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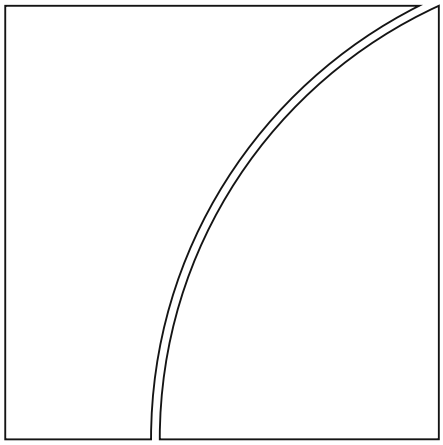

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Evaluating the impact of macroprudential policies on credit growth in Colombia*

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Abstract

Macroprudential tools have been used around the world to counter potential risks and imbalances in the financial sector. Colombia is a good example of a country that has employed a variety of regulatory measures to manage systemic risks in the economy. The purpose of this paper is to evaluate the effectiveness of two such policies with a view to increasing systemic resilience and curbing excesses in the credit supply. The first measure, the countercyclical reserve requirement, was implemented in 2007 to control excessive credit growth. The second was the dynamic provisioning scheme for commercial loans, which was designed to establish a countercyclical buffer through loan loss provision requirements. To perform this analysis, a rich dataset based on loan-by-loan information for Colombian banks during the 2006-09 period is used. A fixed effects panel model is estimated using the characteristics of debtors, banks and the macroeconomy as control variables. In addition, a difference in differences estimation is performed to evaluate the policies' impact. The findings suggest that the dynamic provisions and the countercyclical reserve requirement had a negative effect on credit growth, and that this effect varies according to bank-specific characteristics. Results also suggest that the aggregate macroprudential policy stance in Colombia has worked effectively to stabilize credit cycles, with some preliminary evidence also pointing towards significant effects in reducing bank risk-taking. Moreover, evidence is found that macroprudential policies have worked as a complement to monetary policy, as both have a moderating effect on credit growth when tightened.

JEL classification: *E58, G28, C23*
***Keywords*:** Macroprudential policies, Reserve requirements, Credit growth, Dynamic provisioning, Credit registry data.

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1 Introduction

In the late 1990s, Colombia experienced one of the severest financial crises in its recent history. Early in that decade, the country had undergone a period of structural reforms characterized by a "laissez faire" approach that promoted economic openness and financial liberalization. These factors facilitated enormous inward capital flows, which in Colombia are highly (and positively) correlated with credit (Carrasquilla et al. (2000), Tenjo & López (2002) and Villar et al. (2005)). During these years, there was also a sharp increase in the number of financial institutions and a simultaneous easing of restrictions on financial operations and interest rates. Additionally, total expenditure (public and private) grew at high rates, while deficits in both the private and public sectors signalled an overheated economy. These elements were the main contributors to the credit boom that Colombia experienced during the first half of the 1990s[1].

Throughout this period, a substantial share of households in Colombia took out mortgage loans, encouraged by favorable credit conditions, causing housing prices to soar and adding greatly to households' leverage and financial burdens. The peak in housing prices was, however, followed by a sudden and sharp slump coupled with an abrupt increase in interest rates, following a sudden stop in capital inflows. This led to a credit crunch in the Colombian economy and the 1998-99 crisis (Tenjo & López (2002)). This episode was a painful reminder that, like other countries in the region, Colombia's status as a commodity-exporting, small, open and banking-oriented economy with low levels of domestic saving, makes it especially vulnerable to unexpected swings in the availability of external financing (Uribe (2012)).

Nevertheless, the financial crisis also left many important lessons for monetary and banking authorities. One such lesson is that episodes of excessive credit and asset price growth are especially dangerous for macroeconomic sustainability. In addition, external imbalances and currency mismatches can be particularly costly, since they tend to generate a misallocation of resources, leading to asset and credit bubbles. Furthermore, the need for proper and timely coordination between the agencies in charge of macroeconomic and financial stability was shown to be essential. A flexible exchange rate regime, the search for a sustainable fiscal policy and continuous improvement in financial regulation and supervision were also underlined as key elements if the potential impact and likelihood of future episodes of financial distress were to be mitigated. Last but not least, the crisis showed that financial stability is a necessary condition for macroeconomic stability, and that the achievement of the former is not guaranteed through the use of microprudential instruments; rather, these need to be complemented with macroprudential tools.

Indeed, after the crisis of the 1990s, many prudential measures were implemented and/or modified in Colombia. Some examples are: i) the introduction of caps on loan-to-value (LTV) and changes in debt-to-income (DTI) ratios for mortgage loans; ii) the central bank altered limits on net total FX positions; and iii) the creation of the Financial System Surveillance Committee as a mechanism of coordination among the financial authorities that make up the system's safety net[2].

Following the implementation of these measures, financial stability authorities faced their first test during 2006-09. During these years, the Colombian economy went through a similar situation to that of the mid-

[1] Commercial loans grew at a real rate of 102.7% between December 1990 and December 1995. Mortgage loans grew 101.9% during the same period.

[2] Created in 2003, the Committee comprises the Minister of Finance, the Governor of the Central Bank, the Director of the deposit insurance corporation and the Financial Superintendent.

1990s, that is, excessive capital inflows, abnormally high credit growth and strong house price growth. On the one hand, total real annual lending growth (including leasing operations) rose from 11.8% in December 2005 to 27.3% 12 months later, with real GDP growth of 6.7% at the end of 2006. The increase in aggregate demand was initially driven by an acceleration in investment and subsequently by private consumption, generating some inflationary pressures, with a consequent threat that inflation targets would be exceeded (Cardozo (2012)). The increase in capital flows caused the current account deficit to rise from 1.8% of GDP in the second half of 2006 to 3.6% of GDP by the first half of 2007, suggesting the presence of external imbalances.

In response, the central bank gradually increased its intervention rate, raising it by 400 bps between April 2006 and July 2008, with the aim of moderating the inflationary pressures generated by the strong growth of aggregate demand and credit (Vargas (2011)). However, lending by financial institutions continued to grow at historically high rates, particularly in the commercial and consumer sectors. The transmission of monetary policy was sluggish and the limited reaction of credit dynamics suggested that additional measures would be necessary (Uribe (2012)).

In this context, the central bank decided to set a marginal reserve requirement to dampen both lending growth and private sector leverage. Moreover, in order to prevent possible arbitrage and to limit a potential substitution from domestic to external borrowing, it reactivated a reserve requirement for short-term external debt and a limit on exchange rate derivatives exposure. The aim was both to limit banks' currency mismatches and to reduce gross currency positions, thus limiting counterparty risks. Simultaneously, the Ministry of Finance established a deposit for foreign portfolio investment and, a year later, a minimum holding period for foreign direct investment. The result was a set of macroprudential policies that helped mitigate inflationary pressures while dealing with latent financial risks (Cardozo (2012)). In addition to those measures, the Superintendencia Financiera de Colombia (SFC: Financial Superintendence of Colombia) designed a new system of countercyclical provisions, in the spirit of the Spanish system (Saurina (2009)), which changed provisioning requirements on commercial and consumer loans.

The combination of these policies seems to have caused credit growth to slow since the end of 2007. Thus, when the external shock arrived in 2008, the central bank had scope to act in a countercyclical way, by reducing its policy rate rapidly and aggressively (from 10% in December 2008 to 3% in May 2010) with the aim of mitigating the impact of the cross-border shock to the domestic economy while keeping inflation under control. In contrast to that of many other emerging economies during this period, Colombia's annual GDP growth rate did not move into negative territory (Cardozo (2012)).

Although this would seem to point to the effectiveness of the macroprudential tools discussed, it is difficult to ascertain the individual impact of each instrument, or to isolate their idiosyncratic effects from those of the global financial crisis. Indeed, even the potential effect on the credit cycle of these instruments at the theoretical level has been a subject of debate. For instance, as pointed out by Betancourt & Vargas (2009), the effectiveness of reserve requirements in an inflation targeting regime depends on the degree of substitution between bank deposits and central bank loans and the degree of uncertainty regarding the future policy rate. In any case, the authors conclude that the impact on the price and volume of credit is lower than under a monetary aggregates regime. Nevertheless, others argue that reserve and liquidity requirements can play an important role in influencing the credit supply, especially under scenarios of asymmetric information (Almeida et al. (2004) and Acharya et al. (2007)). Liquid deposits can also act

as a buffer against noisy signals (Calomiris & Kahn (1991)), and these buffers could reduce dependence on the lender of last resort by having banks self-insure against liquidity risk.

