The risk-taking channel and monetary transmission mechanism in Colombia

Paper prepared for the 2nd BIS CCA Conference on

"Monetary policy, financial stability and the business cycle"

Ottawa, 12–13 May 2011

Authors*: Martha López, Fernando Tenjo and Héctor Zárate

Affiliation: Bank of the Republic (Colombia)

Email: mlopezpi@banrep.gov.co, ftenjoga@banrep.gov.co, , hzaratso@banrep.gov.co

---

The Risk-Taking Channel and Monetary Transmission Mechanism in Colombia

Martha López[1]

Researcher, Department of Macroeconomic Modelling, Banco de la República

Fernando Tenjo

Co-Director, Board of Directors - Banco de la República

Héctor Zárate

Chief of the Statistics Department, Banco de la República and Professor at Universidad Nacional de Colombia

Abstract

The recent financial crisis has brought to the forefront the need of a better understanding of the transmission mechanisms of monetary policy. The main step forward in this direction has drawn on work aimed at stressing the role of the financial sector in this transmission. Particular emphasis has been place on how policy actions impact risk perceptions and attitudes of banks and other financial institutions, leading to shifts in the supply of credit. Along these lines, and based on evidence from Colombia, the present paper finds a significant link between low interest rates and banks risk taking based on evidence from Colombia. Lower interest rates raise the probability of default on new loans but reduce that on outstanding loans. Furthermore, this channel of policy transmission depends on some bank, loan and borrower characteristics, as well on macroeconomic conditions such as the rate of growth of the economy.

Key Words: monetary policy, lending standards, risk taking, duration analysis, accelerated failure time models.
JEL Classification: E44, G21, L14.

---

[1]Correspondent author. Tel.:571 3430512; fax: 571 2865936. E-mail address: mlopezpi@banrep.gov.co, ftenjoga@banrep.gov.co, hzaratso@banrep.gov.co.

1. Introduction

This paper explores a dimension of the monetary policy transmission mechanism that has not been assigned due attention in the theoretical literature and empirical studies, namely, the extent to which policy shocks have real effects through their impact on the behavior of banks towards risk.

To a good extent, this motivation for the work relates to the role played by the financial sector in general, and credit markets in particular, during the recent crisis. Beyond that, however, the role of banks and other financial institutions in the monetary transmission mechanism has been underestimated in much of the work conducted by academics and central banks alike.

Recent work has created favorable conditions for a more appropriate approximation to these issues. New conceptual developments have provided a sounder basis for the analysis of how interest rates impact risk perceptions and risk tolerance of banks and how this translates into lending decisions, including quantities, prices and requirements. The well-known lending channel, with its two key related concepts, the financial accelerator and the external finance premium, has been complemented with the risk-taking channel that explains how the effect of the former channel can be enhanced, creating the possibility of buildup of risk and pro-cyclical or self-accumulating processes in the economy.

The availability of large data sets for banks, borrowers and loans, both at the individual country level and for groups of countries, coupled with the development of statistical and econometric devices have also made it possible to conduct comprehensive studies of how monetary policy is transmitted through changes in funding costs of banks and balance sheets, controlling for financial and macroeconomic conditions and bank, borrower and loan characteristics. Central to these exercises is the possibility of estimating the probability of default of individual loans or financial institutions that are the dependent variables in empirical works.

This paper draws from these developments and analyzes empirically the link between monetary policy and risk-taking by banks in Colombia. It uses

a data base, with a quarterly frequency, for more than two million loans for the period 2000:I to 2008:IV.

The paper concludes that low interest rates affect monetary policy by increasing the probability of default of new loans and lowering that for outstanding loans. This result is interpreted in terms of shifts in risk appetite of banks (perception and willingness). It is also found that this effect depends on the strength of balance sheets and on macroeconomic conditions.

The paper is organized as follows. The first section is this brief introduction. Section 2 presents the conceptual framework that links monetary policy and the supply of credit, overviews the key concepts of the lending and the risk-taking channels of monetary policy, and derives predictions on the impact of monetary policy when these channels are active. Section 3 elaborates on the empirical approach to study the occurrence of the above mentioned channels of monetary policy in Colombia, and explains the model and its variables. Section 4 summarizes the main findings of the empirical work. Lastly, the conclusions of the papers are presented in Section 5.

2. Monetary Policy and the Supply of Credit

2.1. Financial variables in the transmission of monetary policy

The recent financial crisis has brought to the forefront the need of a better understanding of the transmission mechanisms of monetary policy. The main step forward in this direction has drawn on previous work aimed at stressing the role of the financial sector in this transmission. The dominant approach, more in line with the traditional Neo-classical school, has been found wanting. This approach underlines the impact of monetary policy on the relative yields of imperfectly substitutable assets (money versus bonds) Borio and Zhu (2008). These, in turn, affect investment (user cost of capital and Tobin's q) and consumption (wealth and inter-temporal substitution effects) decisions, as well as trade flows through real exchange rates (real) Boivin et al. (2009) and Hatzius et al. (2010). Other non-Neo-classical schools, stress similar channels (investment and consumption optimization) but add an expectations channel in the transmission of monetary policy shocks. For this school, the key elements behind the real effects of monetary policy are the presence of price stickiness and the capacity of the monetary authority to anchor inflation expectations. The real effects of monetary policy are

