach presented in section 7.2), two balance-sheet indicators of efficiency (financial efficiency and operational efficiency), liquidity, capitalization, returns to scale, and the Lerner Index for the loans market, to account for market power.

Therefore, the proposed model is estimated as in equation 20 with a robust fixed effects estimation. Given that the estimated panel is a long panel, the Nickel Bias that is generated by the presence of the endogenous variables is reduced and the fixed effects estimation is consistent (Nickell, 1981). [18]

$$\begin{aligned}\Delta \ln y_{i,t} = \beta_0 &+ \sum_{j=1}^{5} \beta_{1,j} \Delta \ln y_{i,t-j} + \sum_{j=1}^{6} \beta_{2,j} \Delta r_{t-j} + \sum_{j=1}^{6} \beta_{3,j} (B_{i,t-1} * \Delta r_{t-j}) \\ &+ \beta_4 \pi_t + \sum_{j=1}^{6} \beta_{5,j} \Delta \ln IPI_{t-j} + \beta_5 MA_{i,t-1} + \beta_6 Tax_t \\ &+ \sum_{j=2}^{4} \beta_{7,j} Q_t^j + \epsilon_{it}\end{aligned} \tag{20}$$

Finally, it is worth explaining two differences between my methodological approach and previous literature.

First, although studies such as Gómez-González & Grosz (2007), Kashyap & Stein (1995), Kashyap & Stein (2000) and Jonas & King (2008) take the growth rate of loans in the bank's balance sheet as the dependent variable, this study is focused on disbursements, because growth rate of loans is not only affected by supply and demand for loans at certain moments in time, but it may also be affected by different events, such as payments of previously issued loans and portfolio purchases. Since the bank-lending channel is defined as a change in loans supply, disbursements could approximate better the equilibrium quantity of the loans market. Additionally, as a robustness test, the proposed methodology (with both a dynamic and non-dynamic approach) was also implemented for data on the growth rate of total loans, commercial loans, consumer loans and micro-credits (total, net of provisions and ordinary, which are strictly funded with bank's resources), in the same time-frame. There was not a statistically significant relationship between the growth rate of loans in the bank's balance-sheet and movements in the Interbank rate. These results are available upon request.

Second, the literature has studied the bank lending channel modeling the

[18] As a robustness test, the dynamic model was also estimated using the Arellano-Bond model for dynamic panels, although it is not recommended for long panels (Lillo & Torrecillas, 2018).

growth rate of loans through both dynamic models (i.e. (Kashyap & Stein, 2000)) and models without dynamic components of the endogenous variable. Gómez-González & Grosz (2007) argue that there is not a clear reason to believe the growth rate of loans may depend on previous values of this variable, unless it does because of demand dynamics, but they argue that these dynamics should be captured by macroeconomic controls and its lags. This study models disbursements using a dynamic panel, after testing if the endogenous variable presents an autocorrelation behavior, and because it is possible that there is some *inertia* in the loans market. There is evidence that the lags of the endogenous variable are statistically significant up to the fifth lag and the fit of the model is substantially better than estimating it without including dynamics of the endogenous model.

8. Results

8.1. Bank Heterogeneity and Efficiency

This study estimates a stochastic frontier for bank's total costs in Colombia, from 2002 to 2014, following the estimation methodology explained in section 7.2, and using Stata's Frontier command (Stata, 2013). The results of this estimation are presented in table 3. This study finds statistically significant evidence of technical inefficiency in Colombia's banking sector, and furthermore, this inefficiency is dependable on bank-specific characteristics.

To analyze the results presented in table 3, consider that the elasticity of total costs to output cannot be analyzed by looking directly at the estimated coefficients of the frontier regression. Because there are interaction terms, these elasticities will be dependable on other variables, so they will depend on bank and time specific data. On the other hand, it is possible to conclude from the estimation results that the cost frontier exhibits a time trend. The coefficient of t is negative, so there is evidence of a reduction of costs over time, but the positive coefficient on the quadratic term of the time trend indicates that this reduction is not linear and may be lower through time (although interactions of t with ot her variables should be analyzed more closely for a definite interpretation too).

Furthermore, the bank-specific characteristics used to model the heteroscedastic variance of the inefficiency term, are all statistically significant. Thus, size, liquidity levels, capitalization and credit risk are important determi-

nants of bank's cost efficiency, and failing to account for this heterogeneity could result in biased estimators of technical efficiency. The sign of these variables and the time trend that was included can be interpreted directly. Size, liquidity, and capitalization are related to higher technical efficiency, whereas higher credit risk (having higher proportions of risky loans) is related to lower cost efficiency.

Table 3. Stochastic Frontier Estimation

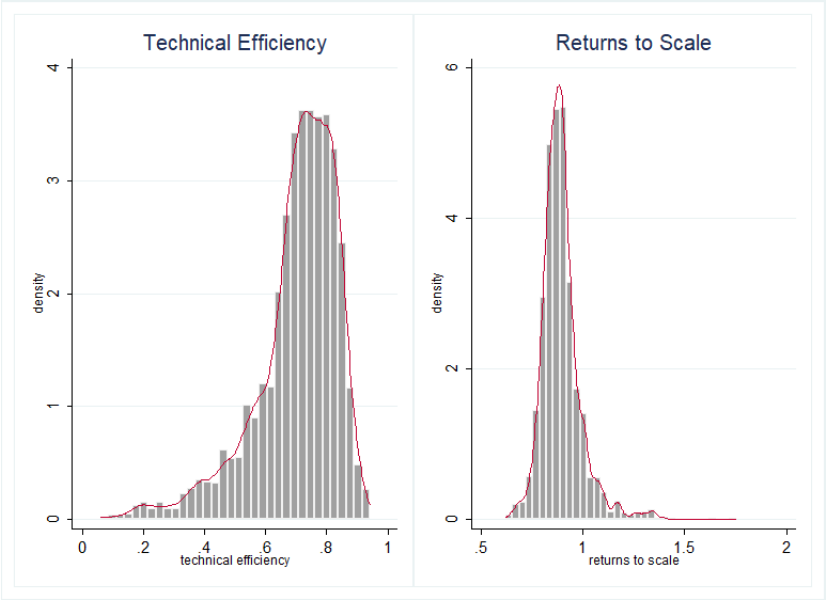
$\ln(C^a/w_3)$	Coeff.	z	σ	Coeff.	z
$\ln y_1$	1.478**	(2.29)	$\ln \sigma_v^2$	-2.478***	(-41.97)
$\ln y_2$	-0.830*	(-1.79)	$\ln \sigma_u^2$		
$\ln y_3$	1.677***	(3.14)	z_1 size	1.90e-11***	(4.88)
$(\ln y_1)^2$	0.0249	(0.85)	z_2 credit risk	-5.131***	(-5.19)
$(\ln y_2)^2$	0.0547***	(3.57)	z_3 liquidity	1.943***	(5.49)
$(\ln y_3)^2$	0.126***	(5.61)	z_4 capitalization	5.649***	(7.40)
$\ln w_1/w_3$	-0.245	(-0.29)	t	-0.132***	(-7.87)
$\ln w_2/w_3$	2.641***	(3.36)	Constant	-1.876***	(-8.23)
$(\ln w_1/w_3)^2$	-0.124**	(-2.02)			
$(\ln w_2/w_3)^2$	-0.0872*	(-1.86)			
$\ln y_1 \ln y_2$	-0.0204	(-0.92)			
$\ln y_1 \ln y_3$	-0.103***	(-4.14)			
$\ln y_2 \ln y_3$	0.0529***	(2.58)			
$\ln(w_1/w_3) \ln(w_2/w_3)$	0.117**	(2.46)			
$\ln y_1 \ln(w_1/w_3)$	0.142***	(3.70)			
$\ln y_1 \ln(w_2/w_3)$	-0.0711**	(-2.23)			
$\ln y_2 \ln(w_1/w_3)$	-0.169***	(-6.31)			
$\ln y_2 \ln(w_2/w_3)$	0.0154	(0.62)			
$\ln y_3 \ln(w_1/w_3)$	0.166***	(4.78)			
$\ln y_3 \ln(w_2/w_3)$	0.0207	(0.63)			
t	-0.475***	(-4.21)			
t^2	0.0102***	(5.77)			
$\ln y_1 t$	0.0411***	(7.69)			
$\ln y_2 t$	-0.0503***	(-14.23)			
$\ln y_3 t$	0.0294***	(6.55)			
$\ln(w_1/w_3)t$	-0.0298***	(-4.00)			
$\ln(w_2/w_3)t$	0.0470***	(7.27)			
Constant	-10.48	(-1.36)			
N = 3,085	Log likelihood	= -1,541.4167			

Note: z statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table presents the estimated coefficients (and the z statistics, of the (costs) Stochastic Frontier estimation, as proposed in equation 15. It also shows the results of the estimation of the technical inefficiency variance (which is assumed to be heteroscedastic, with the variance function depending on a linear combination of bank-specific characteristics), using the FRONTIER command in Stata (Stata, 2013).

Also, as explained in section 7.2, this study estimates technical (cost) efficiency after estimating the stochastic cost frontier for banks, and with the coefficients of the cost function, returns to scale (RTS) were also estimated. Figure 9 presents the empirical distribution of all estimated values of technical efficiency and RTS (for each bank in each period of time), using

a histogram and a Kernel density plot. First, technical efficiency is skewed to the right, and RTS are skewed to the left, although the first presents higher heterogeneity. The mean technical efficiency estimation is 70.13% and 50% of the observations fall between 64.9% and 79.9%. This result is aligned with previous findings in the literature (Almanza-Ramírez, 2012; Fernández & Estrada, 2013; Sarmiento et al., 2014), and can be intuitively interpreted, as if the average bank could have produced the same output, using 70.1% of its costs, if it had no inefficiencies. Additionally, average RTS is 0.89 and half of the observations fall between 0.84 and 0.93, indicating that there are few banks that show increasing returns to scale. In general, Colombia's bank cost structure shows evidence of decreasing returns to scale.

