HAZARDOUS TIMES FOR MONETARY POLICY: WHAT DO TWENTY-THREE MILLION BANK LOANS SAY ABOUT THE EFFECTS OF MONETARY POLICY ON CREDIT RISK-TAKING?

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Abstract

We identify the impact of short-term interest rates on credit risk-taking by analyzing a comprehensive credit register from Spain, a country where for the last twenty years monetary policy was mostly decided abroad. Discrete choice, within borrower comparison and duration analyses show that lower overnight rates prior to loan origination lead banks to lend more to borrowers with a worse credit history and to grant more loans with a higher per-period probability of default. Lower overnight rates during the life of the loan reduce this probability. Bank, borrower and market characteristics determine the impact of overnight rates on credit risk-taking.

Keywords: monetary policy, low interest rates, financial stability, lending standards, credit risk-taking, credit composition, business cycle, liquidity risk.

JEL: E44, E5, G21.

1 Introduction

Problems in the credit markets first surfaced in the summer of 2007. Since then liquidity recurrently evaporated almost entirely from the interbank markets and central banks intervened worldwide on a scale not often seen before. Large reputable banks had to write down substantial portions of their loan portfolios. Market commentators immediately argued that during the long period of very low interest rates, stretching from 2001 to 2005, banks had softened their lending standards and taken on excessive credit risk. But, at the same time, market participants started clamoring for central banks to reduce interest rates again to alleviate their financial predicament. Hazardous times for monetary policy indeed.[1]

But do low short-term interest rates really spur credit risk-taking by banks and are their subsequent sharp increases one of the contributing factors to the current crisis? To answer these questions we study how short-term interest rates influence credit risk-taking by banks using a unique and comprehensive dataset containing bank loan contract information from Spain. Monetary policy was fairly exogenous during the last twenty years in Spain and was mostly "decided in Frankfurt". Hence, we study how the German and then Euro overnight interest rates affected the riskiness of bank loans.

While the impact of changes in the short-term interest rates on the aggregate *volume of credit* in the economy has been widely analyzed [Bernanke and Blinder (1992), Bernanke and Gertler (1995) and Kashyap and Stein (2000) among others], this paper is the first to empirically study its impact on the banks' appetite for credit risk. Recent theoretical work shows how changes in short-term interest rates may affect *credit risk-taking* by financial institutions. As the change in the demand for investment through the interest rate channel may also affect the marginal borrower's riskiness, disentangling demand from supply of credit is one of the key challenges addressed by our empirical contribution.

Lower interest rates —by improving borrowers' net worth— may result in banks to lend to borrowers that were deemed in the past to be too risky [Bernanke, Gertler and Gilchrist (1996)] or to lend to borrowers with fewer pledgeable assets [Matsuyama (2007)]. In the "balance sheet channel" lenders embrace borrowers that were deemed too risky *in the past* but have become in effect less risky due to the lower interest rates. Yet lower interest rates may push financiers beyond this category of 'redeemed borrowers' to finance firms and projects that are actually riskier *in the present*, i.e., to grant loans with a longer maturity (and more liquidity risk) and even a higher per period probability of default (and more *pure* credit risk). This latter effect of low rates has been labeled the "credit risk-taking channel" of monetary policy [following Borio and Zhu (2007)] and can be considered part of the credit channel.

Lower interest rates may reduce the threat of deposit withdrawals [Diamond and Rajan (2006)], abate adverse selection problems in credit markets [Dell'Ariccia and Marquez (2006)] or improve banks' net worth [Stiglitz and Greenwald (2003)], for example, allowing

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1. Nominal rates were the lowest in almost four decades and below Taylor rates in many countries while real rates were negative [see Ahrend, Cournède and Price (2008), Taylor (2007) and multiple editorials and op-eds in *The Wall Street Journal*, *The Financial Times* and *The Economist* for example]. Loan securitization may have intensified risk-taking [Keys, Mukherjee, Seru and Vig (2008), Mian and Sufi (2008)]. Expansionary monetary policy and credit risk-taking followed by restrictive monetary policy possibly led to the financial crisis during the 1990s in Japan [see Allen and Gale (2004) for example].

banks to relax their lending standards and to increase their credit risk-taking. Low levels of short-term interest rates may further make riskless assets less attractive for financial institutions and lead to a search-for-yield [Rajan (2006)]. On the other hand, higher interest rates increase the opportunity costs for banks to hold cash thus making risky alternatives more attractive [Smith (2002)], or may reduce the banks' net worth or charter value enough to make a "gambling for resurrection" strategy attractive [Kane (1989) and Hellman, Murdock and Stiglitz (2000)], thus making the impact of short-term interest rates on credit risk-taking ultimately a critical yet unaddressed empirical question.