Whether one believes that the use of this set of macroprudential policies during that period actually helped towards a smooth adjustment of the Colombian economy during the onset of the global financial crisis, the truth of the matter is that little is known about the real impact of these tools on the supply of credit and/or banks' risk-taking. For the most part, any evaluation of the impact of these measures uses aggregate data, in which it is not possible to distinguish between supply and demand effects. A careful review of the literature for Colombia reveals that there is only one study that evaluates the impact of a specific measure (i.e. countercyclical provisions) on credit cycles using credit registry data (López et al. (2014)).

The experience of Colombia in the 2006-09 period is thus especially rich and unexplored. During this time, the financial authorities simultaneously employed a variety of measures to deal with the build-up of systemic vulnerabilities and to increase the resilience of the financial system. In particular, it is interesting to analyze the potential effect of these measures on credit growth. Therefore, in this paper, the impact of two macroprudential policies is evaluated: i) the marginal (i.e. countercyclical) reserve requirement on deposits and ii) the new dynamic provisioning system for commercial loans.

In evaluating these policies, a micro dataset containing information on over 1.9 million bank-debtor relationships for the period 2006Q1-2009Q4 is utilized. The information, provided by the SFC, is a sample of corporate loans (i.e. those in which the debtor is a legal entity (i.e. a firm), thus excluding individuals). The use of loan-by-loan information is particularly valuable in that it allows different effects to be disentangled and the impact of the macroprudential policies on credit growth to be effectively estimated. Through a series of estimations, using a fixed effects panel data methodology and a difference in differences (DiD) estimation, we find that dynamic provisions and the countercyclical reserve requirement had a negative effect on credit growth; also, that this effect varies depending on individual bank characteristics. Our findings also suggest that the aggregate macroprudential policy stance in Colombia has worked as an effective stabilizer of the credit cycle, and we provide some preliminary evidence for its effectiveness in reducing bank risk-taking. Finally, it is found that macroprudential policies have worked as a complement of monetary policy, with both having a moderating effect on credit growth when tightened.

The remainder of this paper is organized as follows: Section 2 provides a selective review of the related literature. Section 3 describes the data and empirical approach used, while Section 4 discusses the main results. Some concluding remarks follow.

2 Related literature

The proper implementation of a new macroprudential framework requires the evaluation of the potential impact of different policies on some variables of interest. Nevertheless, little is known about the effectiveness of these kind of policies and their interaction with monetary policy. One possible explanation of this fact is that, unlike monetary policy, the macroprudential policy toolkit is comprised of a variety of tools and targets various objectives, which are in fact difficult to disentangle in practice: some macroprudential policies seek to increase the resilience of the financial sector while others may attempt to dampen credit cycles. In other words, and using the terminology initially introduced by Borio & Crockett (2000), the evaluation of the impact of macroprudential tools should take in consideration, simultaneously, the time and cross-sectional dimensions of systemic risk.

In addition to that, cumulative experience and the information required for performing proper evaluations on the effectiveness of macroprudential tools is not particularly rich or available around the globe. On one hand, many macroprudential tools in developed countries have been introduced only in response to the recent crisis, which makes it difficult to empirically assess their effectiveness and transmission channels, and thus provide a guide in the design of said tools going forward (Galati & Moessner (2014) and Turner (2010)). On the other hand, in developing countries, even if the experience with the use of macroprudential policies is richer, the existence of restrictions in terms of data availability and capability for processing this information have limited the possibility of evaluating the effects of different policies.

Given the importance of this subject, some specialized international groups have devoted significant efforts to its analysis. A prime example is the influential report prepared by the CGFS (Committee on the Global Financial System (2012)), which offers a conceptual discussion of the transmission mechanism of a range of instruments, aiming to provide guidance on how the effectiveness of the latter could be judged in practice. One key conclusion is that the effects of capital, liquidity and asset-side tools on different variables of interest tend to be mixed. On one hand, there is consensus in the sense that all of these tools could provide buffers that contribute to the resilience of the financial sector[3], however, there are differing views on the effects on credit cycles: while some evidence indicates that capital-based macroprudential policies affect the price and quantity of credit (though the precise magnitude is uncertain)[4], liquidity-based tools seem to have only transitory effects[5], while the effect of asset-side tools is less well documented, as relatively few countries have utilized LTV and debt to income (DTI) restrictions with countercyclical purposes[6].

Notwithstanding the aforementioned data limitations, the recent interest in macroprudential policies has spawned a host of literature on the evaluation of their impact on a wide array of economic variables of interest. The state-of-the-art in such assessments can be schematically differentiated depending on the information used. In particular, it is possible to find documents that employ aggregate information at the country level, while others use bank level data and, finally, there are those that estimate the impact of macroprudential policies using information at the bank-debtor relationship level or credit registry data. In the theoretical field there are also some works that evaluate the impact of macroprudential policies on different dimensions using Dynamic Stochastic General Equilibrium Models (DSGE) finding that these policies have a potential role dealing with credit cycles and that they are more effective if used as a complement to monetary policies (Angelini et al. (2011), Agénor et al. (2012) and Brunnermeier & Sannikov (2014), among others).

Starting with the first group, it is noteworthy that most of the papers in the literature have used aggregate macro data to evaluate the impact of different policies on some variable of interest (e.g. credit growth or housing prices). These papers commonly perform event studies or panel data regressions at the country level. The overall findings of this literature can be summarized as follows: i) macroprudential policies can reduce the impact of a bust, diminishing the impact on the real economy (Bakker et al. (2012)); ii)

[3]For instance, asset-side tools (such as caps on loan to value - LTV) can play an important role in increasing the resilience of the banking system by decreasing both the probability of default and the loss given default of loans (Committee on the Global Financial System (2012)).

[4]The Macroeconomic Assessment Group (Macroeconomic Assessment Group (2010)) estimates that the median impact of increasing capital ratios by 1 percentage point (pp) is a reduction in lending by 1 to 2 pp.

[5]Evidence for Latin America suggests that increased reserve requirements have a negative impact on the provision of credit. Nevertheless, effects seem to last mostly two and at best 10 months, suggesting that such tools would need to be continuously recalibrated (Committee on the Global Financial System (2012)).

[6]Tightening LTV or DTI ratios tends to reduce real credit growth by 1 to 2 pp and real house price appreciation between 2 to 5 pp. However, the latter effect on prices is not as evident in other studies (Committee on the Global Financial System (2012)).

their tightening is associated with lower bank credit growth and house price inflation (Bruno et al. (2015), Cerutti et al. (2015) and Akinci & Olmstead-Rumsey (2015)); iii) the effects appear to be smaller in more financially developed and open economies (Cerutti et al. (2015)) and; iv) macroprudential policies are more successful when they complement monetary policy by reinforcing monetary tightening, than when they act in opposite directions (Bruno et al. (2015)).

The use of aggregate data has been used, in particular, to examine the use of reserve requirements, as these have been used by several countries in Latin America, including Colombia. The evidence suggests that these requirements had some transitory effects on credit growth and played a complementary role to monetary policy (Tovar et al. (2012) Agénor & da Silva (2016)). In the region, changes in reserve requirements were occasionally quite large, so the impact could have been significant (Montoro & Moreno (2011)). In the same direction, Federico et al. (2014) find that exogenous changes in this tool in Argentina, Brazil, Colombia and Uruguay had a significant effect on output. The use of aggregate information in Colombia also suggests that reserve requirements are important long-run determinants of business loan interest rates and have been effective in strengthening the pass-through from policy to deposit and lending interest rates (Vargas et al. (2010)).

Regarding the second group, some papers have used information at the bank level to evaluate the impact of various macroprudential policies on individual banking indicators. This strand of the literature has mainly found that DTI and LTV ratios seem to be comparatively more effective than capital requirements as tools for containing credit growth (Claessens et al. (2013) and Lim et al. (2011)). In addition, maximum LTV and DTI ratios and limits on credit growth and foreign currency lending are effective in reducing bank leverage during booms; the authors also find that few policies help to stop declines in bank leverage and assets during downturns (Claessens et al. (2013)). Studying the case of China, Wang & Sun (2013) find that reserve requirements and housing related policies can be useful to reduce procyclicality, but are not enough to reduce systemic risks, suggesting that better targeted policies could have greater potential to contain macro financial vulnerabilities.

Other papers, also using information at the bank level, find that the implementation of macroprudential policies can generate spill-over effects that are commonly ignored. For instance, Aiyar et al. (2014) study the effects of bank capital regulation in the UK (time-varying and bank-specific capital requirements), and find that banks tend to reduce lending when capital ratios increase, but that non-UK regulated banks (resident foreign branches) increased lending in response to tighter capital requirements on regulated banks.