Figure 9. Distribution of Technical Efficiency and Returns to Scale



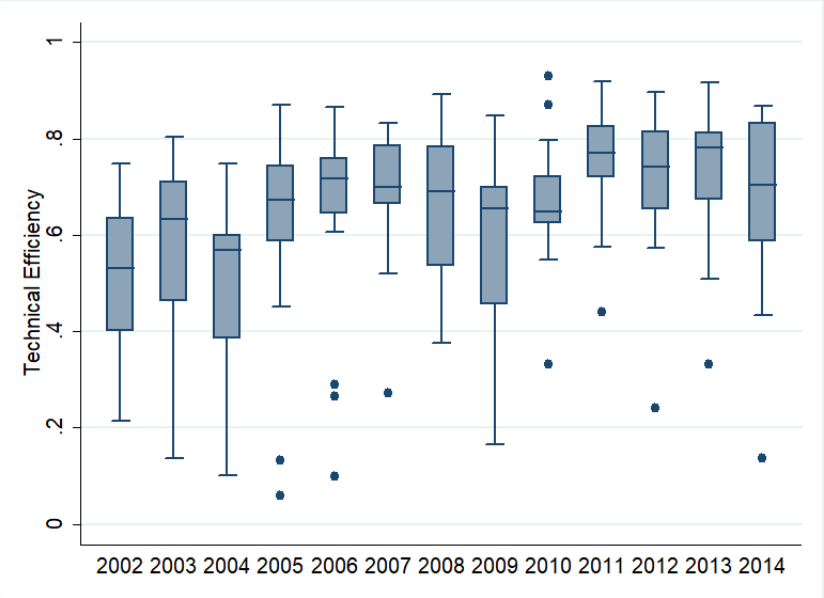
Note: This graph plots the histogram (grey) and Kernel distribution (red) of the estimated Technical Efficiency and the Returns to Scale values for all banks in the sample.

Source: Author's calculation.

Looking at the evolution of the estimated technical efficiency over time, figure 10 shows a slightly increasing trend of technical efficiency, although it also evidences high heterogeneity among banks. This graph suggests that the period from 2005 to 2007, which was characterized by several events of mergers and acquisitions in the industry, was a generally positive one for banks, regarding cost efficiency. Also, in 2008 and 2009 there was a fall in

cost efficiency and increased heterogeneity, that could be linked to the spill-over effects of the world crisis in Colombia's banking sector. From 2010 to 2014, technical efficiency slightly increased and showed a small positive trend.

Figure 10. Evolution of Technical Efficiency



Note: This figure shows the evolution of technical efficiency over time. The figure plots the estimated values of technical efficiency for each December, from 2002 to 2014. The dots in the graph represent outliers, the limits of the boxes represent the upper and lower quartile values (excluding outliers), and the line across the box is the median. The limits of the *whiskers* are the maximum and minimum values, excluding outliers.

Source: Author's calculation.

Furthermore, this study estimates other sources of bank heterogeneity, besides technical efficiency and RTS. I also estimate a Lerner Index to approximate market power of banks in the loans market, using the estimation of the cost function to calculate marginal costs of loans. Also, balance-sheet data was used to calculate capitalization, liquidity, operational efficiency and financial efficiency ratios, which are some of the variables usually considered by analysts to evaluate the performance of the banking sector. All of these variables are time and bank-specific, so the mean value of each variable is presented, for each bank in the sample, in table 4.

Table 4. Bank Heterogeneity

	Technical Efficiency	Returns to Scale	Lerner Index	Capitalization	Liquidity	Financial Efficiency	Operational Efficiency
Big							
Bancolombia	0.66	0.886	0.8	0.145	0.284	0.727	0.0192
Banco de Bogotá	0.591	0.866	0.75	0.147	0.34	0.486	0.0158
Davivienda	0.699	0.886	0.833	0.119	0.272	0.723	0.0171
BBVA Colombia	0.757	0.847	0.839	0.093	0.297	0.724	0.016
Banco de Occidente	0.72	0.856	0.816	0.129	0.338	0.568	0.0119
Banagrario	0.714	0.99	0.875	0.077	0.54	0.507	0.008 (-)
Banco Popular	0.72	0.929	0.853	0.113	0.315	0.389 (-)	0.0103
Granbanco S.A.	0.67	0.87	0.831	0.117	0.468	0.554	0.0108
Banco Cafetero	0.775	0.865	0.814	0.038(-)	0.547	0.719	0.0139
Colpatria Red Multibanca	0.781	0.903	0.871	0.094	0.2	0.66	0.0152
Banco Corpbanca	0.747	0.851	0.762	0.11	0.322	0.808	0.0233
Medium							
Citibank	0.602	0.849	0.74	0.159	0.323	0.776	0.033
Helm Bank	0.71	0.846	0.738	0.124	0.247	0.507	0.0167
Banco Caja Social S.A.	0.658	0.891	0.896	0.106	0.255	0.722	0.015
Sudameris Colombia	0.775	0.817	0.841	0.077	0.447	0.501	0.0114
AV Villas	0.715	0.828	0.86	0.112	0.313	0.637	0.0122
Conavi Banco Comercial S.A.	0.722	0.91	0.85	0.09	0.33	0.665	0.016
Banco Granahorrar S.A.	0.722	0.883	0.83	0.106	0.337	0.583	0.0133
Banco Colmena S.A	0.75	0.924	0.838	0.066	0.372	0.713	0.0152
Megabanco S.A.	0.471 (-)	0.907	0.83	0.058	0.253	0.402	0.0134
Bancoomeva	0.825	1.068	0.883	0.082	0.111	0.781	0.0156
Banco Pichincha S.A.	0.811	0.932	0.85	0.133	0.154	0.643	0.0142
Small							
Anglo Colombiano	0.779	0.906	0.839	0.099	0.268	0.844	0.0202
Bansuperior	0.676	0.871	0.9 (+)	0.143	0.189	0.653	0.0243
Tequendama S.A.	0.735	1.012	0.778	0.106	0.165	0.752	0.0456
Finandina	0.841 (+)	1.279 (+)	0.818	0.144	0.106	0.725	0.0155
Banco Falabella S.A.	0.787	0.922	0.875	0.198	0.074	0.734	0.0226
Bancamía	0.67	1.041	0.895	0.26	0.088	0.705	0.0232
Unión Colombiano	0.667	0.813	0.791	0.114	0.233	0.486	0.0182
Banco W S.A.	0.735	0.962	0.888	0.48 (+)	0.049 (-)	0.726	0.0206
Banco Aliadas S.A.	0.684	0.978	0.858	0.121	0.143	0.664	0.0274
Scotiabank	0.494	0.741 (-)	-0.814 (-)	0.194	0.668 (+)	0.921	0.0606 (+)
Bankboston S.A.	0.735	0.914	0.787	0.217	0.254	0.894	0.0488
Procredit Colombia	0.686	1.1	0.855	0.243	0.18	1.027 (+)	0.0209
Total	0.701	0.894	0.769	0.127	0.307	0.664	0.0193

Note: The symbols (-) and (+) denote the minimum and maximum value of each column. This table shows the average value of each variable for each bank in the sample, and banks are divided into groups according to their average asset size. Technical Efficiency, Returns to Scale and the Lerner Index, were estimated using the results of the Stochastic Frontier Analysis, while Capitalization, Liquidity, Financial Efficiency and Operational Efficiency are balance-sheet ratios. Also, while higher values of Technical Efficiency indicate more efficiency, higher values of Financial Efficiency and Operational Efficiency are indicators of higher inefficiency, but they are defined as such because they are commonly used ratios.

From table 4, *Finandina*, a small bank (in the lowest quartile of asset size), shows the highest average technical efficiency, and it is not only one of the few banks in the sample that exhibit increasing returns to scale (1.279), but the one with the highest value estimated. On the other hand, a mid-size bank, *Megabanco*, is the bank with the lower mean technical efficiency and it does not exhibit increasing returns to scale. The bank with the most decreasing returns to scale is *Scotiabank*. Additionally, the average Lerner Index was 0.769, which shows evidence of high market power of banks in the loans market. The biggest banks show average values of the Lerner Index close to or higher than the average value of the whole sample, but small banks show the highest values, probably because many of them are con-

centrated in the consumer segment, where clients have less market power.

Regarding the balance-sheet ratios, capitalization is on average 12.7% and liquidity is 30.7%, but there is great heterogeneity among banks. The less capitalized bank was *Banco Cafetero*, a public bank, while the most capitalized bank is *Procredit Colombia*, a foreign entity. Regarding liquidity, *Scotiabank* was the most liquid bank (67% of their assets where liquid assets), and the less liquid is *Banco W S.A.*, a local establishment that began operations in 2011. Big banks show higher mean values of liquidity compared to the others, but small banks are the most capitalized, in general.

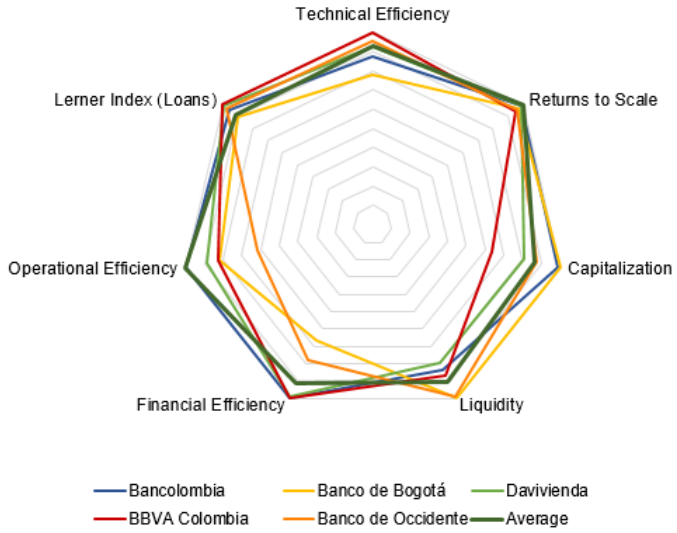
Also, financial efficiency is a commonly analyzed balance-sheet ratio that is used to assess the efficient use of resources, because it shows the relationship of operating expenses (net of interests) to total income. The average financial efficiency ratio is 66%, the minimum is that of *Banco Popular* (39%). Also, the operational efficiency ratio shows the ratio of operating expenses to total assets, so it should also be understood that a higher ratio shows evidence of inefficiency in the use of resources[19]. Because operational expenses are monthly, and assets are a stock, this ratio seems small. Anyway, the average operational efficiency ratio is 1.93%. Also, although the technical, operational and financial efficiency measures give information on banks' inefficiency, technical efficiency considers the whole cost structure of the company, whereas balance-sheet ratios may miss relevant information.

Finally, figure 11 shows the average heterogeneity measures for the complete sample (average) and the five biggest banks, (normalized so that they could be compared in the same graph). Regarding technical efficiency, only 2 banks are above the average and all of them are below the average in RTS (they all show decreasing returns to scale). Also, the two biggest banks are more capitalized than the average, and there is less heterogeneity considering liquidity (all of them are close to the average). Regarding the balance-sheet measures of efficiency, all the five biggest banks show operational efficiency measures below the average, showing a smaller ratio of expenses to assets, although three banks are above the average financial efficiency ratio (are less efficient). Last, four banks show an average Lerner index in the loans market greater than the average, and the other one, *Banco de Bo-*

[19]It should be clear that a bank is more efficient, showing a better relationship of costs to income and costs to assets, when the financial efficiency ratio and the operational efficiency ratio are lower. In contrast, the technical efficiency measure says a bank is more efficient when the measure is higher.

gotá, is close to the average. This evidence suggests market power is greater for the biggest banks.