Motivated by these theoretical developments we study the impact of monetary policy on the credit risk-taking by a particular group of financiers, i.e., banks. Banks may not only arise to overcome key informational and contractual problems in modern theoretical work [as in Diamond (1984) for example], but are also the main providers of credit in most economies (Source: *International Finance Statistics* of the *International Monetary Fund*). Credit risk may be the most important risk type banks face [Kuritzkes and Schuermann (2008)].

An empirical investigation of interest rates and bank risk-taking may be warranted, but it presents steep identification challenges. Comprehensive panel data on individual bank loans is needed to dynamically account for changing loan conditions, to adequately assess credit risk, and to disentangle the supply of credit to risky borrowers from its demand. A fairly exogenous monetary policy and ample controls for other important macroeconomic factors (the growth in real gross domestic product, the inflation rate and a measure of country risk for example) are also crucial for econometric identification.

The *Credit Register* of the *Banco de España* (CIR) is uniquely suited to fulfill these many requirements. The CIR records detailed monthly information on *all*, new and outstanding, commercial/industrial and financial loans (over 6,000 Euros) to non-financial firms by *all* credit institutions in Spain during the last twenty-three years —generating almost twenty-three million bank loan records in total. Its comprehensiveness directly averts any concerns about unobserved changes in bank lending. The CIR contains loan conditions and performance variables that are essential to our analysis, and tracks key borrower and bank characteristics, including borrower and bank identity.

Banks continue to play a key role in the Spanish economy and in the financing of the corporate sector. In 2006 for example their deposits (credits) to GDP equaled 132% (164%). Most non-financial firms had no access to bond financing and the securitization of commercial and industrial loans is still very low (4.8% in 2006).

Spain formally joined the European Monetary Mechanism in 1989; it had implicitly been part since 1988, after joining the European Union in 1986. Monetary conditions consequently became fairly exogenous and basically "set in Frankfurt", first through the fixed exchange rate policy with the *Deutsche Mark* and as of January 1, 1999 within the Eurosystem. Consequently, we can use the German then Euro overnight interbank rates as an exogenous measure of the stance of monetary policy (alternatively, we instrument the Spanish by the German overnight rate, a strong instrument as our later reported results clearly indicate). In addition to the fairly exogenous monetary conditions and, as both the *Deutsche Bundesbank* and the European Central Bank (ECB) were mandated to principally maintain price stability, controlling for other macroeconomic conditions should allay concerns of reverse causality and omitted variables' bias.

Using discrete choice models, within borrower comparison models and duration analyses, we investigate whether short-term interest rates prior to loan origination influence credit risk-taking by banks. One of our main challenges is to disentangle demand from supply of risky credit and to account for potential changes in credit quality of the marginal borrower: When overnight rates are lower, quality possibly worsens as more —and more risky— projects surpass a zero net present value hurdle for example.

We introduce borrower characteristics, or identity, and loan conditions. The former set of controls absorbs the changes in the pool of borrowers, the latter the adjustments banks make trying to keep their level of risk-taking constant (if banks want to keep their credit risk constant they will tighten lending standards when they face a riskier pool of borrowers or projects). We employ within borrower comparisons for further identification. Borrowers connected to multiple banks are grouped as either risky or safe and we study the proportion of their financing provided by banks with a high or low appetite (and/or ability) for credit risk when interest rates change.

Our findings are both robust and economically relevant. Lower interest rates prior to the origination of the loans precede more lending to borrowers with either a *bad* or *no* credit history. More importantly, banks also grant more loans with a substantially higher *hazard rate* (which is a default probability normalized per time; a normalization that is desirable as loan maturity may also be affected by overnight rates). In striking contrast, once loans are outstanding lower interest rates imply lower hazard rates conform to standard theoretical predictions.

In sum, when monetary policy is expansive, not only do banks give more loans to borrowers with either a bad or no credit history, but also the new loans themselves are more hazardous. Consequently, better borrowers' net worth and a higher appetite for liquidity risk are not the only motives for the banks' new engagements. Following a monetary expansion banks also want to take more credit risk. These main findings are robust to many alterations and for example similar in the *Bundesbank* and ECB sub-periods (i.e., before and after 1999).