More recently, efforts have been aimed towards evaluating macroprudential policy tools using credit registry data, which allows quantifying the effects of different tools in a more precise way, since the level of granularity allows disentangling supply and demand effects. Nevertheless, there are still relatively few papers in the literature that have used this information to evaluate certain policies. One remarkable exception is the work done by Jiménez et al. (2015), in which the authors examine the effect of countercyclical provisions on credit growth in Spain and the associated real effects. The authors find that these provisions were successful in reducing the effects of a credit crunch (due to build-up of capital buffers) but they were not as successful in curbing the pre-crisis credit boom. In the same line, López et al. (2014) find that countercyclical provisions in Colombia effectively helped reduce the amplitude of credit cycles. In Brazil, using credit registry data, Martins & Schechtman (2013) find that increases in risk weights on highly leveraged automobile loans significantly reduced such financing. For the case of Uruguay, Dassatti et al. (2015) show that reserve requirements for short-term foreign deposits reduced credit supply. The

authors also find that more affected banks increased their exposure to riskier firms and that larger banks were less affected by this regulation.

In summary, even if the literature on the effectiveness of macroprudential policies is still in an early stage, there is an increasing interest to evaluate the impact of different instruments. At this point, the experience of countries that have employed macroprudential policies in the past is of particular relevance. The findings in the literature suggest that the use of these tools can have significant effects on different variables of interest, such as credit growth and measures of bank performance. There is also evidence that the implementation of these policies is accompanied by some effects outside the banking sector. However, many of these papers employ aggregate or bank level information for their analysis, which is not devoid of identification problems that could affect the validity of the results. Colombia represents an interesting experiment, since it is a country that has employed different macroprudential policies, mainly to dampen credit cycles and reduce systemic risk. Therefore, in what follows an evaluation of two macroprudential policies using a rich data set for commercial loans controlling by some characteristics of debtors and lenders is performed.

3 Data and Methodology

3.1 Experience with macroprudential policies in Colombia: 2006-2009

During the second half of 2006 and through the first semester of 2007, the Colombian financial system experienced a period of rapid credit growth, partially countervailing the Central Bank's monetary policy tightening, aimed at curbing excessive expenditure growth and inflation. Specifically, total loans expanded at an average annual real rate of 25.6% during the period, with consumer loans reaching 41.0% and commercial loans registering a rate of 21.7%. In an attempt to reinforce the sluggish transmission of policy rates and limit credit growth, marginal reserve requirements were introduced in May 2007. In particular, a requirement of 27% was initially placed on current accounts, 12.5% for savings accounts and of 5% for term deposits with a maturity lower than 18 months, though by June the requirement for current and savings accounts was unified at 27%; over this period, policy rates rose from 8.25% to 9.25%. By mid 2008 reserve requirements were again modified in order to partially sterilize the monetary expansion caused by a program of international reserve purchases; specifically, marginal reserve requirements were eliminated by late August, but ordinary reserve requirements were tightened. With the economy starting to show signs of a slowdown, and given the uncertainty around the possible effects of what turned out to be the global financial crisis, certain local lending interest rates rose in the last quarter of 2008 as liquidity risk premia increased. The Central Bank reacted by allowing the currency to depreciate with minimal intervention and by reducing the effective reserve requirement[7], thus expanding local currency liquidity in the market (Vargas et al. (2010) and Montoro & Moreno (2011)). Policy rates followed and began progressively decreasing in December 2008, from a high of 10% (set in July 2008) to 4.5% only six months later.

Moreover, complementary macroprudential measures were also undertaken during this period. In an attempt to contain a potential substitution from local funding to external borrowing, in May 2007 the Central Bank reactivated a reserve requirement for short-term external borrowing, with the hope of

[7] Reductions in the average ordinary reserve requirements were announced in October and came into effect in December of 2008.

reducing currency mismatches[8]. In tandem, the Ministry of Finance established a deposit of 40% on portfolio investment[9] and, one year later, required foreign direct investment to have a minimum retention period of two years, thus discouraging speculative flows. The response of financial authorities to reduce the extent of liquidity and foreign currency mismatches by introducing these limits seems coherent with the lessons derived from the financial crisis of the late 90's, as it became apparent that capital flows are largely intermediated (directly and indirectly) through the domestic banking system, hence inducing important liquidity and foreign currency risks that may materialize if there is a sudden stop in capital flows (Reinhart & Kaminsky (1999), Villar et al. (2005) and Uribe (2011)). These controls on foreign flows were terminated in October 2008.

The dynamics of the local currency commercial loan portfolio, the policy rate and certain macroprudential tools put in place between 2007-2008 can be seen in Figure 1. In addition to the countercyclical reserve requirement mentioned above, the effects of the new provisioning scheme for deposit-taking institutions supervised by the SFC can also be observed. Though the dynamic provisioning model had been announced in previous years (specifically, July 2005), the new regime for commercial loans came in effect in July 2007, where an evident increase in specific provisions can be witnessed[10]. Therefore, even though the provisioning scheme was not conceived as a tool to dampen credit growth, its possible effect on the credit cycle cannot be brushed aside, as some evidence seems to confirm their effect on the latter in Colombia (López et al. (2014)). The credit cycle of the commercial portfolio can also be evidenced in Figure 1: between June 2006 and May 2007, local currency commercial loans grew at an average real annual rate of 26.5%; once the macroprudential tools were activated and for the following two years growth rates decelerated, averaging 13.9%. By the final half of 2009 the cycle was evidently in the downturn, and commercial loans grew at an average rate of 6% between July and December, with a low of 1.6% in December.

3.2 Data

To evaluate the effectiveness of the aforementioned macroprudential policies on credit growth, a quarterly dataset containing loan-by-loan operations for the period comprised between 2006Q1 and 2009Q4 is utilized. The information employed is comprised exclusively of commercial loans in local currency granted by banks to firms[11]. The period for the analysis considers information of the year prior to the adoption of the macroprudential policies to be evaluated as well as the year following their elimination (countercyclical

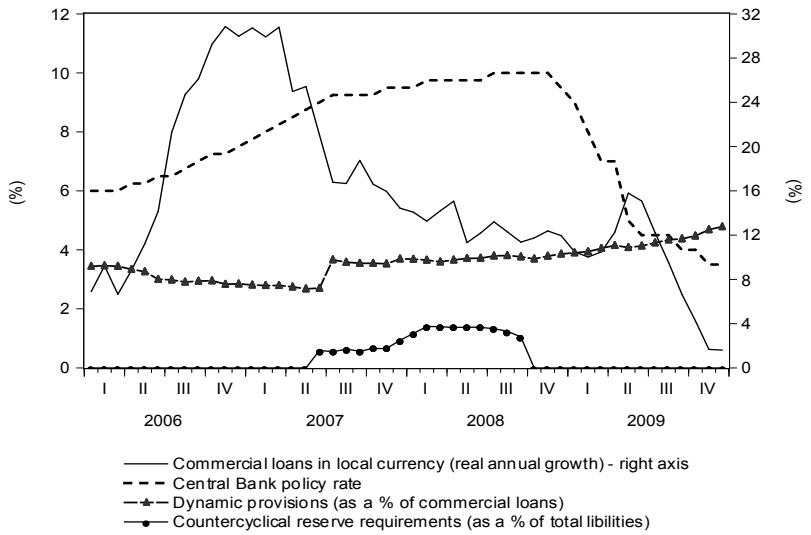
[8] External loans were required a deposit (i.e. reserve) of 40% with a holding period of 6 months.

[9] The deposit on portfolio flows was increased to 50% in May 2008, before being eliminated in October of the same year.

[10] With the new model, individual (i.e. specific) provisions can be calculated with an internal model or with a benchmark model proposed by the Superintendencia Financiera de Colombia (SFC - Financial Superintendence of Colombia). When institutions use the latter model, all inputs in the calculation of the Expected Loss are supplied by the supervisor (i.e. Probability of Default and Loss Given Default). In a nutshell, the methodology for calculating the individual provision consists of estimating two components, an individual procyclical component and an individual countercyclical component. Depending on whether the institution is in a "good phase" or in a "bad" one (to trigger from one to the other, 4 individual indicators on the general financial health of the institution must be above a specified threshold for a period of at least three consecutive months), the formulas to calculate the provisioning level differ; in a "good phase" the accumulation methodology is used, whilst during a "bad phase" the reduction methodology is used. The regulation of the provisioning scheme allows an individual institution facing difficulties, even under a general favorable economic scenario, to compensate part of its provisioning expense, for a particular category, with the use of the countercyclical components obtained from the individual provisions of that loan category.

[11] The information is from the SFC. Variables included in the dataset contain: outstanding value of loan (in local currency), interest rate, maturity, credit rating, payment delays (in days), collateral information, provisions, probability of default and loss given default, among others.