Figure 11. Comparison of heterogeneity measures



Note: The values of the heterogeneity variables presented in this graph were standardized using the maximum value of each, to make comparison easier. Higher values of technical efficiency indicate a bank is more efficient, meanwhile higher values of the ratios known as operational and financial efficiency, indicate a bank is more inefficient. Higher values of the Lerner index indicate higher market power, and RTS, capitalization and liquidity are interpreted directly.

Source: Author's calculation.

8.2. Monetary Policy Transmission

The main objective of this study is to assess if there is evidence of a bank-lending channel, where a monetary policy shock impacts loan supply, and to evaluate if this mechanism is not direct and homogeneous for banks, but heterogeneously determined on bank-specific characteristics. In order to do this, equation 20 was estimated using a robust fixed effects estimation[20], and independent estimations were done for *total* disbursements

[20]Considering there could be questions regarding the significance of a Nickel Bias in the estimation because of the presence of endogenous variables, the model was also estimated using the Arellano-Bond method. Over-identification and autocorrelation in the error term were tested using the Sargent and Arellano-Bond tests, accordingly. Results are consistent between the two approaches so the fixed effects results are presented, con-

(the sum of commercial, consumer, and micro-credits), Commercial and Consumer disbursements, Commercial disbursements and Consumer disbursements. First, the model was estimated without heterogeneous effects to test if there was evidence of a (direct) bank-lending channel. Then, interaction terms were added with each heterogeneity variable independently, to see if the transmission mechanism was indirectly determined by these characteristics.

The methodology followed in this study has an identification issue that should be addressed better in further studies. Loans disbursements may be considered an approximation of the equilibrium quantity of loans demand and supply, but it is not possible to observe supply of loans directly. Macroeconomic controls are added to control for demand shocks in the loans market, so this study considers these results as suggesting supply movements.

Table 5 shows the estimation results for the growth rate of total, consumer and commercial disbursements (together and individually), considering the lag of the estimated technical efficiency measure as the heterogeneity variable in the interaction term. The estimation results of the model estimated without heterogeneity and considering RTS, the Lerner Index, capitalization, liquidity, operational efficiency and financial efficiency as heterogeneity variables in the interaction term, can be found in Annex B.

Also, table 6 shows the *total effect* of a change in the TIB rate, and the coefficient preceding the heterogeneity variable. These effects are the sum of the coefficients of the change in the TIB rate and the sum of the coefficients of the interaction term, considering only the ones that are statistically significant at levels of at least 1%, 5%, and 10%. Additionally, table 7 shows the estimated total effect, at a 10% level of confidence, of a shock to the TIB rate on the growth rate of loans for the *average bank* (considering the average value of the heterogeneity variable).

The estimations without heterogeneity show evidences of the existence of a bank-lending channel in Colombia, particularly through Commercial loans. The estimated total effect of a shock in the TIB rate is negative (at a 10% level) when there is no heterogeneity included (see tables 6 and 7). The results indicate the growth rate of total disbursement would fall 3.26 percentage points after a 1 percentage point increase in the TIB rate (after

sidering this is a long panel (Lillo & Torrecillas, 2018).

controlling for macroeconomic effects). Lags of changes in the TIB rate are statistically significant to explain the growth rate of disbursements in subsequent periods, with closer lags having less explanatory power (see table 9 in Annex B). This shows that a shock in the TIB rate generated by a monetary policy shock, will affect disbursements in subsequent periods (after 2 or 3 months).

Table 5. Technical Efficiency

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.566***	(-14.97)	-0.564***	(-15.78)	-0.568***	(-16.79)	-0.402***	(-7.90)
$\Delta \ln y_{t-2}$	-0.422***	(-10.06)	-0.406***	(-10.08)	-0.407***	(-10.80)	-0.293***	(-6.96)
$\Delta \ln y_{t-3}$	-0.196***	(-4.07)	-0.192***	(-4.27)	-0.196***	(-4.78)	-0.106**	(-2.32)
$\Delta \ln y_{t-4}$	-0.191***	(-5.87)	-0.181***	(-5.91)	-0.169***	(-5.28)	-0.202***	(-4.43)
$\Delta \ln y_{t-5}$	-0.155***	(-5.78)	-0.145***	(-5.69)	-0.154***	(-4.95)	-0.109***	(-3.66)
Δr_{t-1}	-3.055	(-0.24)	-2.19	(-0.17)	2.977	(-0.22)	8.894	(1.35)
Δr_{t-2}	19.41	(-1.67)	18.29	(-1.56)	16.81	(-1.47)	13.98	(1.03)
Δr_{t-3}	29.66***	(-3.89)	30.30***	(-3.88)	32.76***	(-3.54)	23.49***	(3.22)
Δr_{t-4}	-7.253	(-1.20)	-9.887	(-1.40)	-10.68	(-1.18)	-10.55	(-1.35)
Δr_{t-5}	20.69**	(-2.46)	20.16**	(-2.4)	23.22**	(-2.6)	5.246	(0.50)
Δr_{t-6}	-18.51**	(-2.64)	-21.14**	(-2.68)	-21.31**	(-2.56)	-24.61**	(-2.08)
$Tech.Eff._{t-1} * \Delta r_{t-1}$	6.618	(-0.38)	6.148	(-0.34)	-1.479	(-0.08)	-4.411	(-0.47)
$Tech.Eff._{t-1} * \Delta r_{t-2}$	-33.12**	(-2.06)	-32.11*	(-1.98)	-31.19*	(-1.88)	-22.07	(-1.15)
$Tech.Eff._{t-1} * \Delta r_{t-3}$	-32.59***	(-2.99)	-33.50***	(-3.01)	-39.03***	(-2.86)	-19.32*	(-1.93)
$Tech.Eff._{t-1} * \Delta r_{t-4}$	-1.456	(-0.16)	1.832	(-0.18)	3.662	(-0.28)	-5.668	(-0.49)
$Tech.Eff._{t-1} * \Delta r_{t-5}$	-15.42	(-1.34)	-14.7	(-1.28)	-14.32	(-1.21)	2.246	(0.15)
$Tech.Eff._{t-1} * \Delta r_{t-6}$	14.87	(-1.48)	18.47	(-1.63)	19.72	(-1.65)	23.37	(1.41)
π	8.241***	(-3.92)	8.531***	(-3.77)	9.602***	(-4.56)	2.639	(1.16)
$\Delta \ln IPI_{t-1}$	-1.245***	(-7.08)	-1.199***	(-6.74)	-1.238***	(-5.46)	-1.819***	(-9.92)
$\Delta \ln IPI_{t-2}$	-2.090***	(-8.02)	-2.144***	(-8.21)	-2.145***	(-6.90)	-2.740***	(-11.86)
$\Delta \ln IPI_{t-3}$	-0.977***	(-5.17)	-0.978***	(-5.20)	-0.936***	(-4.58)	-1.596***	(-8.11)
$\Delta \ln IPI_{t-4}$	-1.192***	(-10.24)	-1.229***	(-10.05)	-1.203***	(-7.53)	-1.750***	(-9.37)
$\Delta \ln IPI_{t-5}$	-0.579***	(-4.38)	-0.608***	(-4.42)	-0.513**	(-2.43)	-1.204***	(-5.75)
$\Delta \ln IPI_{t-6}$	0.00877	(-0.1)	0.00128	(-0.01)	0.104	(-0.71)	-0.158	(-1.11)
MA	0.237**	(-2.3)	0.238**	(-2.31)	0.264*	(-1.99)		
Tax	-0.609***	(-6.35)	-0.633***	(-6.85)	-0.673***	(-6.81)	-0.249***	(-3.74)
Q^2	0.328***	(-7.18)	0.329***	(-6.82)	0.364***	(-6.36)	0.284***	(8.26)
Q^3	0.360***	(-8.89)	0.366***	(-8.66)	0.398***	(-9.36)	0.358***	(11.17)
Q^4	0.440***	(-10.15)	0.443***	(-9.83)	0.507***	(-10.56)	0.371***	(10.64)
Constant	-0.278***	(-8.00)	-0.280***	(-7.58)	-0.316***	(-8.35)	-0.211***	(-7.64)
N	2,860		2,860		2,822		2,606	

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table presents the estimated coefficients (and the t statistics, of a robust fixed-effects estimation of equation 20, where B takes the values of Technical Efficiency. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Also, from table 6, with a confidence level of 1%, the sum of the coefficients of a shock in the TIB rate is negative for Commercial and Consumer disbursements, meaning that a rise in the TIB rate, reduces the growth rate of these disbursements. The growth rate of consumer and commercial disbursements would fall 1.9 percentage points each, after a 1 percentage point increase in the TIB rate. Anyway, evidence of a bank-lending channel for consumer loans is weaker (only at a 10% level). It is possible that consumer loans show a weaker sensitivity to monetary policy rate inter-

ventions, because they account for a much smaller portion of the bank's total loans, so it is easier for banks to keep stable their loanable resources available for these lines of credit. In other words, it is possible that while demand for consumer loans could be more elastic, the supply of this type of credit is more inelastic.