then derived from frictions in goods markets. It goes without saying that the inclusion by this neo-Keynesian school of inflation expectations in the policy rule of monetary authorities could be interpreted as a way to allow for the effect of financial variables, in particular those embedded in the yield curve, on policy decisions. Looked at more closely, the transmission of monetary policy along these lines really implies, at best, constant interest rate spreads and a passive role for the financial system. In striking contrast with these approaches, there is a growing body of literature that underscores how monetary policy alters the financial conditions of the economy that shape the behavior of economic agents. In particular, this literature focuses on how monetary policy is transmitted to the real economy through its impact on the balance sheets of economic agents and their perception of risk. In turn, this impact depends on the macroeconomic and financial conditions of the economy and on the strength of balance sheets. More concretely, to the extent that these effects converge in the dynamics of the credit market, they conform what is known as the lending channel of the transmission of monetary policy.

2.2. The bank lending channel of monetary policy

There are at least two complementary strands in the literature that emphasize different elements of this channel. One strand originates in a reassessment of the accelerator mechanism and emphasizes the existence of frictions at the level of financial intermediaries derived from asymmetric information in capital and money markets. These frictions are behind the effect of changes in short-term interest rate by the central bank on the external finance premium or the cost of funds for banks and other financial intermediaries Disyatat (2010). In a nutshell, the link between monetary policy shocks and the external finance premium lies in the perceived strength of the balance sheet of financial institutions which determine their expected probability of default. Changes in banks' cost of funds in response to such shocks translate into differing responses in the supply of credit, depending on this probability of default. The risk perceptions of economic agents involved in the previous mechanism are themselves endogenous and unstable. This gives rise to what is known as the risk-taking channel of monetary policy, or the effect that this policy may have on the perception of and willingness of agents to bear risk Disyatat (2010). Borio and Zhu (2008) have formalized the risk-taking channel by showing how monetary policy may strongly influence the risk in portfolios, the pricing of assets, and the spreads and

non-price terms in the extension of credit. The authors underline how this channel operates through the impact of interest rates on valuations, incomes and cash flows, as well as on target rates of return of investors. Furthermore, a central bank that reduces uncertainty regarding the future of the economy may exert a downward influence on risk premia. (Adrian and Shin, 2009a,b) provide a complementary approach to the bank lending channel in general, and the risk-taking channel in particular. For these authors, the latter channel summarizes the set of effects of monetary policy that work through the risk appetite of financial intermediaries that lies behind shifts in the supply of credit. Along these lines, the origin of the risk-taking channel would be agency relationships in the organization of finance in society which manifest themselves in the way financial intermediaries manage their balance sheets, in particular leveraging short term liabilities to finance longer-term assets. Monetary policy not only determines short-term interest rates but also strongly affects the financial conditions of the economy.

2.3. Summary and predictions

A summary of the previous ideas is in order.

Attempts to understand and highlight the active role of banks and financial intermediaries in the transmission of monetary policy have focused their attention on the way policy shocks translate into changes in the supply of credit. This can be put together in terms of two complementary channels, the lending and the risk-taking channels. Of these, while the former points to the transmission of monetary policy as such, the latter refers to how the effects of this policy can be amplified throughout the economy, with important real implications. Firstly, the transmission of monetary policy is highly influenced by: (i) the health of the balance sheet of financial intermediaries (regarding leverage and asset quality) and (ii) the perceptions of risk of economic agents, given (iii) the macroeconomic and financial conditions of the economy. The key element in this process is the external finance premium, or the cost of funding for these intermediaries, which reflects their perceived probability of default. Secondly, monetary policy decisions impact the perceptions of risk and the behavior of economic agents, through its effect on asset valuations, cash flow implications, and risk appetite and tolerance. This means that estimates of probabilities of default of banks and other financial institutions are endogenous and give rise to pro-cyclical and feed-back mechanisms. Lastly, in terms of available policy instruments, the effects of monetary policy derive not only from the level of the short-term interest rate

but also from liquidity and balance sheet management by the central bank and communication strategies of the monetary authority. The level of the policy rate is particularly important as it directly relates to risk-free interest rates and influences the cost of funds for banks and other intermediaries and asset and liability valuations. From the preceding models it is possible to establish a close relationship between the stance of monetary policy, credit spreads, the growth and strength of balance sheets of financial intermediaries and economic activity. Running through this chain of causation is the idea that the short-term interest rates affect not only a wide set of other rates but also the risk appetite and/or the risk-taking capacity of financial intermediaries. With this setting in mind, the literature has put forward various testable hypotheses, such as: (i) the effect of changes in interest rates on the probability of default of loans of banks; (ii) the role played by some features of banks (size, liquidity, leverage, asset quality, etc.) in their response to monetary policy decisions or as determinants of the sensitivity of the external finance premium to these decisions Disyatat (2010). Briefly put, three sets of variables would be at the center of the role of the financial system in the transmission mechanism of monetary policy: interest rates, balance sheet characteristics and the external finance premium of banks or their perceived probability of default.