FIGURE 1: Credit Dynamics, Macroprudential Policies and Central Bank Policy Rate



Source: Superintendencia Financiera de Colombia and Banco de la República; authors' calculations.

reserve requirements) or last modification (dynamic provisions)[12]. The resulting sample consists of over 1.9 million observations and 271,071 unique bank-debtor relationships.

TABLE 1: General characteristics of the firms-only sample
(local currency loan operations)

Total Observations	1,933,044
Banks	22
Debtors	152,323
Bank-debtor relations	271,071

Source: Superintendencia Financiera de Colombia; authors' calculations.

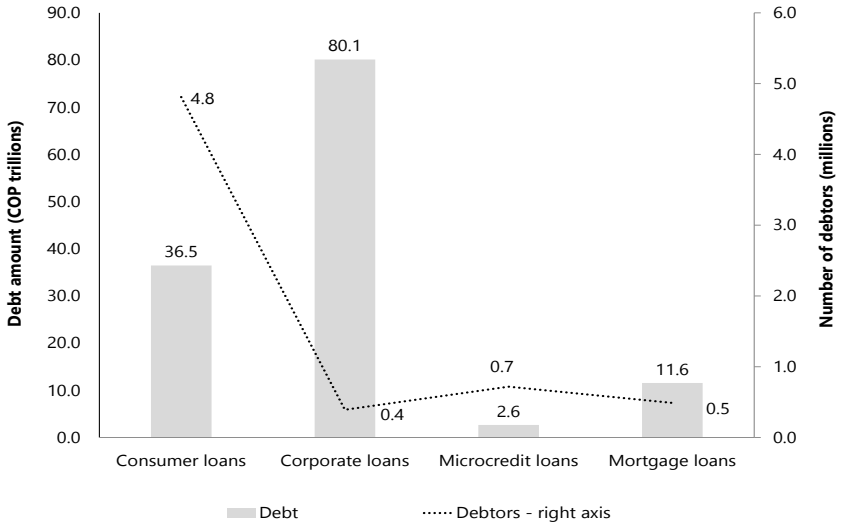
In addition, attention is centered on firms' commercial loans in local currency for two main reasons. On the one hand, firms represent the bulk of credit of Colombian banks, thus embodying the most important debtor of the financial system. As can be seen in Figure 2, commercial loans averaged 60.0% of total local currency loans in the financial system in the period under study, with an average outstanding value of USD 35.8 billion[13]. Of this total, firm's local currency commercial loans with banks represented roughly 84%, implying a concentration of 50.6% of total local currency loans on this kind of debtors. Representativeness on the complete portfolio is of a similar dimension, as local currency loans accounted for close to 95% of total loans, on average, in the period under study.

On the other hand, focus is centered around local currency loans since: i) these account for close to 92% of commercial loans, on average, for the period under analysis; ii) at least one of the macroprudential tools of interest (countercyclical reserve requirements) is targeted at local currency liquidity; and iii) it allows us to not have to deal with the effects on foreign currency loan growth caused by mere movements in exchange rates.

[12] The dynamic provisioning scheme was tightened on June 2008.

[13] Average of the outstanding loan amounts at the end of each year in the period 2006-2009 converted to dollars using the end-of December exchange rate between the COP and the USD of each year.

FIGURE 2: Financial system's debtors and debt amounts
(local currency loans: average 2006Q1-2009Q4)



Source: Superintendencia Financiera de Colombia; authors' calculations.

Importantly, since the variable of interest is loan growth at the bank-client level, one can only incorporate in the sample those debtors that have loans in at least two consecutive quarters. Therefore, the dataset does not consider the value of a new loan on the quarter on which it is granted, unless it is the result of an existing bank-client relationship. A loan for a new bank-debtor relationship would be considered after two consecutive quarters[14].

The sample of firms has some interesting characteristics itself. For instance, as evidenced in Figure 3, there is an evident concentration in the borrowers of the commercial loan portfolio. Indeed, the cumulative distribution of the number of debtors reaches values over 90% much faster than that of the debt amount (Panel A). In particular, while close to 96.5% of the total number of borrowers in a given year have loans of up to USD1 million, their debt roughly accounts for 17.5% of total outstanding commercial loans to firms. On the flip side, around 3.5% of the number of debtors hold close to 82.5% of the outstanding debt.

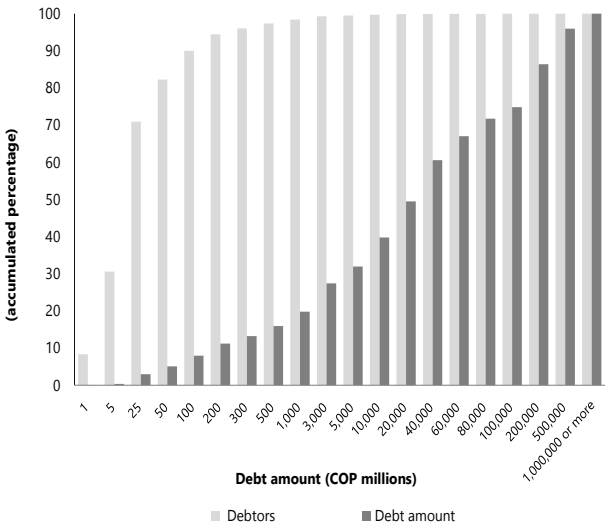
Moreover, the analysis of the average number of banking relationships of borrowers (Panel B) suggests that firms that hold large amounts of debt tend to have a high number of banking connections. Specifically, 3.3% of total debtors, which account for nearly 52% of the outstanding debt, have five or more banking relationships; indeed, less than 7% of total debtors have 4 or more banking connections, but concentrate over 66% of total debt. Most debtors (66.9%) only have one banking relationship in the period of analysis, and represent 10.5% of total debt. Lastly, one can notice that the percentage of debtors gradually decreases as the number of banking relationships is incremented, while the percentage of debt actually tends to increase, especially as one goes from four to five or more banking relationships.

Intuitively, the aforesaid concentration corresponds to large firms, given their enhanced access to formal credit, both in terms of a larger number of counterparts and higher credit lines. Table 2 corroborates said

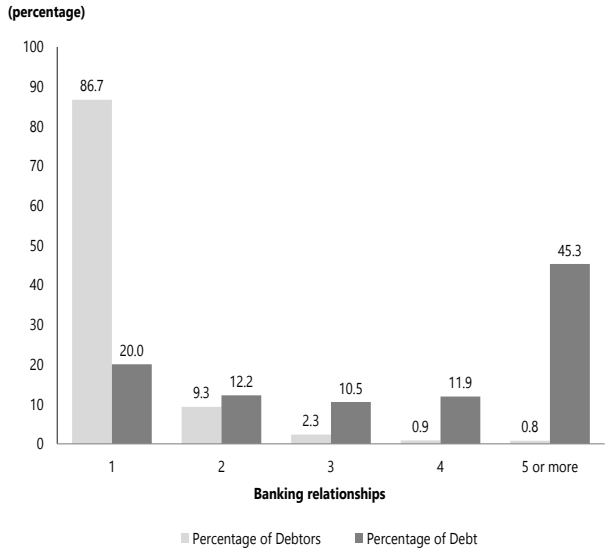
[14]By adjusting the data in this way, one would expect the resulting sample's loan growth to be underestimated when compared to the observed growth. However, this is not the case, as the average annual credit expansion in the sample between 2007-2009 was 23%, which is very close to the actual growth registered in local currency commercial loans in the same period (21%).

FIGURE 3: Debtors and debt amount
(local currency loans: average 2006Q1-2009Q4)

A. Cumulative distribution



B. By number of banking relationships



Source: Superintendencia Financiera de Colombia and Banco de la República; authors' calculations.

intuition. As can be seen, large firms account for close to 70% of total debt in the sample under analysis despite the fact that they represent just 9.9% of the total number of bank-debtor relations. Moreover, when attention is focused only on debtors with 4 or more banking relationships, the representativeness of large firms rises to 80.4% and 28.5% of outstanding debt and number of relationships, respectively.

TABLE 2: Debt amount and bank-debtor relationships, by firm size
(local currency loans: average 2006Q1-2009Q4)

	All observations		**Debtors with # relationships ≥ 4**	
Size	**Debt amount**	**# relationships**	**Debt amount**	**# relationships**
Micro and Small	5.3%	38.9%	1.4%	22.6%
Medium	10.5%	15.7%	6.9%	32.3%
Large	70.3%	9.9%	80.4%	28.5%
Others*	13.9%	35.5%	11.2%	16.7%

*Others corresponds to firms for which it was not possible to determine firm size. It is likely these are small and micro-enterprises.