Table 6. Summary of Total Effects

Heterogeneity B	Type of disbursements y	Sum of coefficients of Δr $< 10\%$	$< 5\%$	$< 1\%$	Sum of coefficients of $\Delta r \times B$ $< 10\%$	$< 5\%$	$< 1\%$
No heterogeneity	Total	-3.263	0.468	0.468			
	Consumer&Commercial	-4.174	-4.174	-0.06			
	Commercial	-1.925	-1.925	2.66			
	Consumer	-1.945	0.323	0.323			
Technical Efficiency	Total	31.84	31.84	29.661	-65.706	-65.706	-32.59
	Consumer&Commercial	29.328	29.328	30.303	-65.61	-33.498	-33.498
	Commercial	34.674	34.674	32.762	-70.226	-39.032	-39.032
	Consumer	-1.125	-1.125	23.488	-19.323	0	0
Operational Efficiency	Total	-5.902	-9.003	-14.653	499.819	778.431	778.431
	Consumer&Commercial	-5.453	-8.47	-14.598	463.567	766.33	766.33
	Commercial	-4.585	-4.585	-10.607	456.786	795.754	795.754
	Consumer	-2.068	-2.068	-11.953	287.628	287.628	287.628
Δ Financial Efficiency	Total	-3.64	-0.027	-0.027	0	0	0
	Consumer&Commercial	-1.918	-0.61	-0.61	0	0	0
	Commercial	-2.461	2.265	2.265	0	0	0
	Consumer	-0.006	-0.006	-0.006	73.803	0	0
Δ Returns to Scale	Total	-3.097	-3.097	1.216	264.587	121.164	0
	Consumer&Commercial	-4.05	-4.05	-4.05	99.104	0	0
	Commercial	-1.722	-1.722	-1.672	115.771	0	0
	Consumer	-1.389	-1.389	-1.389	0	0	0
Δ Capitalization	Total	-3.212	-3.212	0.253	-437.484	-437.484	0
	Consumer&Commercial	-4.172	-4.172	-0.283	-442.964	-442.964	0
	Commercial	-1.943	-1.943	2.514	-407.752	-407.752	0
	Consumer	-0.397	-0.397	-0.397	-211.244	-498.984	0
Δ Liquidity	Total	-1.257	0.251	0.251	-121.895	-121.895	-121.895
	Consumer&Commercial	-1.593	-4.293	-0.249	-118.674	-118.674	0
	Commercial	-1.995	-1.995	2.604	-124.942	-124.942	-124.942
	Consumer	-0.573	-0.573	-0.573	-79.269	0	0
Lerner Index	Total	-0.81	-0.81	-0.81	-2.367	-2.367	-2.367
	Consumer&Commercial	-1.463	-1.463	-1.463	-2.14	-2.14	-2.14
	Commercial	-2.662	-2.662	-2.662	-0.02	-0.02	3.173
	Consumer	33.231	33.231	33.231	-33.299	-33.299	-33.299

Note: Total effects are the sum of the coefficients of the lagged variable and interactions if they are statistically significant at least at a 10%, 5% or 1% level. These coefficients represent the effect of increasing r in one unit (for example from 0.05 to 1.05), so if one wants to analyze the effect of increasing the TIB in 1 percentage point (from 0.05 to 0.06), which is more aligned with a monetary policy shock, these coefficients must be read as percentage points over the growth rate of disbursements (for example a coefficient of -3.2 means -3.2 percentage points).

Introducing the interaction of changes in the TIB rate with heterogeneous characteristics of banks, there is evidence suggesting the transmission of monetary policy depends on these characteristics, as can be seen

in table 6. There is evidence suggesting efficiency (measured as technical efficiency and operational efficiency), market power (measured with the Lerner index) and liquidity are important determinants of the speed and power of the bank-lending channel. Although there is also evidence that capitalization and returns to scale are determinants of the transmission mechanism, there is almost none for financial efficiency.

Table 7. Total Effect on the Average Bank

Heterogeneity B		Type of disbursements y			
Variable name	Mean	Total	Consumer&Commercial	Commercial	Consumer
No Heterogeneity	NA	-3.263	-4.174	-1.925	-1.945
Technical Efficiency	0.7013	-14.241	-16.685	-14.577	-14.677
Operational Efficiency	0.01928	3.736	3.486	4.223	3.479
Δ Financial Efficiency	0.000315	-3.64	-1.918	-2.461	0.018
Δ Returns to Scale	-0.000119	-3.128	-4.062	-1.736	-1.389
Δ Capitalization	0.000057	-3.237	-4.197	-1.967	-0.409
Δ Liquidity	0.000103	-1.269	-1.606	-2.007	-0.581
Lerner Index	0.76871	-2.629	-3.107	-2.677	7.633

Note: To calculate the total effect of a monetary policy shock on *the average bank*, this study considers the total effects at a 10% level, presented on table 6, and the mean of the heterogeneity variable, for each type of disbursements. *Total disbursements* are the sum of Consumer, Commercial and Micro-credit disbursements.

The total effect of technical efficiency on the sensitivity of disbursements to shocks in the TIB rate is negative, as expected from the theoretical model presented in subsection 7.1. This effect is consistent for all types of disbursements, although it is significantly weaker for consumer disbursements. These results suggest that when cost-efficiency increases, the response of disbursements to an increase in the TIB rate is more negative (the reaction is greater or faster). Additionally, monetary policy may significantly lose its power to impact the lending market through banks when they are highly inefficient, considering the direct effect of the shock is positive (after controlling for technical efficiency) and lower (in absolute value) than the indirect shock.

The efficiency of the average bank is 70.13%. For this bank, a 1 percentage point increase in the TIB rate would reduce the growth rate of total disbursements 14.2 percentage points and of commercial disbursements 14.5 percentage points. Moreover, from table 5, the only statistically significant coefficients of Δr were the third, fifth and sixth lags, and the second and third lag for the interaction terms. This suggests that technical efficiency affects the transmission mechanism through the decision-making process of corporate governance, that may be broadly defined on a quarterly basis.

The three biggest banks in Colombia, which also had the highest market shares in the loans market as of 2014, show lower levels of technical efficiency than the average bank, so the power of monetary policy transmitted through the bank lending channel may be significantly affected.

Regarding the balance-sheet measures of efficiency, operational and financial efficiency, the results of the first variable are consistent with the technical efficiency results, but financial efficiency is generally not significant. Operational efficiency, which is the ratio of total operating expenses to total assets, must be interpreted as an inefficiency measure (higher values indicate higher inefficiency). Then, the results suggest that more inefficient banks will react less or slower to an increase in the interbank rate than efficient banks, for all types of disbursements. Also, the effect is smaller for consumer loans than it is for total or commercial loans. The average bank shows an operational efficiency ratio of 0.019, and the total effect of a shock to the interbank rate is positive for all types of disbursements (see table 7). Lower levels of this measure would increase the power of the transmission mechanism.

The financial efficiency ratio, which is the ratio of non-interest operating expenses over total income, does not explain heterogeneous reactions to monetary policy shocks[21]. This shows that this balance-sheet measure of efficiency does not consider the cost structure of the organization and does not seem to determine decisions regarding the supply of loans. This measure leaves out information that is relevant to the decision-making process of banks. The technical efficiency measures from the Stochastic Frontier Analysis, consider various dimensions that cannot be included using balance sheet ratios.

Returns to scale was also included in differences because it was not stationary in levels. The interaction coefficients with this variable are significant for total, consumer and commercial, and commercial disbursements at a 10% level and only for the first lag. The total effect is positive, meaning that higher returns to scale reduces or slows the reaction of disbursements to monetary policy in the subsequent months after the shock. The sensitivity of disbursements of consumer loans to monetary policy shocks is not affected by the level of returns to scale. These results make sense considering that if there is an increase in the TIB rate, the growth rate of total

[21]The financial efficiency variable had to be included in differences because it was not stationary in levels.

disbursements falls (because the direct effect of the monetary policy shock is negative for all types of credit), but the fall is slower for bank's whose costs are reduced by increasing their total loans, although consumer loans are not heterogeneously affected. Bank's with increasing returns to scale should have fewer incentives to reduce loan supply even if they see an increase in the cost of loanable resources if total costs are reduced. Because consumer loans are such a smaller portion of total loans, their supply may be less sensitive to different levels of RTS.

Regarding heterogeneity due to capitalization and liquidity, the results are different to what has been found in the literature for Colombia (Gómez-González & Grosz, 2007). Higher capitalization and higher liquidity impact disbursements growth rate negatively after a positive monetary policy shock, for all types of credit. Results suggest that more capitalized and liquid banks will react faster to changes in the TIB rate, although it was expected for these banks to react slower since capitalization and liquidity would let them replace loanable funds after the shock. This result is worth exploring more closely in further studies. The coefficients for the interaction with liquidity are only significant in the first lag, and for capitalization in the fifth and fourth lag, showing that capitalization is a determinant for the effect of changes in further changes of the TIB rate, but liquidity determines the effect of short-term monetary policy shocks. Anyhow, the total effect for the average bank, after accounting for the indirect effect of capitalization and liquidity, is still negative (the bank-lending channel is present).

Evidence of heterogeneous transmission of monetary policy due to market power, measured with the Lerner index, is rather interesting. This variable is statistically significant at a 1% level for all types of disbursements. The total effect on the growth rate of disbursements after a positive monetary policy shock, for the average bank, is negative for total and commercial loans, but it is positive for consumer loans (see table 7). These results suggest that banks with higher market power reduce the growth rate of disbursements after an increase in the interbank rate, faster than banks with less market power. Although previous literature suggested the effect would be opposite ((Baglioni, 2007), (Brissimis & Delis, 2010)), there could be an intuitive reason. Consider a contractionary monetary policy shock, if the policy rate rises, intermediation costs also rise and banks loanable resources become costlier, so banks that have greater market power will have incentives to impact their supply of loans faster without affecting their market share. On the other hand, if there is an expansionary policy, the cost of funding falls, and then, although they would have incentives to increase

their loans supply, they could be willing to take advantage of their market power keeping higher intermediation spreads. Thus, there could be a heterogeneous response to contractionary and expansionary policies that we are not observing, related banks' market power. This should be studied in further research.

Finally, considering policy implications of these results, the main conclusion that could be drawn from this study, is that the Central Bank should evaluate how banking regulation may affect cost structures. As there is evidence that higher efficiency in the banking sector increases the power of transmission of monetary policy, it is desirable to design regulations that reduce administrative costs and that promote healthy levels of liquidity and capitalization, while carefully limiting or monitoring bank's credit exposure. Also, it should be considered that Colombia's regulation is somewhat lagging in relationship to technology advancements and innovations in the capitals markets and the financial industry, which could negatively affect banks' efficiency in the future. Furthermore, the preliminary results on market power indicate regulation in this matter should consider its effects on total surplus, but it seems that higher market power may increase the power of monetary policy. This last result should definitely be studied more closely.

9. Conclusions

This study evaluates the existence of a bank-lending channel of monetary policy in Colombia and finds evidence that this transmission mechanism exists and is heterogeneous, depending on bank-specific characteristics. To analyze this, this study uses monthly balance-sheet data reported to the Financial Supervisor in Colombia, SFC (*Superintendencia Financiera de Colombia*), for banks from 2002 to 2014. The methodology followed consists, broadly speaking, of two steps. First, the estimation of different bank-specific characteristics and then, the evaluation of the presence of a bank-lending channel, and its dependence on these characteristics.

In the first step, this study considers seven measures of bank heterogeneity: technical (cost) efficiency, returns to scale (RTS), the Lerner index (to proxy market power), capitalization, liquidity, operational efficiency and financial efficiency. Stochastic Frontier Analysis (SFA) is used to estimate a cost function for banks, and to estimate technical efficiency. With the estimated cost function, it was possible to estimate RTS and the marginal cost of loans,

so the Lerner index could also be estimated. Furthermore, banks' balance-sheet data is used to calculate ratios for capitalization, liquidity, operational efficiency and financial efficiency. Second, this study models the growth rate of *total* (the sum of commercial, consumer and micro-credits) disbursements, the sum of commercial and consumer disbursements, and commercial and consumer disbursements individually, using changes in the interbank overnight rate (TIB), macroeconomic and other controls, and the interaction of these bank-specific characteristics with changes in the TIB rate. The TIB rate is considered a proxy for monetary policy because it is highly correlated with the policy rate (TIP)[22].