We also find robust evidence, confirming theoretical predictions, that smaller banks' incentives and ability for risk-taking are more affected by the stance of monetary policy than larger banks' incentives. The effect of the stance of monetary policy on credit risk-taking further depends on bank liquidity and ownership type, and on the level of banking competition and new borrower entry in the local area. All in all, our results suggest that the stance of monetary policy influences banks' appetite for credit risk.

Higher GDP growth reduces lending to borrowers with bad credit history, and lowers credit risk on new *and* outstanding loans. We note that both lower short-term interest rates and higher GDP growth imply higher borrower net worth and, therefore, fewer agency problems between lenders and borrowers. However, the effect of GDP growth on credit risk-taking is different from the effect of short-term interest rates. This implies that there may be other financial inefficiencies [Rajan (2006) and Diamond and Rajan (2006)] that explain the results of this paper. In addition, higher inflation during the life of the loan reduces credit risk, maybe because it cuts the real value of debt [Allen and Gale (2004) and Diamond and Rajan (2006)]. In contrast higher inflation before loan origination implies higher risk taking. Finally, long-term interest rates have a weaker impact on credit risk-taking than short-term rates, possible because banks themselves rely mainly on short-term debt [Diamond and Rajan (2006)].

To the best of our knowledge, Ioannidou, Ongena and Peydró (2007) and this paper are the first to investigate the impact of monetary policy on the credit risk-taking by banks.[2] Ioannidou, Ongena and Peydró (2007) use the Credit Register from Bolivia —where the banking system is almost completely dollarized— from 1999 to 2003. When the federal funds rate decreases, they find, not only do banks take more risk but they also reduce their loan spreads. Despite using credit registers covering different countries, time periods, and monetary policy regimes, both papers find strikingly similar results.

Consequently these results have important policy implications regarding the link between monetary policy and financial stability, and regarding the root causes of the turbulences in credit markets since the summer of 2007. The moment of highest credit risk, our results suggest, is when short-term rates that were very low for a long time period suddenly increase steeply: At that moment, the net worth of an already risky pool of borrowers is suddenly eroded possibly leading to non-performance and defaults. Our results also suggest a way forward: Reducing interest rates again lowers the credit risk of all outstanding loans, making banks more willing to again accept credit risk thereby reducing the tensions in the credit markets.

The rest of the paper proceeds as follows. Section 2 details and explains the testable predictions derived from theory. Section 3 reviews our empirical strategy and introduces the data and the variables employed in our empirical specifications. Section 4 discusses the results on borrower selection, within borrower comparison, and time to default of bank loans. Section 5 summarizes the results, discusses policy implications and concludes.

2. Dell'Ariccia, Igan and Laeven (2008) "provide hints" (*sic*) on the potential effects of monetary policy on banks' risk-taking. In line with our findings, their results are consistent with the idea that low interest rates in the U.S. may have loosened lending standards both directly and through their effect on real estate prices. Den Haan, Sumner and Yamashiro (2007) find that restrictive monetary policy reduces consumer and real estate lending in particular and argue that high short-term rates could imply a decline in bank risk-taking. Gertler and Gilchrist (1993), Gertler and Gilchrist (1994) and other papers documenting the strength of the balance sheet channel show that contractionary monetary policy results in less bank lending to small firms, findings that are consistent not only with lower borrower net worth but also with less bank risk-taking. Indeed Black and Rosen (2008) show that a lowering of the federal funds rate lengthens loan maturity and reallocates lending from large to small firms. And in a different setting Bernanke and Kuttner (2005) find that higher unanticipated interest rates reduce equity prices. One of their interpretations of this finding is that tight money may reduce the willingness of stock investors to bear risk. Rigobon and Sack (2004) show that higher interest rates reduce equity prices, especially on NASDAQ where arguably more risky firms are listed.

2 Literature Review and Testable Implications

2.1 Credit Channel of Monetary Policy

Does the stance of monetary policy, short-term interest rates in particular,[3] affect the appetite for credit risk of financial intermediaries? In addressing this question, that is key to our investigation, one needs to recognize a large literature in economics that has investigated whether and exactly how the conduct of monetary policy has effects for the real economy.