Source: Superintendencia Financiera de Colombia and Superintendencia de Sociedades; authors' calculations.

Table 3 presents some interesting characteristics of the data as well. In particular, one can see that, on average, close to 42% of the outstanding debt amount corresponded to loans with a time-to-maturity of less than one year, whilst in terms of the number of bank-debtor relationships this share was 33.3%. This result indicates that there are loans of significant amount which were granted with a term of less than a year. The opposite occurs with non-performing loans. In this case, the share of debt represented by loans with more than 30-days overdue is lower than the share of bank-debtor observations which meet the same criteria. The latter implies that loans of a larger amount have lower levels of risk materialization. It may be argued that this is associated with the fact that such loans are extended to client-firms, which

have shown adequate credit behavior in previous loan operations. Regarding guarantees, it is found that around 29% of loans in the sample, both in terms of total outstanding debt and number of bank-debtor relationships, have eligible collateral backing the operation.

TABLE 3: Debt amount and bank-debtor relationships, by certain loan characteristics
(local currency loans: average 2006Q1-2009Q4)

	Debt amount	**# relationships**
Maturity $<$ 1 year	42.1%	33.3%
Non-Performing loans	2.3%	10.8%
Collateralized loans	29.4%	28.6%

Source: Superintendencia Financiera de Colombia; authors' calculations.

Lastly, the mean amount of loans granted in the sample reached USD84,018, with a median time-to-maturity of 1.4 years and an annual interest rate of 20.9% (Table 4). The measures of variability of these variables are indicative of the significant dispersion in this portfolio generated by the heterogeneity of the debtors in the sample (e.g. the median outstanding debt amount is a mere USD9,805).

TABLE 4: Descriptive statistics
(local currency loans: 2006Q1-2009Q4)

Measure	**Debt amount (USD)**	**Loan rate (%)**	**Maturity (years)**
Central tendency	84,018.2	20.9	1.4
Dispersion	266,287.6	5.4	1.0

The measure of central tendency corresponds to the mean in the case of the debt amount, while the median is used for the interest rate and maturity of the loan. Consistent with this, the measure of dispersion is the standard deviation, in the case of the first variable, and the median absolute deviation otherwise. The usage of the median and median absolute deviation for the loan rate and maturity is a consequence of outliers in the data. These are the result of errors in the information reported by the institutions.

Source: Superintendencia Financiera de Colombia; authors' calculations.

3.3 Estimating the Effects of Macroprudential Policies

In order to evaluate the effects on lending of the macroprudential tools that are being analyzed, a loan-by-loan database is employed. As there are many factors that may influence lending dynamics, different types of control variables are used to obtain a more precise measure of the macroprudential tools' impact on the variable of interest. In particular, these controls include a set of macroeconomic variables, as well as bank and bank-debtor characteristics. A set of dummy variables is also included to take into account potential seasonal effects.

Different equations are estimated to check whether the effect on lending of different variables, such as the real cycle, the monetary policy stance, and banks' and firms' riskiness, is altered in the presence of macroprudential policies. In performing all these estimations, a panel methodology using fixed effects is employed[15]. A DiD estimation is also performed to evaluate the impacts of the policies using a counterfactual.

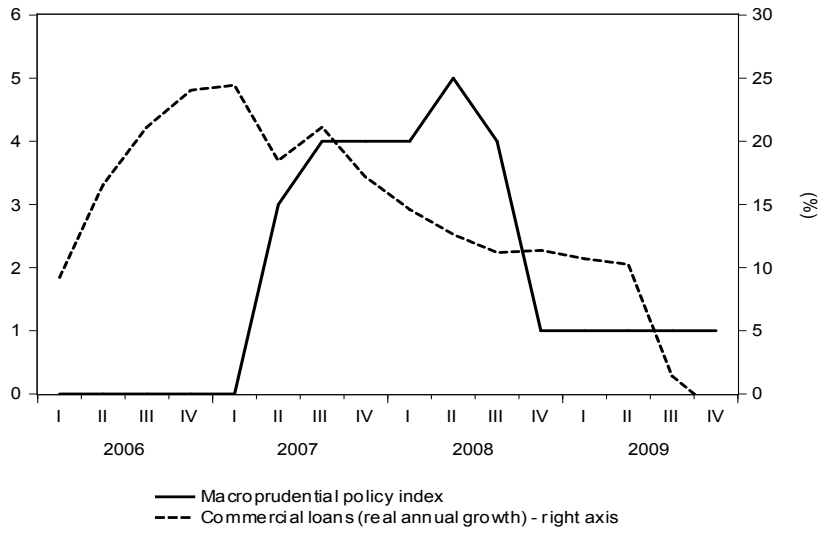
[15]The Hausman test was performed for all equations and statistical evidence to use the fixed effects approach was found.

3.3.1 Variables' Description[16]

In practical terms, the dependent variable that is considered to evaluate the effect of the macroprudential tools on lending is the quarterly growth of the actual value of loans ($\Delta LogCredit_{br,t}$). For this purpose, the specification used for the two macroprudential policies mentioned is: i) the ratio between the total amount of dynamic provisions and total commercial loans ($DP_{br,t}$); and ii) the amount of the countercyclical reserve requirement to total liabilities ratio ($CRR_{br,t}$). Importantly, all the individual macroprudential policies included in this paper are calculated for each bank in quarter t, thus accounting for the differential impact of the former given the balance-sheet structure of each institution.

Additionally, as some of the macroprudential tools were active at the same time, an aggregate variable is used to estimate the joint effect of the tools ($MPPindex_t$). This index captures the macroprudential policy stance of the country, and is defined as the sum of the individual policies' dummy variables (dummies that take the value of 1 if the policy is in place and 0 otherwise)[17]. Figure 4 presents the aggregate index along with real annual growth in commercial credit and in commercial non-performing loans. As can be seen, macroprudential policy was implemented in a countercyclical fashion, with most policies being activated by mid-2007; a period of rapid credit growth. Following the activation of these policies a deceleration in loan growth is readily observable. Though it is important to keep in mind that other factor where at work during the dynamics in credit markets here presented, particularly the collapse of Lehman Brothers in 2008, the observed relationship between these variables points towards a linkage that should, at the very least, be better understood.

FIGURE 4: Macroprudential Policy Index and Commercial Loans
(2006Q1-2009Q4)



Source: Superintendencia Financiera de Colombia and Banco de la República; authors' calculations.

Control variables are divided in three groups: macroeconomic, bank-specific and bank-debtor relationship. The first group includes the following variables in annual changes: real GDP growth ($\Delta LogGDP_t$), the

[16] The precise definition of the variables employed in the regressions is found in Appendix A.

[17] In constructing the index, the following macroprudential policies are considered: i) countercyclical reserve requirements, ii) dynamic provisions, iii) external borrowing requirement, iv) deposit on portfolio investment and v) minimum holding period for FDI.

change in the interbank rate as a proxy of the monetary policy stance ($\Delta MPrate_t$), the real growth in the exchange rate ($\Delta LogEXrate_t$) and the real growth in the current account deficit ($\Delta LogCAdeficit_t$). Moreover, a dummy variable to control for the global financial crisis (D_Crisis_t) is included.

In terms of bank controls several financial ratios commonly used in the bank-lending channel literature are included, such as the liquidity ratio ($BankLiquidity_{br,t}$), return on assets ($BankROA_{br,t}$), bank size ($BankSize_{br,t}$), the deposits to total liabilities ratio ($BankFundComposition_{br,t}$) and an indicator signalling whether a bank is close to the regulatory minimum capital ratio ($BankSignalling_{br,t}$)[18]. Moreover, a variable that captures the total ordinary reserve requirements' stance ($ORR_{br,t}$) is included, so as to control for changes in this tool which might affect local currency liquidity during the period analyzed in this paper[19]. Finally, the external borrowing requirement ($EBR_{br,t}$) is used as a bank control variable, as changes in this tool could have indirect effects on local currency liquidity.

For bank riskiness, a dummy variable that takes the value of 1 if the bank's Z-score indicator[20] ($D_Zscore_{br,t}$) is below a particular percentile of the banking systems' Z-score at each period[21]. To examine the possible differential effects that macroprudential policies can have on the credit supply of heterogeneous banks, idiosyncratic characteristics of these are included as interaction variables with the evaluated policies, in line with Aiyar et al. (2014). Specifically, dummies that take the value of 1 when the bank's individual indicator is above a particular percentile of the variable's distribution at a given moment in time are used[22].

The bank-debtor relationship controls are related to the loans' collateral and the debtor's riskiness. In particular, a dummy variable is defined to distinguish if the loans have eligible collateral ($D\_Collateral_{br,t}$) and, as a proxy for debtor riskiness, a dummy variable based on the number of days a loan has been past due is used. Specifically, this variable takes the value of 1 when any of the loans of a specific debtor has been past due for more than 30 days in quarter t or at least one of the previous three quarters ($D\_FirmRisk_t$).