The findings of this study are twofold. The first are related to heterogeneity in the banking sector in Colombia, and the second, to the heterogeneous transmission of monetary policy through the banking sector. Mainly, this study finds statistically significant evidence of technical inefficiency in Colombia's banks. Also, there is evidence of a bank-lending channel that is heterogeneously determined by bank efficiency. Technical efficiency, operational efficiency, market power and liquidity are important determinants of the speed and power of the transmission of monetary policy through the lending market. Although there is also evidence that capitalization and RTS are determinants of the transmission mechanism, there is almost no evidence for financial efficiency.

Technical efficiency is determined by bank-specific characteristics, and failing to account for this fact could result in biased estimators. Size (total assets), liquidity and capitalization levels, and credit risk are important determinants of banks' cost efficiency. The average measure of efficiency for Colombia's banking sector is 70.13%, a result that is aligned with previous studies (Almanza-Ramírez, 2012; Fernández & Estrada, 2013; Sarmiento et al., 2014). Furthermore, the period from 2005 to 2007, (when several events of mergers and acquisitions happened), was a period of high cost efficiency. The 2008 crisis affected banks' technical efficiency, but it increased after 2010 (where several new banks entered the industry).

Also, there is evidence that the banking sector exhibits, in general, decreasing RTS (with an average measure of 0.89). The average Lerner Index was 0.769, which shows evidence of high market power of banks in the loans market. The biggest banks show average values of the Lerner index close to or higher than the average value of the whole sample, but small banks

[22]The TIP is not used directly because it exhibits too little variation.

show the highest values, probably because many of them are concentrated in the consumer segment, where clients have less market power. Big banks show higher mean values of liquidity compared to the others, but small banks are the most capitalized, in general.

Regarding the monetary policy transmission, the estimations without heterogeneity suggest there is a bank-lending channel in Colombia, particularly through commercial loans. The estimated total effect of a shock in the TIB rate is negative. The results indicate the growth rate of total disbursements would fall 3.26 percentage points after a 1 percentage point increase in the TIB rate. The growth rate of consumer and commercial disbursements would fall 1.9 percentage points each, after a 1 percentage point increase in the TIB rate. Also, the effect of a shock in the TIB rate is not immediate, it takes at least two or three months to impact disbursements. The transmission mechanism is weaker through consumer loans, probably because they account for a much smaller portion of the bank's total loans, so it is possible that their supply is more inelastic.

Furthermore, introducing the interaction of changes in the TIB rate with bank-specific characteristics gives statistically significant evidence of heterogeneous transmission of monetary policy. The total effect of technical efficiency on the sensitivity of disbursements to shocks in the TIB rate is negative. When cost-efficiency increases, the negative response of the growth rate of disbursements to an increase in the TIB rate is faster. Additionally, monetary policy may significantly lose its power to impact the lending market through banks when they are highly inefficient, considering the direct effect of the shock is positive (after controlling for technical efficiency) and lower (in absolute value) than the indirect shock. Moreover, the three biggest banks in Colombia, which also had the highest market shares in the loans market as of 2014, show lower levels of technical efficiency than the average bank, so the power of monetary policy transmitted through the bank lending channel may be significantly affected.

Regarding the operational and financial efficiency ratios, the effects of the first are aligned with those of technical efficiency, but the second is generally not significant. These measures are simplistic and may leave out relevant information on the banks' cost structure, that is gathered by the technical efficiency measure. Financial efficiency, particularly, seems to be biased because it does not seem to determine decisions regarding the supply of loans, while the other two measures do. Analysts and policymakers should consider these flaws when taking decisions using these ratios.

RTS is significant in determining the transmission of monetary policy through both consumer and commercial loans. A higher measure of RTS reduces or slows the reaction of disbursements to monetary policy in the subsequent months after the shock. Also, regarding heterogeneity due to capitalization and liquidity, the evidence is different to what has been found in other studies for Colombia (Gómez-González & Grosz, 2007). Higher capitalization and higher liquidity impact disbursements growth rate negatively after a positive monetary policy shock, for all types of credit, meaning that more capitalized and liquid banks will react faster to changes in the TIB rate. Finally, the Lerner index, as a measure of market power, is highly significant to explain heterogeneous response of all types of disbursements. Banks with higher market power reduce the growth rate of disbursements after an increase in the interbank rate, faster than banks with less market power, contrary to what is suggested in the literature (Baglioni, 2007; Brissimis & Delis, 2010).

Considering these findings, Central Banks should evaluate how banking regulation may affect cost structures. This may affect the power of monetary policy by weakening or strengthening one of its transmission mechanisms. It will be desirable to design regulations that reduce administrative costs and that promote healthy levels of liquidity and capitalization, while carefully limiting or monitoring bank's credit exposure. Considering Colombia's regulation is lagging in regards of technological advancements and innovations in the financial industry, this could be negatively affecting power of monetary policy due to inefficiencies in the banking sector. Also, the preliminary findings on market power indicate that regulation in this matter should consider its effects on welfare, but it seems that higher market power may improve the transmission mechanism of monetary policy. This last conclusion should be tested more closely in further studies.

Finally, this study explores heterogeneous transmission of monetary policy considering bank-specific characteristics that had not been considered for the Colombian case and it is, to my knowledge, one of the few studies to consider the relationship between technical efficiency and monetary policy transmission. However, there are certain points that could be explored deeper and weaknesses that should be addressed in further studies.

Regarding the technical efficiency measure,profit efficiency should also be considered as a possible determinant for the transmission mechanism. Also, the methodology followed in this study to identify the bank-lending chan-

nel has an identification issue. Loans disbursements may be considered an approximation of the equilibrium quantity of loans demand and supply, but it is not possible to observe supply of loans directly. Furthermore, there could be endogeneity with the heterogeneity variables, and the results of the effects of the Lerner index, capitalization and liquidity deserve further analysis. To do this, it would be desirable to evaluate if there is a differentiated response to contractionary and expansive monetary policy shocks. Finally, size could also be included as a bank-specific characteristic, and an heterogeneous transmission of monetary policy through interest rates of different credit products could also be explored in further analysis.

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Annexes

A. Summary - Monetary Policy Transmission in Colombia

Table 8. Studies on Monetary Policy Transmission in Colombia

Cite	Transmission Mechanism	Hypothesis	Period	Results
Amaya (2005)	Credit Channel (Interest rates)	The reaction of credit and deposits interest rates, after monetary policy shocks, is heterogeneous between both markets and among banks.	1996-2004	Reaction is heterogeneous. In the deposits market, the maximum response is observed after 6 months, an increase in the policy rate results in proportional increase of the market rate proportionally. In the credit market, the maximum response is observed after 4.4 months, but some banks increase their rates more than the policy decision. The reaction is higher for credits than deposits. In the short-run, the variance of interest rates is driven by the interbank rate, but in the long-run, it is driven by inflation and intermediation costs.
Huertas et al. (2005)	Credit Channel (Interest rates)	Monetary policy interventions affect credits and deposits interests of banks.	2001-2004	Changes in the monetary policy intervention rate directly impact short-term interest rates in the credit market (TIB and REPO rates). Treasury and preferential loans, and deposits' interest rates are affected directly by the TIB rate. Changes in the DTF (deposit) rate impact the interest rates of ordinary and consumer loans.
Melo-Velandia & Becerra-Camargo (2006)	Credit Channel (Interest rates)	There is a short-term and long-term relationship between the TIB rate (credits) and the DTF rate (deposits), with the monetary policy intervention rate.	2001-2005	A monetary policy shock affects the TIB more than the DTF. An increase of 100 basis points in the intervention rate generates a 68 basis points increase in the TIB rate, that stabilizes in 38 basis points. The effect on the DTF rate is of 7 basis points.
Gómez-González & Grosz (2007)	Bank-lending Channel	Banks' financial health (measured by capitalization and liquidity) reinforce the bank-lending channel.	1995-2005	A positive shock to the policy rate reduces the growth-rate of commercial loans (only). Capitalization and liquidity reinforce this channel (the fall is higher for banks with lower capitalization and liquidity ratios).
López et al. (2011)	Risk-taking Channel	Monetary policy shocks impact banks' willingness to bear risk, through the impact on balance-sheet data, affecting the transmission through the credit market.	2000-2008	After expansive shocks, banks are more tolerant to lower quality loans and the perceived risk of outstanding loans is reduced. Hazard rates increase when the policy rate increases, and decrease when the policy rate is reduced. Bigger banks exhibit lower loan risk (lower hazard rates), but hazard rates increase when banks are more dependable on the interbank market as the source of loanable resources.
Gómez et al. (2016)	Credit Channel (Interest rates)	The impact of monetary policy on the interest rates of different types of loans is heterogeneous.	2003-2014	The transmission of monetary policy to interest rates in the credit market is complete after 8 months and is heterogeneous by type of loans and maturities. Bank-specific characteristics are not significant determinants of this response. Interest rates of commercial loans (particularly preferential loans) are more sensitive than consumer interest rates. Credit cards and mortgage loans are less sensitive (they are constrained by regulatory limits or price stickiness).