Short-term interest rates may affect investment and hence firms' demand for credit (the classical interest rate channel), while at the same time short-term interest rates may affect credit markets and the banking system in particular [for the credit channel of monetary policy transmission, see Bernanke and Gertler (1995)].[4] Because of credit market imperfections —asymmetries of information and incompleteness of contracts— contractive monetary policy may reduce the ability and incentive of banks to supply loans [Bernanke and Blinder (1988), Bernanke and Gertler (1989), Lang and Nakamura (1995), Gertler and Gilchrist (1994), among others]. Bernanke and Blinder (1992) indeed find that significant movements in bank aggregate lending volume follow changes in the stance of monetary policy.[5] To control for loan demand, Kashyap and Stein (2000) analyze whether there are also important cross-sectional differences in the way that banks respond to monetary policy shocks. They find that illiquid banks respond most and that this variation can be attributed to bank size.

Higher levels of interest rates directly and/or indirectly reduce borrowers' net worth [Bernanke and Gertler (1995)]. This reduction in net worth worsens the agency problems between banks and their borrowers in turn making banks fly to quality [Bernanke, Gertler and Gilchrist (1996) and Bernanke, Gertler and Gilchrist (1999)]. In Matsuyama (2007) borrowers are heterogeneous in productivity and asset pledgeability, and banks change their optimal *credit composition* among borrowers according to the business cycle —in fact, there is a change in credit composition without a change in bank volume. Lower short-term rates for example increase borrowers' net worth making banks more willing to lend to borrowers with fewer pledgeable assets.

2.2 Credit Risk-Taking Channel of Monetary Policy

All theories discussed so far show that expansive monetary policy may increase the volume of loan supply, in particular to borrowers that in the past looked too risky (borrowers with a bad credit history for example that due to an improvement in their net worth are not so risky anymore). However, none of these theories necessarily imply higher risk-taking by the banks, i.e., granting loans with a higher default probability.

In Diamond and Rajan (2006) banks take more risk when monetary policy is expansive. In their model, which provides "a liquidity version of the lending channel" of the monetary policy transmission mechanism, banks finance illiquid long-term projects with liquid

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3. In Bernanke and Blinder (1992) and Christiano, Eichenbaum and Evans (1996), among others, the overnight interest rate is an indicator for the stance of monetary policy. The ECB targets the overnight rate as a measure of the stance of its monetary policy.

4. The credit channel comprises both a balance sheet and a bank-lending channel. The latter channel can also be viewed as a balance sheet channel for banks (see Bernanke (2007) for a recent review of this literature).

5. Den Haan, Sumner and Yamashiro (2007) find that monetary policy differently affects consumer, real estate, and business lending by banks. In fact, contractive monetary policy does not decrease the volume of business loans for example. Their findings may be caused by a decline in bank risk-taking when short-term interest rates are high.

demand deposits. This mismatch makes banks reluctant to grant risky loans in times of liquidity shortages. Depending on the aggregate liquidity conditions, monetary intervention can play a useful role by limiting the depositors' incentives to withdraw. Banks will respond by continuing, rather than curtailing, risky credit. Consequently, the stance of monetary policy may affect the banks' appetite for risk.[6]

In Dell'Ariccia and Marquez (2006) banks' incentives to screen depend on their cost of financing, which in turn is determined by short-term interest rates. When there is a monetary tightening, to recover their losses on the "loans to lemons" when not screening, banks have to increase the average loan rate more than the observed increase in the policy rate. This pass-through is clearly larger than if banks were screening. Consequently, if interest rates decrease, the banks' incentives to screen borrowers and to fly to quality (with a lower default probability) wane. Banks also lower their screening standards when there are many loan applicants that are new to *all* banks. A decline in the cost of funds in Sengupta (2007) likewise facilitates entry of outside banks into "high-risk" credit markets, as inclusion of non-credit worthy borrowers in their loan portfolio becomes possible. And in Ruckes (2004) improvements in economic outlook and declines in the average default probability of the borrowers lowers the lenders' screening activity, intensifies price competition and boosts lending to low quality borrowers.

In general, because of information, contract and competition imperfections, banks may act risk aversely, and the degree of their risk aversion may depend not only on their borrowers' but also on their own net worth, Stiglitz and Greenwald (2003) argues. Lower interest rates increase the value of the banks' portfolio of securities and loans, thereby raising banks' net worth and capital. This in turn increases their ability and incentives to take credit risk [see also Stiglitz (2001)].[7]

Rajan (2006) discusses whether and how the stance of monetary policy may affect the risk-appetite of financial intermediaries.[8] Because of incentives, contractual and informational imperfections, managers of financial intermediaries may take excessive risk when interest rates are low. Financial intermediaries may increase their exposure to liquidity risk for example by exploiting their duration mismatch and by lending more to risky long-term projects. This enhanced risk-taking yields extra returns during normal times. However the extra risk becomes problematic when monetary policy tightens and liquidity evaporates.[9]

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6. In Diamond and Rajan (2006) an entrepreneur gets either an early or a late payoff that is fixed (and known). Introducing uncertainty about the payoff level will influence the amount lent to the entrepreneur, we conjecture, without altering the main results of the model. In consequence, monetary policy may affect both the level of liquidity and credit risk taken by the banks.