3.3.2 Estimating the Effects on Credit Growth

As stated above, to estimate the different equations, a fixed effects panel methodology is implemented, where the two dimensions of the panel are time (t) and the bank-debtor relationship (br). Equation (1) is estimated to assess the effect of the macroprudential tools on lending dynamics. It can be expressed as:

$$\Delta LogCredit_{br,t} = \delta_{br} + \sum_{j=1}^{2} \beta_j MacroTool^j_{br,t-i} + \sum_{j=1}^{5} MacroControls^j_{t-i} + \sum_{j=1}^{7} BankControls^j_{br,t-i} + BDRControls_{br,t-i} + quarter_t + \varepsilon_{br,t} \quad (1)$$

[18] Specifically, the indicator takes a value of 1 if the bank's total capital ratio is below the regulatory minimum of 9% plus 200 basis points.

[19] This variable is included at the bank-level and is constructed as the average amount of reserves held in quarter t as a share of total liabilities in the same quarter. Remuneration on these reserves by the Central Bank are deducted from the numerator, as they effectively imply a lower effective requirement.

[20] The Z-score variable is defined as the ratio between the sum of the capital ratio and the mean of the ROA and the standard deviation of the ROA. This measure is negatively related with a bank's probability of default.

[21] The threshold chosen is the 25^{th} percentile.

[22] In particular, dummies for size ($D\_Size_{br,t}$), leverage ratio ($D\_Leverage_{br,t}$), funding composition ($D\_Funding_{br,t}$) and liquidity ($D\_Liquidity_{br,t}$) are utilized. The threshold chosen is the 75^{th} percentile.

where δ_{br} are the bank-debtor relationship fixed effects, $quarter_t$ contains the set of dummy variables to consider seasonal effects, $MacroControls_{t-i}$ are the macroeconomic variables aforementioned, $BankControls_{br,t}$ contains the financial indicators described above, and $BDRControls_{br,t-i}$ includes the variables related to the firms' or loans' characteristics[23]. The indicator j is a counter for the variables employed in each category, while subscript i denotes the lag. To evaluate the effect of the macroprudential tools on the dependent variable, one is interested in the statistical significance of each of the parameters that multiply these variables ($\beta_j \quad \forall j = 1, 2$). As one of the main objectives of these tools is to reduce excessive credit growth, the expected signs for these parameters are negative.

Likewise, to confirm whether the effect of the business cycle over credit growth is altered by the stance of the macroprudential policies, in equation (2) an interaction term between $\Delta LogGDP_{t-i}$ and $\Delta MPPindex_t$ is included. In this case, as the macroprudential tools that are evaluated tend to increase the costs of new disbursements, the effect of GDP growth on loan dynamics should be lower when the stance of the macroprudential policy is tightened. Therefore, γ is expected to be statistically negative.

$$\begin{aligned}\Delta LogCredit_{br,t} = \delta_{br} + \sum_{j=1}^{2} \beta_j MacroTool^j_{br,t-i} + \sum_{j=1}^{5} MacroControls^j_{t-i} + \sum_{j=1}^{7} BankControls^j_{br,t-i} \\ + BDRControls_{br,t-i} + \gamma \Delta MPPindex_t * \Delta LogGDP_{t-i} + quarter_t + \varepsilon_{br,t} \end{aligned} \tag{2}$$

Another analysis is performed using equation (3), where the intention is to test if a strong stance of the macroprudential policies reinforces the negative impact that increases in the monetary policy rate should have on lending dynamics (credit channel). Then, if this is the case, θ should be statistically lower than zero. The estimated equation can be written as:

$$\begin{aligned}\Delta LogCredit_{br,t} = \delta_{br} + \sum_{j=1}^{2} \beta_j MacroTool^j_{br,t-i} + \sum_{j=1}^{5} MacroControls^j_{t-i} + \sum_{j=1}^{7} BankControls^j_{br,t-i} \\ + BDRControls_{br,t-i} + \theta \Delta MPPindex_t * \Delta MPrate_{t-i} + quarter_t + \varepsilon_{br,t} \end{aligned} \tag{3}$$

Additionally, on one hand it is interesting to evaluate if macroprudential policies affect the risk-taking decisions of financial institutions. In equation (4), ρ evaluates if these policies affect the selection of debtors depending on their risk profile (i.e. risk-taking channel). On the other hand, it is interesting to evaluate whether macroprudential policies have different effects depending on the financial health of banking institutions. A significant coefficient of α suggests that the effect of these tools on lending is conditioned on the financial situation of lenders (lending channel)[24]. In order for these effects to be significant, both ρ and α should be statistically lower than zero. The model can be expressed as:

$$\begin{aligned}\Delta LogCredit_{br,t} = \delta_{br} + \sum_{j=1}^{2} \beta_j MacroTool^j_{br,t-i} + \sum_{j=1}^{5} MacroControls^j_{t-i} + \sum_{j=1}^{7} BankControls^j_{br,t-i} \\ + BDRControls_{br,t-i} + \psi D\_Zscore_{br,t} + \alpha \Delta MPPindex_t * D\_Zscore_{br,t} \\ + \tau D\_FirmRisk_{br,t} + \rho \Delta MPPindex_t * D\_FirmRisk_{br,t} + quarter_t + \varepsilon_{br,t} \end{aligned} \tag{4}$$

[23] $BDRControls$ include $CollateralizedLoans_{br,t}$ for all equations and in addition, $D\_FirmRisk_{br,t}$ for equation (4).

[24] As the bank's riskiness measure depends on the Z-score, that is a function of the bank's ROA and capital ratio, the latter are removed from the $BankControls_{br,t}$ and replaced by the bank riskiness measure. Moreover, for this equation, $FirmControls$ also include the $D\_FirmRisk_{br,t}$ indicator.

To complement the previous analysis, equation (1) is re-estimated using the macroprudential index ($MPPindex_t$) instead of the individual tools' variables. In this case, β represents the marginal effects on credit growth of the macroprudential policy stance, and is expected to have a negative sign. Equation (5) is expressed as:

$$\Delta LogCredit_{br,t} = \delta_{br} + \beta \Delta MPPindex_t + \sum_{j=1}^{5} MacroControls_{t-i}^{j} + \sum_{j=1}^{7} BankControls_{br,t-i}^{j} + BDRControls_{br,t-i} + quarter_t + \varepsilon_{br,t} \quad (5)$$

The impact of macroprudential policies can be conditioned by bank-specific characteristics. To delve further on this aspect, one can exploit the cross-sectional dimension of said characteristics in order to evaluate whether the effects of the policies are affected by different banking dimensions (i.e. X_k). For instance, one can test if the policies have distinct effects between large and small banks (i.e. size dimension), or if funding composition (intensity of core liabilities) is a relevant characteristic for differentiating the effects of macroprudential policies on credit growth. It is expected that characteristics relating to capital ratios and the size of financial intermediaries alter the way countercyclical provisions affect credit supply, as provisions are an expense, thus directly pertaining to bank profitability and its ability to show organic growth. Meanwhile, the funding composition of banks and liquidity ratios should affect the reaction of banks to a tightening in reserve requirements, as these are analogous to a tax on deposits. Equation (6) allows one to test these hypothesis.

$$\Delta LogCredit_{br,t} = \delta_{br} + \sum_{j=1}^{2} \beta_j MacroTool_{br,t-i}^{j} + \sum_{j=1}^{5} MacroControls_{t-i}^{j} + \sum_{j=1}^{7} BankControls_{br,t-i}^{j} + BDRControls_{br,t-i} + \sum_{j=1}^{2}\sum_{k=1}^{3} \theta_{jk} MacroTool_{br,t-i}^{j} * X_k + quarter_t + \varepsilon_{br,t} \quad (6)$$

On a final note, it is worth mentioning that both null observations and outliers were removed. In particular, values below the 1^{st} percentile and over the 99^{th} percentile of the credit growth variable were dropped. Moreover, for all the equations, based on the statistical significance of the parameters, the value of $i = 0, 1$ or 2 is selected for the control variables as well as the macroprudential tools.

4 Results

4.1 Results Using Panel Data

The main results from the econometric model explained above can be found in the Tables below. In particular, Table 5 depicts the estimated coefficients for the first five equations described in Section 3.3.2. As can be seen, macroprudential policies associated with higher provisioning and reserve requirements effectively have a negative effect on loan growth (equations (1) - (4)). These results are as expected, as both policies could increase the cost of intermediating funds; in the first case associated with higher provisioning expenses, and in the other with a shift in funding composition away from reservable (partially insured) liabilities. Moreover, the change in the MPP index, which captures the aggregate stance of macroprudential policy, also has a negative and significant effect on credit growth (equation (5)).