B. Monetary Policy and Heterogeneity Estimation Results

Table 9. No Heterogeneity

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.550***	(-14.12)	-0.550***	(-14.82)	-0.555***	(-16.49)	-0.398***	(-7.81)
$\Delta \ln y_{t-2}$	-0.409***	(-10.92)	-0.397***	(-10.94)	-0.396***	(-11.84)	-0.283***	(-6.32)
$\Delta \ln y_{t-3}$	-0.188***	(-4.51)	-0.187***	(-4.68)	-0.188***	(-5.11)	-0.0912*	(-1.88)
$\Delta \ln y_{t-4}$	-0.196***	(-6.50)	-0.188***	(-6.56)	-0.174***	(-5.77)	-0.196***	(-4.30)
$\Delta \ln y_{t-5}$	-0.155***	(-6.47)	-0.146***	(-6.31)	-0.156***	(-5.41)	-0.107***	(-3.59)
Δr_{t-1}	1.743	(-1.29)	2.265	(-1.5)	2.154	(-1.29)	4.905***	(3.92)
Δr_{t-2}	-3.720**	(-2.10)	-4.121**	(-2.24)	-4.694**	(-2.15)	-1.963	(-1.36)
Δr_{t-3}	7.687***	(-4.71)	7.612***	(-4.55)	6.213***	(-3.08)	9.251***	(6.34)
Δr_{t-4}	-9.616***	(-6.28)	-9.928***	(-6.03)	-9.568***	(-4.81)	-13.75***	(-7.15)
Δr_{t-5}	9.965***	(-4.75)	9.904***	(-4.49)	13.03***	(-5.13)	6.690***	(4.77)
Δr_{t-6}	-7.710***	(-6.13)	-7.768***	(-6.17)	-6.967***	(-4.68)	-7.547***	(-4.24)
π	8.486***	(-4.12)	8.749***	(-3.95)	10.01***	(-4.83)	2.298	(1.06)
$\Delta \ln IPI_{t-1}$	-1.295***	(-7.62)	-1.246***	(-7.20)	-1.283***	(-5.62)	-1.834***	(-9.60)
$\Delta \ln IPI_{t-2}$	-2.119***	(-8.84)	-2.163***	(-9.01)	-2.159***	(-7.45)	-2.770***	(-11.22)
$\Delta \ln IPI_{t-3}$	-0.978***	(-5.58)	-0.970***	(-5.53)	-0.931***	(-4.98)	-1.663***	(-8.32)
$\Delta \ln IPI_{t-4}$	-1.154***	(-9.22)	-1.182***	(-9.00)	-1.160***	(-6.67)	-1.814***	(-9.25)
$\Delta \ln IPI_{t-5}$	-0.572***	(-3.64)	-0.593***	(-3.65)	-0.504**	(-2.21)	-1.228***	(-5.90)
$\Delta \ln IPI_{t-6}$	0.0409	(-0.37)	0.0356	(-0.33)	0.133	(-0.85)	-0.180	(-1.31)
MA	0.237**	(-2.26)	0.238**	(-2.26)	0.263*	(-1.95)	0.159	(1.61)
Tax	-0.615***	(-6.29)	-0.639***	(-6.79)	-0.681***	(-6.77)	-0.250***	(-3.86)
Q^2	0.338***	(-7.45)	0.338***	(-7.1)	0.373***	(-6.68)	0.285***	(8.28)
Q^3	0.361***	(-9.64)	0.365***	(-9.36)	0.397***	(-10.04)	0.361***	(11.25)
Q^4	0.448***	(-10.7)	0.450***	(-10.34)	0.512***	(-10.94)	0.380***	(10.74)
Constant	-0.284***	(-8.56)	-0.285***	(-8.09)	-0.321***	(-8.91)	-0.216***	(-7.87)
N	2,958		2,958		2,920		2,669	

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table presents the estimated coefficients (and the *t* statistics, of a robust fixed-effects estimation of equation 20, where B is the Operational Efficiency ratio. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Table 10. Operational Efficiency

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.553***	(-14.89)	-0.554***	(-15.59)	-0.558***	(-17.09)	-0.394***	(-7.71)
$\Delta \ln y_{t-2}$	-0.409***	(-11.09)	-0.397***	(-11.07)	-0.396***	(-12.07)	-0.282***	(-6.19)
$\Delta \ln y_{t-3}$	-0.186***	(-4.54)	-0.184***	(-4.71)	-0.186***	(-5.16)	-0.0936*	(-1.98)
$\Delta \ln y_{t-4}$	-0.194***	(-6.52)	-0.186***	(-6.59)	-0.173***	(-5.79)	-0.196***	(-4.34)
$\Delta \ln y_{t-5}$	-0.155***	(-6.44)	-0.146***	(-6.30)	-0.156***	(-5.42)	-0.107***	(-3.72)
Δr_{t-1}	5.650**	(-2.5)	6.128**	(-2.55)	6.022**	(-2.45)	0.00970	(0.00)
Δr_{t-2}	-9.359***	(-4.67)	-9.733***	(-4.73)	-10.25***	(-3.85)	-4.774	(-1.06)
Δr_{t-3}	3.101*	(-1.83)	3.017*	(-1.75)	1.248	(-0.6)	9.067***	(3.57)
Δr_{t-4}	-13.53***	(-6.02)	-13.63***	(-5.77)	-13.49***	(-5.40)	-14.13***	(-4.62)
Δr_{t-5}	14.99***	(-5.67)	15.31***	(-5.32)	19.10***	(-5.61)	9.886**	(2.56)
Δr_{t-6}	-6.746***	(-4.39)	-6.548***	(-4.15)	-5.957***	(-3.32)	-6.886**	(-2.75)
$Ope.Eff. * \Delta r_{t-1}$	-174.3	(-1.47)	-172.3	(-1.41)	-169	(-1.45)	287.6***	(2.80)
$Ope.Eff. * \Delta r_{t-2}$	317.4***	(-4.68)	316.2***	(-4.73)	313.9***	(-5.07)	162.4	(0.57)
$Ope.Eff. * \Delta r_{t-3}$	244.8***	(-9.76)	246.0***	(-10.02)	266.8***	(-8.85)	20.61	(0.17)
$Ope.Eff. * \Delta r_{t-4}$	216.2***	(-3.42)	204.1***	(-2.99)	215.1***	(-3.47)	43.85	(0.30)
$Ope.Eff. * \Delta r_{t-5}$	-278.6*	(-1.79)	-302.8*	(-1.78)	-339.0*	(-1.95)	-217.4	(-0.87)
$Ope.Eff. * \Delta r_{t-6}$	-79.03	(-1.47)	-95.27	(-1.67)	-85.54	(-1.32)	-42.81	(-0.25)
π	8.682***	(-4.03)	8.917***	(-3.89)	10.22***	(-4.63)	2.223	(1.03)
$\Delta \ln IPI_{t-1}$	-1.265***	(-7.33)	-1.217***	(-6.93)	-1.255***	(-5.46)	-1.822***	(-9.92)
$\Delta \ln IPI_{t-2}$	-2.102***	(-8.32)	-2.147***	(-8.48)	-2.148***	(-7.08)	-2.743***	(-11.67)
$\Delta \ln IPI_{t-3}$	-0.978***	(-5.20)	-0.973***	(-5.16)	-0.937***	(-4.66)	-1.629***	(-8.17)
$\Delta \ln IPI_{t-4}$	-1.159***	(-8.53)	-1.188***	(-8.38)	-1.171***	(-6.52)	-1.789***	(-9.26)
$\Delta \ln IPI_{t-5}$	-0.561***	(-3.37)	-0.585***	(-3.41)	-0.496**	(-2.14)	-1.222***	(-5.88)
$\Delta \ln IPI_{t-6}$	0.0256	(-0.24)	0.0189	(-0.18)	0.115	(-0.76)	-0.173	(-1.30)
MA	0.239**	(-2.29)	0.240**	(-2.29)	0.264*	(-1.96)		
Tax	-0.615***	(-6.30)	-0.639***	(-6.78)	-0.680***	(-6.71)	-0.247***	(-3.66)
Q^2	0.335***	(-7.21)	0.335***	(-6.89)	0.370***	(-6.52)	0.282***	(8.57)
Q^3	0.358***	(-9.18)	0.362***	(-8.94)	0.395***	(-9.58)	0.357***	(11.31)
Q^4	0.443***	(-10.33)	0.445***	(-9.99)	0.508***	(-10.62)	0.373***	(10.98)
Constant	-0.283***	(-8.32)	-0.284***	(-7.89)	-0.321***	(-8.70)	-0.211***	(-7.87)
N	2939		2939		2901		2651	

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table presents the estimated coefficients (and the t statistics, of a robust fixed-effects estimation of equation 20, where B is the Operational Efficiency ratio. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Table 11. Financial Efficiency

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.548***	(-13.76)	-0.549***	(-14.44)	-0.554***	(-16.12)	-0.392***	(-7.68)
$\Delta \ln y_{t-2}$	-0.411***	(-10.97)	-0.400***	(-10.98)	-0.398***	(-11.82)	-0.286***	(-6.28)
$\Delta \ln y_{t-3}$	-0.191***	(-4.54)	-0.190***	(-4.71)	-0.190***	(-5.13)	-0.0920*	(-1.92)
$\Delta \ln y_{t-4}$	-0.197***	(-6.39)	-0.190***	(-6.44)	-0.175***	(-5.72)	-0.195***	(-4.36)
$\Delta \ln y_{t-5}$	-0.154***	(-6.46)	-0.145***	(-6.33)	-0.155***	(-5.40)	-0.105***	(-3.66)
Δr_{t-1}	2.14	(-1.58)	2.726*	(-1.8)	2.653	(-1.55)	5.284***	(3.99)
Δr_{t-2}	-3.613*	(-1.82)	-4.033*	(-1.95)	-4.726*	(-1.99)	-2.233	(-1.50)
Δr_{t-3}	7.646***	(-4.76)	7.578***	(-4.64)	6.163***	(-3.15)	8.927***	(5.22)
Δr_{t-4}	-9.714***	(-6.49)	-10.07***	(-6.25)	-9.736***	(-5.03)	-13.48***	(-6.91)
Δr_{t-5}	10.09***	(-4.88)	10.03***	(-4.61)	13.24***	(-5.27)	7.081***	(4.94)
Δr_{t-6}	-8.051***	(-6.38)	-8.144***	(-6.49)	-7.402***	(-4.97)	-7.814***	(-4.09)
$Fin.Eff. * \Delta r_{t-1}$	32.07	(-0.61)	29.78	(-0.54)	55.12	(-0.88)	73.80*	(1.75)
$Fin.Eff. * \Delta r_{t-2}$	64.66	(-1.4)	59.98	(-1.26)	37.56	(-0.71)	8.323	(0.17)
$Fin.Eff. * \Delta r_{t-3}$	67.6	(-1.05)	87.76	(-1.2)	99.31	(-1.23)	-39.86	(-0.65)
$Fin.Eff. * \Delta r_{t-4}$	64.14	(-1.35)	70.01	(-1.45)	48.72	(-0.98)	84.20	(1.33)
$Fin.Eff. * \Delta r_{t-5}$	-38.22	(-0.91)	-31.09	(-0.74)	-19.48	(-0.42)	-19.82	(-0.32)
$Fin.Eff. * \Delta r_{t-6}$	4.886	(-0.07)	1.753	(-0.02)	52.55	(-0.61)	128.9	(1.18)
π	8.632***	(-4.01)	8.957***	(-3.85)	10.23***	(-4.68)	2.175	(0.98)
$\Delta \ln IPI_{t-1}$	-1.289***	(-7.68)	-1.241***	(-7.27)	-1.280***	(-5.64)	-1.824***	(-9.48)
$\Delta \ln IPI_{t-2}$	-2.109***	(-8.74)	-2.155***	(-8.86)	-2.152***	(-7.27)	-2.729***	(-10.99)
$\Delta \ln IPI_{t-3}$	-0.972***	(-5.68)	-0.969***	(-5.62)	-0.937***	(-5.08)	-1.615***	(-7.93)
$\Delta \ln IPI_{t-4}$	-1.147***	(-9.25)	-1.177***	(-9.09)	-1.160***	(-6.87)	-1.775***	(-8.94)
$\Delta \ln IPI_{t-5}$	-0.565***	(-3.60)	-0.588***	(-3.63)	-0.500**	(-2.23)	-1.188***	(-5.61)
$\Delta \ln IPI_{t-6}$	0.0466	(-0.44)	0.0401	(-0.38)	0.144	(-0.93)	-0.147	(-1.10)
MA	0.240**	(-2.28)	0.242**	(-2.29)	0.268*	(-1.99)		
Tax	-0.618***	(-6.25)	-0.642***	(-6.72)	-0.683***	(-6.68)	-0.243***	(-3.69)
Q^2	0.338***	(-7.44)	0.339***	(-7.06)	0.375***	(-6.67)	0.287***	(8.49)
Q^3	0.360***	(-9.52)	0.365***	(-9.18)	0.397***	(-9.82)	0.361***	(11.47)
Q^4	0.446***	(-10.73)	0.449***	(-10.3)	0.513***	(-10.86)	0.379***	(10.94)
Constant	-0.283***	(-8.52)	-0.285***	(-8.01)	-0.323***	(-8.83)	-0.215***	(-7.96)
N	2,958		2,958		2,920		2,669	