7. Because of equity rationing, the shocks to the banks' net worth may not be immediately reversible, explaining their potentially large adverse macro-economic consequences. Lower interest rates may also reduce moral hazard and adverse selection problems in credit markets, thereby lessening credit rationing [Stiglitz and Weiss (1981)].

8. Lower policy rates may for example reduce the loan-deposit rate spread, shrink the financial intermediation margin and whet bankers' incentive to take risk to meet some profitability target *(European Central Bank Financial Stability Review*, December 2007). See also Caballero (2006).

9. Ahrend, Cournède and Price (2008), Taylor (2007) and Shiller (2007) discuss excess risk-taking in general. Borio (2003) and Borio and Lowe (2002) assert that monetary policy narrowly focused on controlling short-run goods price inflation is less likely to exert control over credit expansions and asset price inflation (followed by subsequent busts). The increase in the number of booms and busts in recent years is thus, in part, a corollary to "the death of inflation". Borio and Zhu (2007) maintain that recent changes in banking regulation and the financial system may have amplified the impact of monetary policy on the risk-taking by financial intermediaries. Adalid and Detken (2007) find a correspondence between liquidity shocks and aggregate asset prices during asset price boom or bust episodes for 18 OECD countries since the 1970s. Kyotaki and Moore (1997) show how falling interest rates and rising asset prices cause a lending boom by increasing collateral values. As asset prices and collateral values decrease, All in all, lower short-term interest rates may increase the banks' incentives to take both more liquidity risk (i.e., more loans with a longer maturity) and credit risk (i.e., loans with a higher probability of default). To analyze credit risk-taking controlling for liquidity risk therefore requires investigating the probability of loan default normalized per time period.

2.3 Four Testable Hypotheses

To summarize, there are four testable predictions arising from the theory discussed so far:

(H1) Lower short-term interest rates lead to more lending to borrowers that in the past were riskier but that, because of their higher net worth for example, are now worth engaging.

(H2) Lower interest rates increase the credit risk-taking by banks, i.e., banks not only engage borrowers that are observably riskier *ex ante* but also borrowers with a higher probability of default per time period.

(H3) Default rates are at their highest level when —after a period of low interest rates which boosted credit risk-taking— a significant monetary tightening devalues the net worth of the (outstanding) risky borrowers.

(H4) Not all types of banks are equally affected. Smaller banks for example —because of their lower net worth, lack of diversification and difficulties accessing liquidity during tighter times— whet their appetite for risk more in response to an expansionary monetary policy.

Yet, it is important to note that not all banking theory implies that higher short-term rates go hand-in-hand with decreased credit risk-taking. Higher interest rates increase the opportunity costs for banks to hold cash (held as an insurance against high deposit withdrawals), making risky alternatives more attractive [Smith (2002)]. Higher interest rates may also reduce banks' net worth or charter value, driving banks towards a "gambling for resurrection" strategy [Kane (1989) and Hellman, Murdock and Stiglitz (2000)].[10] Given these conflicting theoretical predictions, determining the impact of monetary policy on bank risk-taking is ultimately a non-trivial, but mostly unaddressed, empirical question.

loan defaults occur. Finally, Allen and Gale (2004) point out that while monetary policy may influence risk taking and hasten the creation of a bubble, it may also help solve credit problems once the bubble bursts.

10. See also Bhattacharya (1982), Matutes and Vives (2000) and Cordella and Levy-Yeyati (2003).

3 Empirical Strategy

Essential ingredients to econometrically identify the impact of monetary policy stance on credit risk-taking are: (1) A disaggregated and comprehensive dataset on bank loans; (2) a measure of bank credit risk-taking that reflects the loan default risk per period of time; (3) a number of steps to disentangle supply of risky credit from its demand (employing loan and borrower characteristics/identity and interactions with bank characteristics), and (4) an exogenous stance of monetary policy. Spain delivers all of them as the *Credit Register* of the *Banco de España* (CIR) contains comprehensive information on Spanish bank lending over the last twenty-three years, a period during which Spain had a reasonably exogenous monetary policy.