The impacts of the relevant macroeconomic controls used in the distinct specifications show consistency in their effect on loan dynamics. On one hand, higher economic growth leads to an increase in lending, consistent with the procyclicality exhibited in credit markets: a growing economy requires financing for investment projects and higher consumption of goods, while at the same time improves the balance-sheet of the private sector, increasing bank's willingness to lend (Kiss et al. (2006)). On the other, the policy rate has a negative and consistently significant effect on credit growth, highlighting the countercyclical nature of monetary policy and the effectiveness of its tool. In addition, this last result conveys an important implication, namely, it confirms the complementarity between macroprudential and monetary policy, as they both have a moderating effect on loan growth when tightened (as was the case in the 2007-2008 period).

Pertaining to the effect of the interaction between the MPP index and real GDP growth (equation (2)), results show that this is also consistent with the notion that macroprudential policy serves as a stabilizing tool in the economy. In particular, when the macroprudential policy stance is tightened, the expansionary effects of economic growth on credit are reduced, thus dampening the prociclicality of loan growth. The interaction with the policy rate (equation (3)) has the expected sign, with macroprudential policy reinforcing the effect of monetary policy. However, the coefficient is not statistically significant.

In addition, equation (4) provides an interesting insight as to the role of macroprudential policy in altering banks' risk-taking behavior. As can be seen, firms with a higher risk profile are associated with lower loan growth. Moreover, results show that when macroprudential policies are in place, the access to credit of riskier debtors is further reduced. Regarding bank's riskiness, it can be seen that intermediaries with higher financial fragility are characterized by higher loan growth, but more importantly, that once the macroprudential policies are in place their credit supply is more severely affected than that of their more stable peers. Thus, a tightening of the aggregate macroprudential policy stance adversely affects the selection of debtors depending on their risk profile (i.e. risk taking channel), while at the same time suggesting that the effect on credit is conditioned to the lenders' financial situation (i.e. lending channel).

It is interesting to note that the requirement on external borrowing does not have a statistically significant effect on credit dynamics. Though this might be expected, considering that the endogenous variable is local currency loan growth, there could potentially be indirect effects on domestic currency lending associated with tighter foreign currency liquidity in the market. Nevertheless, this result is consistent with the findings reported by Ostry et al. (2010), who survey a number of papers on the role of the 2007-2008 capital controls in Colombia and find that they had no effect in reducing the volume of net foreign flows[25]. Lastly, ordinary reserve requirements, net of remuneration by the Central Bank, are also found to have a statistically non-significant effect on loan growth in the period under study.

As mentioned in section 3.3.2, the effect of macroprudential policies can be influenced by bank-specific characteristics. Thus, equation (6) tries to exploit the cross-sectional dimension of the data. As can be seen in Table 6, results are consistent with those found on equations (1) - (5), confirming the negative effect of the evaluated MPP on loan growth. In addition, it is interesting to note that the effect of dynamic provisions on loan growth is moderated for banks with larger value of assets (i.e. size) and which are more concentrated on traditional funding sources, while it is intensified for those with a higher leverage ratio. These results seem to suggest that larger banks exhibit more prudent behavior on their loan portfolio origination practices, which would also be consistent with a more traditional funding structure (i.e. more core deposits vis-a-vis wholesale funding). Conversely, a higher leverage ratio could be the reflection

[25]The papers surveyed in Ostry et al. (2010) for the case of Colombia are Concha & Galindo (2008), Cárdenas (2007) and Clements & Kamil (2009).

TABLE 5: Estimation Results on Credit Growth

Relevant Exogenous variables	Equations (1)	(2)	(3)	(4)	(5)
$DP_{br,t}$	-0.514***	-0.614***	-0.509***	-0.398***	
$CRR_{br,t}$	-0.668**	-0.642***	-0.731***	-0.649***	
$\Delta MPPindex_t$					-0.008***
$\Delta MPPindex_t * \Delta GDP_{t-1}$		-0.135***			
$\Delta MPPindex_t * \Delta MPrate_t$			-0.083		
$\Delta MPPindex_t * D\_FirmRisk_t$				-0.003***	
$D\_Firm\ Risk_t$				-0.065***	
$\Delta MPPindex_t * D\_Zscore_t$				-0.005***	
D_Zscore_t				0.003*	
$\Delta LogGDP_{t-1}$	0.402**	0.380***	0.474***	0.305***	0.530***
$\Delta MPrate_t$	-0.517***	-0.426***	-0.493***	-0.266*	-0.423***
$EBR_{br,t}$	0.162	0.192	0.090	0.111	
$ORR_{br,t}$	0.083	0.019	0.089	0.057	0.040
Observations	1,614,534	1,614,534	1,614,534	1,614,534	1,614,534
Hausman Test p-value	0.000	0.000	0.000	0.0000	0.000
F Test p-value	0.000	0.000	0.000	0.0000	0.000

* Statistically significant at the 10% level.

** Statistically significant at the 5% level.

*** Statistically significant at the 1% level.

Source: authors' calculations.

of higher risk appetite from the bank. Indeed, during the period under study, larger banks exhibited an average ratio of risky commercial loans[26] to total commercial loans which was one percentage point lower than that of smaller banks (6.6% against 7.6%); the reverse holds for more levered banks (8.3% vs 7.1%)[27].

On the other hand, the effect of the countercyclical reserve requirement on loan growth is moderated for banks with higher levels of liquidity, but is intensified for those of larger size and a more traditional funding structure. The effect of higher liquidity and more traditional funding is in line with intuition; regarding the former, more liquid institutions have available funds (or can readily liquidate investments) to grant new loans, whilst the latter will be relatively more affected by a tax on deposits, which constitute a traditional funding source[28]. The result for size could be associated with larger banks holding larger shares of demand deposits, which in turn have higher requirements than term deposits. Indeed, for the period under analysis, larger banks had an average share of term deposits on total deposits of around 28%, whilst for smaller banks this ratio reached 40.5%.

[26] In Colombia, loans are given a credit score that goes from A to E, where A is the highest credit quality. Risky commercial loans are defined as those with a credit score different from A.

[27] The means of the indicators here compared are statistically different.

[28] Deposits are defined as the sum of demand deposits, current accounts and term deposits.

TABLE 6: Estimation Results on Credit Growth - Cross Sectional Analysis

Relevant Exogenous variables	
$DP_{br,t}$	-0.819***
$CRR_{br,t}$	-3.231***
$DP_{br,t} * D\_Leverage_{br,t}$	-0.345***
$DP_{br,t} * D\_Size_{br,t}$	0.217**
$DP_{br,t} * D\_Funding_{br,t}$	0.430***
$CCR_{br,t} * D\_Liquidity_{br,t}$	0.938***
$CCR_{br,t} * D\_Size_{br,t}$	-0.812**
$CCR_{br,t} * D\_Funding_{br,t}$	-0.830***
Observations	1,459,331
Hausman Test p-value	0.000
F Test p-value	0.000

* Statistically significant at the 10% level.

** Statistically significant at the 5% level.

*** Statistically significant at the 1% level.

Source: authors' calculations.

4.2 Difference in Differences Estimation

The effects of macroprudential policies on credit growth were confirmed using DiD analysis. It is arguable that a significant effect on loan growth at a specific period in time could be related to other events occurring at the moment, and not necessarily due to the effects of the macroprudential policies in place. Thus, the identification of a causal relationship is clearer using a counterfactual and performing a DiD estimation (commonly used in policy evaluation analysis).

In particular, the impact of the policy experiments regarding dynamic provisioning and marginal reserve requirements on credit availability at the loan level are tested. For the definition of the counterfactual, the levels of provisions and reserve requirements that banks would have constituted are calculated assuming that each requirement was enacted one year before the actual implementation date[29]. This policy evaluation technique follows closely the work done by Jiménez et al. (2015) for assessing the impact of the dynamic provisioning scheme in Spain[30].

After calculating the changes in each bank's provisioning and reserve requirements, assuming that the policies were implemented one year before, a DiD estimation is performed so as to compare the lending

[29] In constructing the counterfactual for dynamic provisions, the reference model developed by the SFC in 2007 to calculate Loss Given Default and Probability of Default was used. It is interesting to note that since the establishment of dynamic provisions in Colombia, all institutions have used the reference model provided by the supervisor, though they are allowed to use internal models as well. In calculating the counterfactual for the marginal reserve requirement, the initial weights introduced in May 2007 were used (i.e. 27% for current accounts, 12.5% for savings accounts and 5% for term deposits with a maturity of up to 18 months.)