3. The Risk-taking channel: empirical approaches and application to Colombia

3.1. Two lines of research

The bulk of the empirical work on the bank lending and the risk-taking channels can be grouped into two categories:

(i) The first is centered in the idea of the external finance premium or perceived probability of default as influenced by both interest rate decisions of the central bank, conditional on a set of bank specific characteristics, and the state of the economy. This line of research follows the intuition that policy rates affect the willingness to and the capacity of agents to bear risks, and includes the estimation of the perceived probability of default in terms of "expected default probabilities" or "loan hazard rates", proxies for the likelihood of a loan not being repaid. Some of the works in this group are: Gambacorta (2009), Jimenez et al. (2009) and Altunbas et al. (2009a). Altunbas et al. (2010) analyze determinants of probabilities of default at the bank level.

6

(ii) The second group of studies, with a longer tradition, looks for a direct link, also conditioned by bank-specific characteristics, between changes in the policy rate and the supply of credit. The rationale behind this is that the dynamics of some components of the balance sheet of financial intermediaries (the stock of outstanding loans, in this case) is an indication of the risk appetite of these agents as influenced by policy decisions. Some of the papers in this group are: Altunbas et al. (2009b), Kashyap and Stein (2000) and Ioannidou et al. (2009), which is more of a combination of the two approaches.

As already mentioned, there is research on the transmission mechanism of monetary policy at the level of borrowing firms, lending banks, or individual loans, and mostly assembling data for sample of countries. ECB (2009) summarizes the main results of a comprehensive survey of papers on the subject for the euro area, and concludes that "the various credit channels are part of monetary policy transmission in the euro area(and that) recent empirical results point to an amplification of monetary policy impulses via the so-called risk-taking channel" (p. 79).

3.2. A study of the risk-taking channel for Colombia

The present paper follows very closely the research by Jimenez et al. (2009), which can be singled out as a major representative of the first category of works mentioned above. The authors analyze the impact of short-term interest rates on the probability of loan default in Spain. They do this for both before loan origination and during the life of a loan, and controlling for bank, firm, loan and macroeconomic characteristics. For this, they put together a sample of business loans with a quarterly frequency for the period 1985:I to 2006:II. The work in question proposes a measure of credit risk or a proxy for a conditional perceived probability of default which the authors name the hazard rate or the probability of loan default during each period of the life of the loan given that default did not occur before. The findings derived by Jimenez and his colleagues are interesting, to say the least. They find that "low interest rates increase bank-risk taking, reduce credit risk in banks in the very short run but worsen it in the medium run(In addition) higher GDP growth reduces credit risk on both new and outstanding loans". As the authors in question rightly stress, the basic ingredients of the empirical strategy are: a valid measure of bank credit risk; a methodology that accounts for the dynamic context of the exercise; and exogeneity of monetary

7

policy.

3.2.1. A measure of bank risk.

The basis for the estimation of a measure of bank risk is a data set for Colombia, consisting of quarterly information on 2,095,755 individual commercial loans for the period 2000:I to 2008:IV provided by Superfinanciera. The data set also includes information for borrower, lending bank, and some details of the loans such as their amount, collateralization, maturity and payment information (whether in default or not, defining default as a situation in which the loan has not been served for more than three months). With this information it is possible to construct, ex post, a probability of default of each loan. This is a proxy for loan risk or, as Jimenez et al. (2009) put it, the hazard rate of the loan.

3.2.2. Dynamics of the probability of default.

Monetary policy affects the probability of default of a loan not only at the time of origination, but also, and differently, during its life. This is the idea behind the hazard rate defined above, which is derived from a conditional hazard function over the time of maturity of the loans until, and if, it defaults. This function gives the "per-period probability of loan default provided the loan survives to that period". (ibid.). The estimation of this function relies on duration analysis models, which allows for the effect of a set of observable and time-varying explanatory variables, including monetary policy shocks, in the determination of hazard rates for each loan and in each period that it is not in default.

3.2.3. The stance of monetary policy.

It should be taken into account that, in principle, there could be a two-way relation between loan risk and monetary policy. This would be the case when, for example, the monetary authority has an implicit or explicit concern over the stability of the banking sector and translates it into its reaction function. In this case, the policy rate is not exogenous and the econometric exercise would have to deal with identification problems.

Jimenez et al. (2009) solve this problem in their study for Spain using the German overnight interbank rate of interest for the period 1988-1999, and the Euro overnight interbank rate thereafter. In a related study for Bolivia, Ioannidou et al. (2009) use the Fed target rate, taking into account that the

local economy is highly dollarized. Solving probable identification problems in this study for Colombia could, in a first instance, be more complex, since monetary policy in this country is conducted with more degrees of freedom than in the two aforementioned countries.

It can be argued, however, that during the period of the study, 2000 to 2008, the central bank in Colombia did not **systematically** take into account bank risk considerations in its policy decisions on interest rates. Furthermore, when the central bank showed concern over the dynamics of credit markets and its relation with bank risk, it resorted to other instruments, in particular changes in reserve requirements, to address this problem.

On the basis of these arguments, it can be contended that, for the purposes of this work, which is to examine the response of banks' willingness to bear risk to changes in interest rates by the central bank, the (real) interbank rate of interest, closely determined by the policy rate, can be considered exogenously determined.

Nevertheless, we add a robustness exercise where instead of using directly the policy interest rate we use the deviation of the natural interest rate as suggested by Gambacorta (2009). The results of our empirical analysis did not change.

3.3. The model

We use a duration or hazard function model to study the time to default of individual bank loans. Duration models applied to this problem can provide answers to questions such us, what is the probability that a bank loan defaults in the following quarter after the occurrence of a negative shock, given it has survived up to that moment? In duration models the dependent variable is duration, in this case, the time that it takes for a loan to change from a state to another.