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table presents the estimated coefficients (and the t statistics, of a robust fixed-effects estimation of equation 20, where B is the Financial Efficiency ratio. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Table 12. Liquidity

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.552***	(-14.48)	-0.552***	(-15.20)	-0.556***	(-16.82)	-0.395***	(-7.60)
$\Delta \ln y_{t-2}$	-0.411***	(-10.96)	-0.398***	(-10.96)	-0.397***	(-11.82)	-0.283***	(-6.26)
$\Delta \ln y_{t-3}$	-0.190***	(-4.51)	-0.188***	(-4.68)	-0.188***	(-5.10)	-0.0919*	(-1.92)
$\Delta \ln y_{t-4}$	-0.195***	(-6.48)	-0.187***	(-6.53)	-0.173***	(-5.72)	-0.197***	(-4.37)
$\Delta \ln y_{t-5}$	-0.154***	(-6.46)	-0.145***	(-6.34)	-0.154***	(-5.35)	-0.108***	(-3.57)
Δr_{t-1}	2.147*	(-1.78)	2.699*	(-1.96)	2.561	(-1.64)	4.734***	(3.86)
Δr_{t-2}	-3.655*	(-2.00)	-4.044**	(-2.14)	-4.598**	(-2.07)	-1.987	(-1.39)
Δr_{t-3}	7.751***	(-4.68)	7.690***	(-4.54)	6.276***	(-3.04)	9.222***	(6.26)
Δr_{t-4}	-9.692***	(-6.70)	-9.998***	(-6.37)	-9.641***	(-5.10)	-14.01***	(-7.14)
Δr_{t-5}	10.02***	(-4.82)	9.944***	(-4.54)	13.09***	(-5.19)	6.980***	(4.82)
Δr_{t-6}	-7.830***	(-6.13)	-7.885***	(-6.17)	-7.126***	(-4.75)	-7.496***	(-4.19)
$\Delta Liquidity * \Delta r_{t-1}$	-121.9***	(-2.97)	-118.7**	(-2.70)	-124.9***	(-2.87)	20.60	(0.25)
$\Delta Liquidity * \Delta r_{t-2}$	-9.624	(-0.20)	-15.34	(-0.30)	-31.19	(-0.55)	5.416	(0.09)
$\Delta Liquidity * \Delta r_{t-3}$	52.14	(-0.81)	56.31	(-0.86)	45.85	(-0.64)	-66.40	(-0.84)
$\Delta Liquidity * \Delta r_{t-4}$	48.49	(-0.77)	39.56	(-0.62)	49.62	(-0.75)	112.9	(1.59)
$\Delta Liquidity * \Delta r_{t-5}$	-80.66	(-1.50)	-81.82	(-1.47)	-67.24	(-1.15)	-79.27*	(-1.74)
$\Delta Liquidity * \Delta r_{t-6}$	52.6	(-0.93)	61.25	(-1.03)	48.42	(-0.72)	-13.99	(-0.23)
π	8.575***	(-3.96)	8.847***	(-3.81)	10.05***	(-4.57)	2.309	(1.07)
$\Delta \ln IPI_{t-1}$	-1.282***	(-7.62)	-1.233***	(-7.18)	-1.270***	(-5.57)	-1.835***	(-9.50)
$\Delta \ln IPI_{t-2}$	-2.104***	(-9.00)	-2.148***	(-9.17)	-2.142***	(-7.50)	-2.756***	(-11.15)
$\Delta \ln IPI_{t-3}$	-0.968***	(-5.67)	-0.962***	(-5.65)	-0.920***	(-5.05)	-1.639***	(-8.05)
$\Delta \ln IPI_{t-4}$	-1.152***	(-9.03)	-1.181***	(-8.84)	-1.160***	(-6.64)	-1.794***	(-9.07)
$\Delta \ln IPI_{t-5}$	-0.560***	(-3.47)	-0.583***	(-3.51)	-0.494**	(-2.14)	-1.212***	(-5.75)
$\Delta \ln IPI_{t-6}$	0.0505	(-0.45)	0.0455	(-0.41)	0.141	(-0.89)	-0.179	(-1.34)
MA	0.231**	(-2.18)	0.232**	(-2.18)	0.257*	(-1.9)		
Tax	-0.614***	(-6.31)	-0.639***	(-6.81)	-0.681***	(-6.78)	-0.242***	(-3.68)
Q^2	0.337***	(-7.51)	0.337***	(-7.16)	0.372***	(-6.7)	0.285***	(8.49)
Q^3	0.359***	(-9.76)	0.364***	(-9.49)	0.395***	(-10.16)	0.363***	(11.46)
Q^4	0.448***	(-10.76)	0.450***	(-10.42)	0.511***	(-10.97)	0.379***	(10.90)
Constant	-0.285***	(-8.51)	-0.286***	(-8.07)	-0.322***	(-8.86)	-0.214***	(-8.00)
N	2,958		2,958		2,920		2,669	

Note: *t* statistics in parentheses; $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$. This table presents the estimated coefficients (and the *t* statistics, of a robust fixed-effects estimation of equation 20, where B is the Liquidity ratio. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Table 13. Capitalization

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.550***	(-14.17)	-0.550***	(-14.84)	-0.555***	(-16.58)	-0.394***	(-7.65)
$\Delta \ln y_{t-2}$	-0.408***	(-10.81)	-0.397***	(-10.81)	-0.396***	(-11.81)	-0.283***	(-6.25)
$\Delta \ln y_{t-3}$	-0.188***	(-4.51)	-0.186***	(-4.68)	-0.188***	(-5.11)	-0.0914*	(-1.88)
$\Delta \ln y_{t-4}$	-0.196***	(-6.32)	-0.188***	(-6.37)	-0.174***	(-5.65)	-0.194***	(-4.33)
$\Delta \ln y_{t-5}$	-0.157***	(-6.44)	-0.148***	(-6.32)	-0.157***	(-5.39)	-0.108***	(-3.60)
Δr_{t-1}	1.74	(-1.25)	2.261	(-1.46)	2.156	(-1.26)	4.837***	(3.77)
Δr_{t-2}	-3.464**	(-2.05)	-3.889**	(-2.20)	-4.457**	(-2.11)	-2.136	(-1.47)
Δr_{t-3}	7.651***	(-4.71)	7.552***	(-4.53)	6.094***	(-3.03)	9.302***	(6.08)
Δr_{t-4}	-9.945***	(-6.39)	-10.26***	(-6.15)	-9.895***	(-4.88)	-13.72***	(-7.31)
Δr_{t-5}	10.34***	(-4.93)	10.29***	(-4.66)	13.40***	(-5.22)	6.752***	(4.52)
Δr_{t-6}	-7.790***	(-6.43)	-7.863***	(-6.48)	-7.080***	(-4.83)	-7.564***	(-4.04)
$\Delta Capital. * \Delta r_{t-1}$	55.9	(-0.42)	36.16	(-0.25)	49.62	(-0.3)	287.7*	(1.82)
$\Delta Capital. * \Delta r_{t-2}$	-135.5	(-1.21)	-109.2	(-0.95)	-144.1	(-0.94)	64.78	(0.21)
$\Delta Capital. * \Delta r_{t-3}$	-38.34	(-0.21)	-43.92	(-0.24)	12.76	(-0.06)	261.5	(1.49)
$\Delta Capital. * \Delta r_{t-4}$	123.1	(-0.48)	151.3	(-0.6)	108.3	(-0.4)	-499.0**	(-2.39)
$\Delta Capital. * \Delta r_{t-5}$	-437.5**	(-2.69)	-443.0**	(-2.69)	-407.8**	(-2.37)	-234.8	(-0.52)
$\Delta Capital. * \Delta r_{t-6}$	100.4	(-0.53)	123.9	(-0.59)	119.9	(-0.55)	-245.8	(-0.92)
π	8.468***	(-4.15)	8.727***	(-3.98)	10.01***	(-4.91)	2.322	(1.06)
$\Delta \ln IPI_{t-1}$	-1.300***	(-7.58)	-1.251***	(-7.15)	-1.290***	(-5.59)	-1.857***	(-9.72)
$\Delta \ln IPI_{t-2}$	-2.121***	(-8.76)	-2.164***	(-8.92)	-2.163***	(-7.36)	-2.792***	(-11.59)
$\Delta \ln IPI_{t-3}$	-0.983***	(-5.57)	-0.975***	(-5.53)	-0.936***	(-5.00)	-1.657***	(-8.24)
$\Delta \ln IPI_{t-4}$	-1.150***	(-8.81)	-1.178***	(-8.51)	-1.154***	(-6.42)	-1.786***	(-9.03)
$\Delta \ln IPI_{t-5}$	-0.562***	(-3.53)	-0.585***	(-3.55)	-0.494**	(-2.13)	-1.191***	(-5.79)
$\Delta \ln IPI_{t-6}$	0.0446	(-0.41)	0.0389	(-0.36)	0.139	(-0.87)	-0.154	(-1.14)
MA	0.236**	(-2.21)	0.237**	(-2.2)	0.263*	(-1.91)		
Tax	-0.615***	(-6.27)	-0.639***	(-6.78)	-0.681***	(-6.75)	-0.241***	(-3.68)
Q^2	0.341***	(-7.47)	0.340***	(-7.1)	0.377***	(-6.61)	0.293***	(8.82)
Q^3	0.362***	(-9.57)	0.366***	(-9.3)	0.398***	(-9.97)	0.365***	(11.83)
Q^4	0.449***	(-10.72)	0.451***	(-10.34)	0.514***	(-10.84)	0.383***	(11.17)
Constant	-0.285***	(-8.56)	-0.287***	(-8.09)	-0.323***	(-8.82)	-0.218***	(-8.22)
N	2,958		2,958		2,920		2,669	