[30] Another possible way of defining the counterfactual is to use the information of the banks or institutions for which the new rule does not apply. Thus, Jiménez et al. (2015) evaluate the difference between banks that are and are not subject to dynamic provisions in Spain. The authors also make comparisons among different periods of interest. This approach is not applicable in the case of Colombia, since the evaluated requirements apply to all deposit-taking institutions.

intensity of the same bank before and after each policy shock. In that line, the identification strategy stems from the time dimension (i.e. before and after the policy shock). The estimated equation is given by:

$$\Delta LogCredit_{bf}(Impactperiod) = \delta_f + \beta Macrotool(counterfactual)_b + controls_{bf} + \varepsilon_{bf} \quad (7)$$

where $\Delta LogCredit_{bf}(Impactperiod)$ refers to the change in the log of credit from bank b to firm f in the one-year window after the implementation of each macroprudential tool. Fixed effects are captured by δ_f and $controls_{bf}$ are the same variables at the bank-level that are employed in the previous equations. The parameter β can be interpreted as the additional annual change in credit growth with respect to the baseline group (i.e. counterfactual). In other words, β is interpreted as a semi-elasticity (the change in credit growth to the average firm in response to a one unit increase in the macroprudential requirement). As highlighted by Jiménez et al. (2015), even though one analyzes the same bank before and after the shock, one needs to control for bank fundamentals that could be differently affected. By using firm fixed effects, one is able to capture both observed and unobserved time-varying heterogeneity in firm characteristics that could affect credit demand.

The results of the estimations suggest that an increase of 1 percentage point (pp) in the provisioning to commercial loans ratio (for the period it would correspond to an increase from 3.7% to 4.7%, on average) leads to a decrease of 0.97 pp in credit growth. In the case of the countercyclical reserve requirement, an increase of 10 basis points in the marginal reserve requirements to total liabilities ratio (for the period it would be an increase from 0.4% to 0.5%, on average) corresponds to a decrease of 0.8 pp in credit growth[31]. These results confirm that both policies significantly affected credit growth.

5 Concluding remarks

Following the Global Financial Crisis of 2007-08, considerable interest has been focused on the potential of macroprudential policies as a complement to microprudential and monetary policy. In a nutshell, macroprudential tools are designed to mitigate systemic vulnerabilities by limiting the build-up of risk (the time series dimension of systemic risk) and increasing the resilience of the financial system (cross-sectional dimension). In this way, these tools help to foster and maintain financial stability. Nevertheless, despite their recent renaissance in developed economies, these tools have been most actively used in developing countries. In this respect, analyzing the experience of emerging economies in the use of macroprudential policies can shed some light on their potential effectiveness, for example, in curbing credit growth.

To this end, our paper uses a micro dataset containing information for over 1.9 million observations in the 2006Q1-2009Q4 period. The use of loan-by-loan information is particularly valuable in that it allows different effects to be disentangled and the impact of two distinct macroprudential policies on credit growth to be effectively estimated. Using a fixed effects panel data method, we find that dynamic provisions and the countercyclical reserve requirement have a negative effect on loan growth. Our results also provide evidence of the differential effect that these policies have on financial intermediaries' credit

[31] The shocks considered above (i.e. a 100 basis points (bp) increase in DPP and a 10 bp increment in CRR) are equivalent to assuming an increment of 23% and 10% in the average dynamic provisions and marginal reserve requirements, respectively, during the analysis period. If a homogeneous increase in average requirements and provisions of 15% during the analysis period is contemplated, the resulting increments in DP and CRR would be equivalent to 71 bp and 21 bp, leading to a decrease of 69 bp and 92 bp in credit growth, accordingly.

supply depending on their idiosyncratic characteristics. In particular, the effect of dynamic provisions is weakened in banks with a higher value of assets and a larger share of deposits in their liability structure, while it is intensified for those with higher leverage ratios. With respect to the countercyclical reserve requirement, it is found that its effect is moderated for banks with a higher share of liquid assets, but is reinforced for those of larger size and a more traditional funding structure. Moreover, the results of the DiD estimation provide further evidence for the moderating effect of the evaluated macroprudential policies on credit dynamics.

Additionally, the findings presented in this paper support the notion that these policies have been historically used as a complement of monetary policy, thus increasing the stabilizing effects of interest rate changes on credit cycles. In other words, these policies have been used in a countercyclical way, thereby helping to reduce the procyclicality of credit. Another key finding is that macroprudential policies seem to be effective in influencing banks' risk-taking behavior. In particular, a tightening of the aggregate macroprudential policy stance is shown to reduce the access of riskier debtors to credit, and to have a stronger negative effect on the credit supply from less stable financial institutions. This preliminary evidence of the effect of macroprudential policies on banks' risk-taking should be further explored, as it constitutes a significant channel through which these policies can affect financial markets[32]. In fact, Altunbas et al. (2016), using bank-level data, suggest that these policies have a significant impact on bank risk; also, that these effects differ depending on banks' specific balance sheet characteristics.

Our results are particularly relevant for policy makers as they highlight an important fact; that macroprudential policies seem to be effective in dampening credit cycles, thus helping to mitigate systemic vulnerabilities and risk build-ups. They also seem to be complementary to monetary policy. The findings also seem to confirm the effectiveness of a broad spectrum of macroprudential policy tools that are designed to bolster resilience and target risk accumulation through various channels and intermediate objectives. They also suggest that the effects of these policies affect different banks and debtors in varying ways, depending on banks' financial health and borrower credit quality. Thus, the choice of tool is non-trivial, and should take into account the idiosyncratic effects of each instrument so as to utilize the most effective policy at hand for the chosen objective.

[32] A similar analysis, using loan-by-loan information for Colombia, is currently being prepared in a separate paper.

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Appendix A Variables

Table 7: Variables Description

Type of Variable	Variable	Description
Dependent Variable	$\Delta LogCredit$	Quarterly growth of the actual value of loans for each bank-debtor relationship.
Macroprudential Policies	DP	Dynamic provisions to commercial loans ratio for each bank.
	CRR	Countercyclical reserve requirement to total liabilities ratio for each bank.
	$\Delta MPPindex$	Quarterly change in the Macroprudential Policy Index. The index captures the aggregate macroprudential policy stance of the country, and is defined as the sum of the individual policies' dummy variables (dummies that take the value of 1 if the policy is in place and 0 otherwise).
Macroeconomic Controls	$\Delta LogGDP$	Annual real GDP growth (constant prices of 2012).
	$\Delta MPrate$	Annual real change in the interbank rate.
	$\Delta LogCAdeficit$	Real annual change in the current account deficit (constant prices of 2012).
	$\Delta LogEXrate$	Real annual change in the exchange rate (constant prices of 2012). The exchange rate considered is COP to USD. The level of the latter is expressed relative to the CPI.
	D_Crisis	Dummy equal to 1 in quarters between 2008Q3-2009Q4.
Bank characteristics	$BankLiquidity$	Ratio between the sum of cash and liquid investments and total assets.
	$BankFundComposition$	Deposits to total liabilities ratio.
	$BankROA$	Ratio between bank annualized profits and total assets annual average.
	$BankSignalling$	Dummy that takes the value of 1 if the bank's total capital ratio is below 11% and 0 otherwise.
	$BankSize$	Natural logarithm of total assets.
	D_Zscore	Dummy that takes the value of 1 if the bank's Z-score (ratio between the sum of the capital ratio and the mean of ROA and the standard deviation of ROA) is below the 25^{th} percentile of the banking systems' Z-score at each period.
	ORR	Ordinary reserve requirement to total liabilities ratio. Central Bank remuneration of this requirement is deducted from the numerator.
	EBR	External borrowing requirement to total liabilities ratio.
	$D\_Leverage$	Dummy that takes the value of 1 if the bank's leverage ratio (share of total assets to equity) is above the 75^{th} percentile of the banking system's leverage at each period.
	D_Size	Dummy that takes the value of 1 if the bank's size is above the 75^{th} percentile of the banking system's size at each period.
	$D\_Funding$	Dummy that takes the value of 1 if the bank's funding composition is above the 75^{th} percentile of the banking system's funding composition at each period.
	$D\_Liquidity$	Dummy that takes the value of 1 if the bank's liquidity is above the 75^{th} percentile of the banking system's liquidity at each period.
Firm characteristics	$D\_Collateral$	Dummy that takes the value of 1 if the largest amount of credit for each bank-debtor relationship has eligible collateral, 0 otherwise.
	$D\_FirmRisk$	Dummy that takes the value of 1 if in quarter t firm f had non-performing loans outstanding in t or in one of the previous 3 quarters (even with another bank).

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