Let T represent the time that elapses before the occurrence of the default of the loan. The passage of time is often referred as a spell. Following Jimenez et al. (2009), a simple way to describe the behavior of a spell is through its survivor function, $S(t) = P(T \geq t)$, which yields the probability that the spell T last at least to time t. Alternatively, the hazard function determines the conditional probability that the spell ends in a short time after t provided that it has reached time t, that is:

$$\lambda(t) = \lim_{\Delta\xi \to 0} \frac{-dlogS(t)}{df} = \frac{f(t)}{S(t)} \qquad (1)$$

9

Where $f(t)$ is the density function associated with the distribution of spells. In this case, the hazard rate provides us with a per-period measure of risk taking. When $\lambda(t)$ is increasing in t, the hazard is said to exhibit positive duration dependence.

Usually, when estimating hazard functions it is convenient to assume a proportional hazard specification:

$$\lambda(t, X(t), \beta) = \lambda_0(t)exp(\beta'X_t) \qquad (2)$$

Where $X(t)$ is known as a vector of covariates or explanatory variables, β is a vector of unknown parameters and λ_0 is the baseline hazard function. In our benchmark model we use a Weibull specification for the baseline hazard rate λ_0, where $\lambda_0(t) = \lambda\alpha t^{\alpha-1}$, which is monotonically increasing if $\alpha > 1$, and monotonically decreasing if $\alpha < 1$. Our benchmark model has this specification because after one or two initial quarters overdue, repayments could become conditionally more likely over the life of the loan. However, the scale parameter is a function of some explanatory variables. In other words, the risk of default is not proportional to changes in covariates. However, testing proportional hazard specification was rejected when we use the test proposed by Shoenfeld (1980) and graphical analysis of the residuals. Thus, the accelerated Failure Time Model arises, in this context the conditional hazard rate is:

$$\lambda(t|\mathbf{x}) = \lambda_0(texp(-\mathbf{x}'\beta))exp(\mathbf{x}'\beta) \qquad (3)$$

This is an acceleration of the baseline hazard $\lambda_0(t)$ if $exp(-\mathbf{x}'\beta) > 1$ and a deceleration if $exp(-\mathbf{x}'\beta) < 1$.

In addition, we perform robustness checks using different probability distributions. The estimation technique used maximum likelihood estimation with a Newton-Raphson algorithm and took into account right censoring.

The variables included in the model are the following:

3.4. Hazard rate.

As explained above, the dependent variable in the model is the hazard rate, which is a proxy of the riskiness of a loan in a given period. It should be interpreted as its time-varying probability of default.

The independent variables can be grouped in different categories:

3.5. Interest rate.

Monetary policy impacts loan risk doubly: prior to the origination of a loan in period ζ [$INTERESTRATE_{\zeta-1}$] and during each of the periods of the life of the loan until it eventually defaults or is due in period T [$INTERESTRATE_{\zeta+T-1}$]. In other words, changes in the policy rate can have two separate effects on bank risk: as new loans are originated and on existing loans. As mentioned above, the interest rate used in the estimation is the real inter-bank rate of interest.

3.6. Bank-specific variables (measured prior to the loan origination period)
  (i) Size [BANK $SIZEb_{b\zeta-1}$]: measured in terms of assets and entered as the relative size of the bank (in percentage points) vis--vis the other banks in the sample.
 (ii) Own Funds [$OWNFUNDS/TOTALASSETS_{b\zeta-1}$]: measured as the ratio of bank equity to total bank assets. It is also the inverse of the leverage of the bank
 (iii) Interbank position [$INTERBANKPOSITION/TOTALASSETS_{b\zeta-1}$]: the ratio of net inter-bank lending to the bank to its total assets.
 (iv) Relative non performing loans position [$BANKNPL_{b\zeta-1} - NPL_{\zeta-1}$]: difference between the bank and other banks' level of nonperforming loans.

3.7. Borrower-specific variables (measured at the period of loan origination)
  (i) $RISK_f$: a dummy variable equal to "1" if the borrower was overdue any time before on another loan.
 (ii) Age [$LN(2 + Age of borrower_{f\zeta})$]: measured by the number of years from the first time the borrower took a loan from a bank.

3.8. Loan-specific variables (measured at the period of loan origination)
  (i) Size [$LN(SIZEOFTHELOAN_{l\zeta})$]: measured by the natural logarithm of the amount of the loan.
 (ii) $COLLATERAL_l$: a dummy variable equal to "1" if the loan is collateralized and to "0" if it is not collateralized.
 (iii) $MATURITY_l$: dummies for each of three categories, namely, loans of 3 months to one year of maturity, 1 to 3 years, and 3 to 5 years.

3.9. GDP growth

annual percentage growth rate of GDP on a quarterly basis. As in the case of interest rates, this variable has two separate effects on hazard rates, one at origination and another effect during the life of the loan [$GDPG_{\zeta-1}$, $GDPG_{T-1}$ or $GDPG_{t-1}$]. A summary of descriptive statistics is provided in Table 1.