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table presents the estimated coefficients (and the t statistics, of a robust fixed-effects estimation of equation 20, where B is the Capitalization ratio. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Table 14. Returns to Scale

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.563***	(-14.57)	-0.561***	(-15.24)	-0.565***	(-16.39)	-0.393***	(-7.63)
$\Delta \ln y_{t-2}$	-0.412***	(-9.57)	-0.399***	(-9.64)	-0.401***	(-10.58)	-0.287***	(-6.09)
$\Delta \ln y_{t-3}$	-0.181***	(-3.93)	-0.180***	(-4.12)	-0.187***	(-4.62)	-0.0955*	(-1.94)
$\Delta \ln y_{t-4}$	-0.185***	(-5.70)	-0.178***	(-5.91)	-0.165***	(-5.11)	-0.201***	(-4.26)
$\Delta \ln y_{t-5}$	-0.143***	(-6.02)	-0.136***	(-6.15)	-0.147***	(-4.96)	-0.110***	(-3.62)
Δr_{t-1}	1.385	(-0.97)	1.885	(-1.23)	1.873	(-0.97)	5.445***	(4.15)
Δr_{t-2}	-4.313**	(-2.53)	-4.858**	(-2.73)	-5.612**	(-2.62)	-0.739	(-0.52)
Δr_{t-3}	7.252***	(-4.3)	7.140***	(-4.11)	5.562**	(-2.53)	10.04***	(7.14)
Δr_{t-4}	-8.067***	(-5.20)	-8.506***	(-4.99)	-8.111***	(-3.71)	-14.51***	(-8.22)
Δr_{t-5}	9.788***	(-5.36)	9.829***	(-5.05)	13.13***	(-5.39)	6.839***	(4.46)
Δr_{t-6}	-7.757***	(-6.27)	-7.654***	(-6.07)	-6.696***	(-4.71)	-9.210***	(-5.31)
$\Delta RTS * \Delta r_{t-1}$	121.2**	(-2.58)	99.10*	(-1.73)	115.8*	(-1.8)	-13.78	(-0.32)
$\Delta RTS * \Delta r_{t-2}$	-54.91	(-1.44)	-39.23	(-0.90)	-10.65	(-0.18)	35.64	(0.69)
$\Delta RTS * \Delta r_{t-3}$	32.12	(-0.43)	43.45	(-0.53)	23.94	(-0.24)	55.69	(0.95)
$\Delta RTS * \Delta r_{t-4}$	-73.89	(-1.15)	-26.13	(-0.29)	-46.45	(-0.46)	-92.39	(-1.39)
$\Delta RTS * \Delta r_{t-5}$	143.4*	(-2.02)	115.6	(-1.41)	92.1	(-0.98)	19.89	(0.34)
$\Delta RTS * \Delta r_{t-6}$	-130.7	(-1.33)	-166.3	(-1.56)	-163.3	(-1.33)	53.52	(0.67)
π	7.860***	(-3.95)	8.194***	(-3.82)	9.081***	(-4.69)	2.399	(1.02)
$\Delta \ln IPI_{t-1}$	-1.284***	(-7.51)	-1.229***	(-6.97)	-1.268***	(-5.53)	-1.845***	(-9.88)
$\Delta \ln IPI_{t-2}$	-2.134***	(-8.73)	-2.179***	(-8.91)	-2.169***	(-7.35)	-2.752***	(-11.22)
$\Delta \ln IPI_{t-3}$	-1.003***	(-5.76)	-0.995***	(-5.68)	-0.942***	(-5.06)	-1.638***	(-7.90)
$\Delta \ln IPI_{t-4}$	-1.196***	(-10.37)	-1.231***	(-10.33)	-1.209***	(-7.78)	-1.744***	(-8.89)
$\Delta \ln IPI_{t-5}$	-0.611***	(-4.66)	-0.634***	(-4.60)	-0.545**	(-2.59)	-1.181***	(-5.69)
$\Delta \ln IPI_{t-6}$	-0.00116	(-0.01)	-0.0114	(-0.12)	0.0892	(-0.58)	-0.118	(-0.88)
MA	0.247**	(-2.4)	0.248**	(-2.39)	0.273**	(-2.04)		
Tax	-0.607***	(-6.43)	-0.632***	(-6.90)	-0.674***	(-6.82)	-0.243***	(-3.76)
Q^2	0.332***	(-7.29)	0.331***	(-6.86)	0.364***	(-6.39)	0.296***	(8.53)
Q^3	0.358***	(-9.52)	0.362***	(-9.24)	0.392***	(-10.13)	0.363***	(10.91)
Q^4	0.442***	(-10.53)	0.443***	(-10.12)	0.504***	(-10.88)	0.381***	(10.18)
Constant	-0.276***	(-8.26)	-0.277***	(-7.79)	-0.310***	(-8.61)	-0.219***	(-7.59)
N	2,857		2,857		2,819		2,613	

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: *t* statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This table presents the estimated coefficients (and the *t* statistics, of a robust fixed-effects estimation of equation 20, where B takes the values of the estimated Returns to Scale for each bank at each point in time. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.

Table 15. Lerner Index

Independent variables	Dependent variable $\Delta \ln y_t$ (disbursements)							
	(1) Total		(2) Consumer&Commercial		(3) Commercial		(4) Consumer	
$\Delta \ln y_{t-1}$	-0.567***	(-15.08)	-0.566***	(-15.88)	-0.568***	(-16.65)	-0.402***	(-7.94)
$\Delta \ln y_{t-2}$	-0.420***	(-9.99)	-0.405***	(-10.10)	-0.405***	(-10.63)	-0.295***	(-7.02)
$\Delta \ln y_{t-3}$	-0.185***	(-3.99)	-0.183***	(-4.18)	-0.188***	(-4.64)	-0.108**	(-2.34)
$\Delta \ln y_{t-4}$	-0.186***	(-5.90)	-0.178***	(-6.00)	-0.166***	(-5.28)	-0.204***	(-4.47)
$\Delta \ln y_{t-5}$	-0.150***	(-5.98)	-0.141***	(-5.90)	-0.151***	(-4.97)	-0.109***	(-3.61)
Δr_{t-1}	-10.43***	(-5.45)	-10.41***	(-5.27)	-10.26***	(-4.86)	33.23***	(4.06)
Δr_{t-2}	9.083***	(-5.29)	8.963***	(-4.96)	7.657***	(-4.21)	27.76	(1.22)
Δr_{t-3}	22.62***	(-20.58)	22.66***	(-20.41)	21.51***	(-18.98)	17.85	(1.55)
Δr_{t-4}	-5.173***	(-3.74)	-5.610***	(-3.94)	-5.540***	(-3.35)	-2.216	(-0.20)
Δr_{t-5}	1.073	(-0.42)	1.148	(-0.47)	2.798	(-1.01)	-0.784	(-0.03)
Δr_{t-6}	-16.91***	(-8.73)	-17.06***	(-8.90)	-16.03***	(-6.50)	-31.12	(-1.66)
$\Delta Lerner I_{t-1} * \Delta r_{t-1}$	14.71***	(-11.1)	15.37***	(-10.42)	15.05***	(-8.5)	-33.30***	(-3.52)
$\Delta Lerner I_{t-1} * \Delta r_{t-2}$	-15.86***	(-5.94)	-16.23***	(-5.85)	-15.59***	(-5.29)	-34.99	(-1.29)
$\Delta Lerner I_{t-1} * \Delta r_{t-3}$	-19.20***	(-13.71)	-19.30***	(-13.62)	-19.71***	(-10.08)	-9.369	(-0.66)
$\Delta Lerner I_{t-1} * \Delta r_{t-4}$	-3.757***	(-2.84)	-3.661**	(-2.72)	-3.192**	(-2.16)	-14.28	(-1.05)
$\Delta Lerner I_{t-1} * \Delta r_{t-5}$	11.13***	(-4.86)	11.01***	(-5.15)	13.10***	(-5.34)	9.005	(0.30)
$\Delta Lerner I_{t-1} * \Delta r_{t-6}$	10.61***	(-5.8)	10.67***	(-5.9)	10.32***	(-4.32)	27.12	(1.26)
π	7.932***	(-3.74)	8.229***	(-3.61)	9.242***	(-4.35)	2.561	(1.12)
$\Delta \ln IPI_{t-1}$	-1.263***	(-7.21)	-1.214***	(-6.81)	-1.259***	(-5.53)	-1.819***	(-10.09)
$\Delta \ln IPI_{t-2}$	-2.132***	(-8.09)	-2.181***	(-8.26)	-2.186***	(-6.96)	-2.730***	(-11.81)
$\Delta \ln IPI_{t-3}$	-1.010***	(-5.22)	-1.007***	(-5.19)	-0.968***	(-4.62)	-1.590***	(-8.07)
$\Delta \ln IPI_{t-4}$	-1.201***	(-9.89)	-1.234***	(-9.72)	-1.211***	(-7.41)	-1.746***	(-9.42)
$\Delta \ln IPI_{t-5}$	-0.585***	(-4.42)	-0.610***	(-4.44)	-0.516**	(-2.43)	-1.200***	(-5.68)
$\Delta \ln IPI_{t-6}$	-0.00295	(-0.03)	-0.00782	(-0.09)	0.0939	-0.64	-0.154	(-1.10)
MA	0.242**	(-2.32)	0.243**	(-2.33)	0.268*	(-2.00)		
Tax	-0.601***	(-6.39)	-0.626***	(-6.89)	-0.666***	(-6.78)	-0.250***	(-3.76)
Q^2	0.334***	(-7.21)	0.334***	(-6.84)	0.370***	(-6.42)	0.285***	(8.26)
Q^3	0.360***	(-8.79)	0.365***	(-8.57)	0.397***	(-9.29)	0.354***	(11.05)
Q^4	0.443***	(-10.05)	0.446***	(-9.71)	0.510***	(-10.49)	0.370***	(10.47)
Constant	-0.280***	(-7.92)	-0.282***	(-7.51)	-0.318***	(-8.31)	-0.209***	(-7.55)
N	2,860		2,860		2,822		2,606	

Note: t statistics in parentheses; $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$. This table presents the estimated coefficients (and the t statistics, of a robust fixed-effects estimation of equation 20, where B takes the values of the Lerner Index for the loans market. The dependent variable is the growth rate of disbursements. Regression (1) considers *total* disbursements (the sum of commercial, consumer and micro-credits disbursements), regression (2) the sum of consumer and commercial disbursements, regression (3) and (4) consider commercial and consumer disbursements, accordingly.