4. Results

The way the model was specified allows for a wide range of mechanisms through which changes in interest rates affect risk perceptions, risk tolerance and, in general, the behavior or economic agents. The exercise is designed not only to illustrate the impact of lower interest rates on this behavior, but also to make explicit or to deepen into the channels through which this impact takes place. However, the effect of lower interest rates on the balance sheet of lending institutions, one of the central factors that explain how enhancing mechanisms arise and eventually lead to the overextension of balance sheets, cannot be envisaged from the exercise above. The link from lower interest rates to balance sheets and then to hazard rates is thus not made explicit in the model. In spite of this, the results obtained are promising and lend interesting support to the conceptual framework presented in the previous sections of this paper. All the regression coefficients analyzed above are statistically significant. In Table 2 we present the results. Our benchmark model, as explained before, is the Weibull specification (column 1)

4.1. Interest rates and hazard rates.

The main finding of this paper sheds light on how monetary policy is transmitted through the credit market in Colombia. This finding is similar to Jimenez et al. (2009) finding for Spain:

(i) Lower interest rates raise hazard rates on new loans (-0.013),

(ii) But reduce the hazard rate on outstanding loans (0.133).

These two results provide evidence in favor of the hypothesis put forward in this and other papers that lower interest rates impact the behavior of lending institutions by affecting their attitude towards risk. Banks respond to a more expansive monetary policy in a way that indicates higher tolerance

to lower quality loans, and a reduced perceived risk for outstanding loans. As a robustness exercise we present the results with a different measure of the stance of monetary policy: the deviation of the interest rate with respect to the natural interest rate (part Two in Table 2, column 1) and the basic results remain unchanged.

With these results in mind it is possible to see how changes in the stance of monetary policy would affect the perceived probability of default of a loan. This is done by calculating an annualized hazard rate for a loan with mean characteristics but with a maturity of twelve months, and for two paths of monetary policy: (i) an increase of interest rate from its mean at loan origination (2.18% in real terms) to its maximum level at maturity (4.76% also in real terms), and (ii) a reduction of this rate from the mean level at origination (real 2.18%) to its minimum level at maturity (real -0.59%) see Figure 1.

Whereas the first policy path (rate increase) raises the annualized loan hazard rate from 1.69% to 2.64%, the second (rate reduction) lowers the annualized loan hazard rate from 1.69% to 0.01%. These results suggest asymmetric effects of shifts in monetary policy to an expansive or a restrictive stance. Hazard rates of outstanding loans are more sensitive to downward than to upward movements in policy rates.

A new avenue for the analysis of the transmission of monetary policy could derive from here, more centered in hazard rates than in market rates of interest. In a nutshell, the response of banks to policy shocks, in terms of credit supply, depends, ceteris paribus, not on the magnitude of changes in policy rates but on how these changes affect the banks' perception and tolerance towards risk. It follows, from here, that the central bank in Colombia is relatively more effective when it tries to stimulate the economy by lowering interest rates than when it tries to slow it down through higher rates.

4.2. Control variables.

The interpretation of the results for control variables contribute to determine if there are features of the behavior of lending institutions that strengthen the persistence mechanisms embedded in the risk-taking channel.

4.3. As regards the bank-specific variables included in the model

(i) Bank size. Larger banks exhibit lower hazard rates or, in other words, face lower loan risk. The reason for this negative relationship could lie
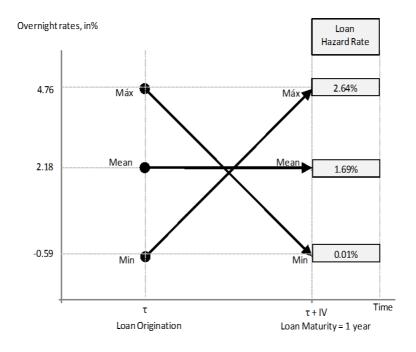
13

Figure 1: Monetary Policy Paths and Loan Hazard Rate

in the direct links that connect bank size with relative power in the market for savings, liquidity and interbank resources. This advantage of larger banks enables them not only to fund their liabilities at lower rates, but also to diversify their funding sources.

(ii) Own funds. The negative sign of the coefficient indicates that banks with a higher ratio of own funds to total assets exhibit a lower hazard rate. This may be interpreted as a sign of self-discipline on the part of banks: they lend more carefully when there is a larger proportion of their own resources involved in their lending activities.

Alternatively, a more interesting interpretation can be obtained if use is made of concepts more akin to the literature on lending and risk-taking channels. The same result can be read as an indication of a positive relationship between leverage and hazard rates, which would suggest

14

that a buildup of risks accompanies the expansion of banks' balance sheets. This mechanism is, in fact, a key ingredient of the risk-taking channel.

(iii) Dependence on the interbank market. The results indicate that the more a bank depends on the interbank market for funds, the higher the hazard rate on its loan portfolio. This may be interpreted as a sign that, independently of the level of the interest rate, and of changes in it, the bank with more reliance on the interbank market faces higher funding costs (a less favorable external finance margin). These higher costs have to be transferred to lending rates, in particular to lower quality borrowers and loans. There seems to be an element of persistence enhancing in this mechanism and even of overextension of the balance sheet of the banks.

(iv) Response to non-performing loans. The finding that banks with a higher incidence of non-performing loans vis--vis other banks exhibit worse loan risk may appear counter-intuitive at first sight, since it suggests that the bank with a heavier load of low quality assets consciously persists in risky lending. However, there is room for an alternative interpretation in line with the previous paragraph: relatively lower quality assets imply higher funding costs that are transmitted to lending rates that, in turn, further deteriorate hazard rates.

Again, this result is evidence of the persistence enhancing mechanisms that characterize the risk-taking channel.

4.4. For loan-specific characteristics the results are the following

It was found that smaller and shorter-maturity loans are more risky, which clearly coincides with what can be expected in a credit market with asymmetric information and economics of scale in the lending activity. The positive sign on the coefficient for collateral seems counter-intuitive and difficult to interpret on the basis of existing literature.

4.5. For borrower-specific characteristics

It was found, in line with what could be expected, that borrowers who have defaulted in the past exhibit a higher probability of worse hazard rates on new loans. This result also confirms that there is persistence in the credit

market that is enhanced by the behavior of banks, probably derived from higher interest rates that are charged on loans to "bad" borrowers.

The other result, that "older" borrowers exhibit higher hazard rates, seems counter-intuitive and difficult to interpret on theoretical grounds.

4.6. Growth and risk-taking.

The results on GDP growth reinforce the notion that there is, embedded in the behavior of banks, a mechanism that changes their perception of risk in response, in this case, to macroeconomic conditions. A higher rate of growth of the economy increases the hazard rate of new loans and lowers that of outstanding loans. Higher growth makes banks more optimistic and tolerant to risk, and this, in turn, implies that lower quality loans are originated. On the other hand, the same higher rates of growth positively impact the perception of risk on outstanding loans and reduce their probability of default through, among other things, cash flow implications.

4.7. Other specifications

In order to check robustness of the results we estimate several models under different distributions. Table 2 (columns 3 to 5) shows that our main results remain unaffected.

In addition, the literature on the bank-lending and risk-taking channels underscores the fact that the transmission of monetary policy depends on some characteristics of banks. This contention has been tested here through the interaction of these characteristics with changes in interest rates by the monetary authority. Columns 6 and 7 from Table 1 present these results. On the one hand, the effect of a reduction in interest rates on the hazard rate for new loans is reinforced in the case of lower-sized banks. On the other hand, banks with a lower ratio of own resources to total assets or, more precisely, more leveraged banks, also strengthen the negative impact of a reduction in policy rates on the hazard rates of new loans. This highlights two amplification mechanisms of monetary policy, one related to the size of banks and the other to their balance sheets characteristics. The results for interactions with other bank-specific characteristics are not robust.

16

5. Conclusions

Based on empirical evidence for Colombia, this paper finds a statistically significant link between interest rates and banks' risk taking. Lower interest rates increase the probability of default on new loans and reduce that on outstanding loans. This effect of monetary policy is partially attenuated by bank size, but amplified by bank leverage. This amplification reflects what theory refers to as "persistence enhancing mechanisms" that underlie the pro-cyclical character of financial markets.

The picture depicted in the previous paragraph corresponds to a dimension of the monetary policy transmission mechanism not often sufficiently taken into account. In this dimension, risk perceptions play a central role and banks are not passive conduits for policy shocks.

It can also be concluded that banks' balance sheets are a key element in the transmission of monetary policy. As argued in this paper, the quality of assets and the degree of leverage both affect and are affected by risk considerations. The results of this paper clearly confirm the links from balance sheets to risk perceptions and tolerance, but only hint at those in the opposite direction.

Short-term interest rates are also an important price in the economy. They are an explanatory variable in the determination of loan risk of individual banks, beyond their relationship with longer-term rates and their role in the formation of expectations. Risk-taking channel literature underlines the effect of the level of short-term rates on cash flows and asset valuation, elements that have been put forward in this paper as contributing to explain the positive relationship between policy rates and the probability of default on outstanding loans.

The findings of this paper suggest that, in spite of the prominent role of interest rates in the transmission of monetary policy, the mechanism as such has to be understood carefully. In the first place, just as the model in this paper did, interest rates will have to be translated into hazard rates or perceived probabilities of default on loans and of borrowers. Secondly, the relationship between interest rates and hazard rates is essentially non-linear. As argued in Section 4 above, banks' response to policy shocks depends not so much on the magnitude of these shocks as on how they affect perceived probabilities of default. And this, in turn, is also a function of some bank-specific characteristics and of macroeconomic and financial conditions. Again, risk perceptions lie at the heart of the transmission of monetary policy.

17

Interestingly, the implications of this view go back to, and complement the pioneering work by Stiglitz and Weiss (1981) on imperfect information and credit rationing. The authors propose a non-linear relationship between interest rates and the "expected return to the bank" on its loans, with the latter being determined by the adverse selection and incentive effects emerging from asymmetric information. Informational imperfections then affect the supply of credit making it bend backwards at some unspecified level of the interest rate. To a good extent, the bank lending and risk-taking channels represent a more elaborated and modern version of the views expressed by Stiglitz and Weiss almost thirty years ago, with the emphasis placed on agency relations on the side of banks. The findings of this paper may also give rise to implications for the conduct of monetary policy in Colombia. On the one hand, it is clear from what has been shown and said that monetary policy and policies toward financial stability are closely linked. On the other hand, the asymmetric effects of shifts in monetary policy to an expansive or a restrictive stance should serve as guidance on future policy decisions. In particular, the fact that the central bank seems to be relatively less effective when it shift to a more restrictive stance, could be translated into a few guiding points that monetary authorities may take into account in the future: (i) the risks involved in delaying a necessary shift to a more restrictive policy stance, and (ii) the eventual convenience of complementing interest rate increases with other instruments that contribute to accelerate the transmission of higher rates.

Acknowledgements

References

Adrian, T., Shin, H., 2009a. Financial intermediaries and monetary economics. Federal Reserve Bank of New York, Staff Reports No. 398, October.

Adrian, T., Shin, H., 2009b. Prices and quantities in the monetary policy transmission mechanism. Federal Reserve Bank of New York, Staff Reports No. 396, October.

Altunbas, Y., Gambacorta, L., Marques, I. D., 2009a. An empirical assessment of the risk-taking channel. paper presented at the BIS/ECB conference on "Monetary policy and financial stability", 10-11 September.

Altunbas, Y., Gambacorta, L., Marques, I. D., 2009b. Bank risk and monetary policy. Banca D'Italia, Working Paper No. 712, May.

Altunbas, Y., Gambacorta, L., Marques, I. D., 2010. Does monetary policy affect bank-risk taking? BIS Working Papers No. (298).

Boivin, J., Kiley, M., Mishkin, F., 2009. How has the monetary transmission mechanism evolved over time. Prepared for the third Handbook of Monetary Economics, presented at the Federal Reserve Conference on Key Developments in Monetary Policy, October 9, 2009.

Borio, C., Zhu, H., 2008. Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism. BIS Working Papers No. 268, December.

Disyatat, P., 2010. The bank lending channel revisited. BIS Working Papers No. 297, February.

ECB, 2009. Monetary policy and loan supply in the euro area. ECB Monthly Bulletin, October.

Gambacorta, L., 2009. Monetary policy and the risk-taking channel. BIS Quarterly Review, December.

Hatzius, J., Hooper, P., Mishkin, F., Schoenbholtz, K., Watson, M., 2010. Financial conditions indexes: A fresh look after the financial crisis. mimeo.

Ioannidou, V., Ongena, S., Peydró, J., 2009. Monetary policy, risk-taking and pricing: evidence from a natural experiment. paper presented at the NBER Summer Institute, Cambridge, MA.

Jimenez, G., Ongena, S., Peydró, J., Saurina, J., 2009. Hazardous times for monetary policy: What do twenty-three million bank loans say about the

effects of monetary policy on credit risk-taking? Paper presented at the American Finance Association Meetings, San Francisco.

Kashyap, A., Stein, J., 2000. What do a million observations on banks say about the transmission of monetary policy? American Economic Review 90 (3), 407–428.

Shoenfeld, D., 1980. Chi-squared goodness-of-fit tests for the porpotional hazard regresion model. Biometrika 67, 145–153.

Stiglitz, J., Weiss, A., 1981. Credit rationing in markets with imperfect information. The American Economic Review 71 (3), 393–410.

Table 1. Descriptive Statistics

Variables	Definition	Mean	Std.Dev	Min	Max
Default	1 if default, i.e. if three months after the date of maturity or the date of an interest payment, the debt balance remains unpaid	0.099	0.298	0.000	1.000
INTEREST RATE (%)	Real TIB (interbank rate)	2.183	1.711	-0.593	4.764
BANK SIZEb (%)	Relative size of the bank vis-a vis the other banks	8.467	5.366	0.034	20.672
OWN FUNDS/TOTAL ASSETSb (%)	The amount of bank equity over total bank assets	5.096	2.752	0.093	101.080
INTERBANK POSITION/TOTAL ASSETSb(%)	The net amount of interbank lending by the bank over total assets	-1.028	2.880	-23.330	10.461
BANK NPLb-NPL(%)	The difference between the bank and the other banks level of NPLs	0.000	11.394	-80.440	29.743
BORROWER RISKf (0/1)	1 if the borrower was overdue any time before on another loan	15.184	35.886	0.000	100.000
LN(2+AGE AS BORROWERf)	Age is the number of years from the first time the firm borrowed from a bank	2.889	0.683	1.386	3.727
LN(SIZE OF THE LOANI)	The log of the loan amount	16.308	1.510	12.467	19.499
COLLATERALI(0/1)	1 if the loan is collaterized	0.522	0.500	0.000	1.000
MATURITY 3m-1y (0/1)	1 if the loan matures between 3 months and 1 year	0.058	0.234	0.000	1.000
MATURITY 1y-3y (0/1)	1 if the loan matures between 1 year and 3 years	0.148	0.355	0.000	1.000
MATURITY 3y-5y (0/1)	2 if the loan matures between 3 year and 5 years	0.206	0.404	0.000	1.000
GDPG(%)	Growth in real gross domestic product	0.048	0.023	-0.005	0.084
EFFICIENCY RATIO (%)	Operating Margin/Total Assets	0.392	0.458	-0.975	0.994
FINANCIAL INCOME/ATA(%)	Interest income plus dividends received over average total assets	2.558	0.300	1.988	3.133

Table 2. Non Time-Varying Duration Models

Independent Variables	Weibull		Lognormal		Logistic		Normal	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
INTEREST RATE $_{\zeta-1}$	-0,0131	***	-0,0200	***	-0,0180	***	-0,1262	***
INTEREST RATE $_{\zeta+T-1}$	0,1330	***	0,1011	***	0,1188	***	0,7987	***
BANK SIZE $_{b\zeta-1}$	-0,0232	***	-0,0217	***	-0,0243	***	-0,1535	***
OWN FUNDS/TOTAL ASSETS $_{b\zeta-1}$	-0,0228	***	-0,0349	***	-0,0466	***	-0,2347	***
INTERBANK POSITION /TOTAL ASSETS $_{b\zeta-1}$	0,0206	***	0,0238	***	0,0195	***	0,1679	***
BANK NPL $_{b\zeta-1}$ - NPL $_{\zeta-1}$	0,0054	***	0,0055	***	0,0059	***	0,0393	***
BORROWER RISK $_{f\zeta-1}$ (0/1)	0,0005	***	0,0003	***	0,0003	***	0,0029	***
LN (2+AGE AS BORROWER $_{fl\zeta}$)	0,0375	***	0,0054	***	-0,0040	***	0,3271	***
LN (SIZE OF THE LOAN $_{l\zeta}$)	-0,0114	***	-0,0111	***	-0,0102	***	-0,0337	***
COLLATERAL $_l$ (0/1)	0,3437	***	0,3329	***	0,3330	***	2,0724	***
FINANCIAL CREDIT $_l$ (0/1)								
MATURITY $_l$ 0m.-3m. (0/1)	-1,0102	***	-0,8798	***	-0,8753	***	-4,8370	***
MATURITY $_l$ 3m.-1y. (0/1)	-0,3250	***	-0,2508	***	-0,2352	***	-2,1767	***
MATURITY $_l$ 1y.-3y. (0/1)	0,0251	***	0,0333	***	0,0459	***	-0,0024	***
MATURITY $_l$ 3y.-5y. (0/1)								
GPDG $_{\zeta-1}$	0,9547	***	1,0746	***	0,7250	***	7,7296	***
GPDG $_{\zeta+T-1}$	-12,5974	***	-13,6722	***	-14,8366	***	-97,3673	***
TIME TREND	-0,0058	***	0,0037	***	0,0020	***	0,0033	***
TIME TREND ^{2}	-0,0002	***	-0,0008	***	-0,0011	***	-0,0086	***
CONSTANT	2,6345	***	2,6273	***	2,7490	***	12,0662	***
ln(á) (duration dependence)	0,5703	***	0,6629	***	0,3850	***	4,3274	***
Log pseudolikehood	-609386		-579179		-588617		-1456861	

Table 2. Non Time-Varying Duration Models: Part Two

Independent Variables	Weibull Coefficient	Sig.	Weibull with interaction Coefficient	Sig.	Weibull with interaction Coefficient	Sig.
INTEREST RATE $_{\zeta\text{-}1}$			-0,0430	***	-0,0154	***
INTEREST RATE $_{\zeta\text{+}T\text{-}1}$			0,1342	***	0,1328	***
LNATURAL $_{\zeta\text{-}1}$	-0,0045	***				
LNATURAL $_{\zeta\text{+}T\text{-}1}$	0,1754	***		***		
INTEREST RATE $_{\zeta\text{-}1}$ * BANK SIZE$_{b\zeta\text{-}1}$			0,0036			
INTEREST RATE $_{\zeta\text{-}1}$ * OWN FUNDS$_{b\zeta\text{-}1}$					0,0006	***
BANK SIZE $_{b\zeta\text{-}1}$	-0,0237	***	-0,0308	***	-0,0235	***
OWN FUNDS/TOTAL ASSETS $_{b\zeta\text{-}1}$	-0,0226	***	-0,0225	***	-0,0252	***
INTERBANK POSITION /TOTAL ASSETS $_{b\zeta\text{-}1}$	0,0192	***	0,0200	***	0,0199	***
BANK NPL $_{b\zeta\text{-}1}$ - NPL $_{\zeta\text{-}1}$	0,0056	***	0,0053	***	0,0054	***
BORROWER RISK $_{f\zeta\text{-}1}$ (0/1)	0,0005	***	0,0005	***	0,0005	***
LN (2+AGE AS BORROWER $_{fl\zeta}$)	0,0409	***	0,0383	***	0,0373	***
LN (SIZE OF THE LOAN $_{l\zeta}$)	-0,0112	***	-0,0109	***	-0,0114	***
COLLATERAL $_l$ (0/1)	0,3422	***	0,3440	***	0,3429	***
FINANCIAL CREDIT $_l$ (0/1)						
MATURITY $_l$ 0m.-3m. (0/1)	-1,0141	***	-1,0083	***	-1,0102	***
MATURITY $_l$ 3m.-1y. (0/1)	-0,3214	***	-0,3237	***	-0,3252	***
MATURITY $_l$ 1y.-3y. (0/1)	0,0211	***	0,0263	***	0,0251	***
MATURITY $_l$ 3y.-5y. (0/1)						
GPDG $_{\zeta\text{-}1}$	0,8327	***	0,9013	***	0,9446	***
GPDG $_{\zeta\text{+}T\text{-}1}$	-9,4598	***	-12,6153	***	-12,5946	***
TIME TREND	-0,0061	***	-0,0059	***	-0,0058	***
TIME TREND ^{2}	-0,0003	***	-0,0002	***	-0,0002	***
CONSTANT	2,7283	***	2,6832	***	2,6491	***
ln(á) (duration dependence)	0,5696	***	0,5703	***	0,5703	***
Log pseudolikehood	-609386		-609144		-609379	