3.1 Disaggregated and Comprehensive Dataset on Bank Loans

We aim to study the impact of the stance of monetary policy on the credit risk-taking of banks. We are therefore in the first place not interested in the impact of monetary policy on the risk of total outstanding loan portfolios, but want to focus on the credit risk of new loans being granted.

The CIR, first employed by Jiménez and Saurina (2004) and Jiménez, Salas and Saurina (2006) contains confidential and very detailed information at the loan level on (almost) *all* loans granted by *all* credit institutions operating in Spain during a twenty-three year period. The CIR is *almost* comprehensive, as the reporting threshold for a loan is only 6,000 Euros. This low threshold alleviates any concerns about unobservable changes in bank credit to small and medium sized enterprises, which may be influenced by changes in monetary policy.[11] We have borrower, bank and loan information. For the *borrower* we know its identity, province, industry, bank indebtedness level, credit history and the number of banking relationships; for the *bank* we know its identity, legal status, size, non-performing loan ratio and other bank characteristics; and for the *loan* we know the type of instrument, currency, maturity, degree of collateralization, default status, and amount.

We do not have information on the interest rate of the loan. However, when we control for an individual bank risk premium, the empirical results we report are unaffected.[12] Moreover, Jiménez, Salas and Saurina (2006) show that collateral requirements are softened during expansions, while Delgado, Salas and Saurina (2007) find that average loan size (in real terms) and loan maturity increase in upturns. Therefore, it seems reasonable to expect a decline in the loan risk premium during expansions, given that the other risk control tools present in the loans are also relaxed.

Our sample consists of new business loans, granted to non-financial firms by commercial, savings banks and credit cooperatives (the 95% of all the Spanish

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11. See Gertler and Gilchrist (1993), Gertler and Gilchrist (1994), Bernanke and Gertler (1995) and Bernanke, Gertler and Gilchrist (1996) for example. Incomplete coverage of the widely used U.S. (National) Survey of Small Business Finances or the more recent Loan Pricing Corporation datasets [e.g., Petersen and Rajan (1994), Berger and Udell (1995), Bharath, Dahiya, Saunders and Srinivasan (2006), and Calomiris and Pornrojnangkool (2006)] may therefore complicate any analysis of bank risk-taking. The reporting threshold in the *Deutsche Bundesbank*'s Credit Register dealt with in Ongena, Tümer-Alkan and von Westernhagen (2007) is 1,500,000 Euros. Other than the Bolivian register employed in Ioannidou and Ongena (2008) and Ioannidou, Ongena and Peydró (2007), we know of no comprehensive credit register (with no or low reporting threshold) that contains borrower identity and individual loan performance.

12. As in Martin-Oliver, Salas and Saurina (2006) we calculate a risk premium for each individual bank and subtract the average risk premium of all banks in that quarter.

financial system), where non-Spanish subsidiaries and branches are excluded. We use quarterly data information from 1984:IV to 2006:IV, which includes at least a complete business cycle in Spain. Every quarter all new loans are selected and tracked over time until they become impaired, repaid or still outstanding at the end of 2006.

We work at the loan level because econometric identification (further discussed below) requires variation in both borrower characteristics and loan conditions. In addition, Den Haan, Sumner and Yamashiro (2007) document that contractive monetary policy does not necessarily reduce the volume of business lending, while Hernando and Martínez-Pagés (2001) find no bank lending channel operative in Spain. Both findings suggest that focusing on new business loans allows us to determine the changes in loan composition without overlooking the concurrent changes in loan volume across loan categories (despite these priors we control for the growth in total and individual bank loan volume in the robustness subsection).

All in all, we have complete records on almost twenty-three million loans.[13] In order to keep estimations manageable, we randomly sample 3% of these new loans in the CIR and work with 674,127 loans or 1,987,967 loan-quarter observations. We select firms on the basis of their tax identification number to obtain a random sample.[14] We use the same set of loans throughout the paper, unless otherwise stated.[15]

3.2 Measuring Credit Risk

We first measure credit risk-taking with ex ante borrower-level proxies. Employing discrete choice models, we analyze whether a loan is granted to a borrower with a good or bad credit history (depending on default on another loan in the previous 6 months), and alternatively, with or without credit history (in the latter case the borrower has more uncertain cash flows).

As explained in Section II an (almost) ideal measure of credit risk is the probability of default of individual loans that is normalized per time period. Indeed, lower short-term rates may lead to more lending to non-prime borrowers and/or a lengthening of average loan maturity. However, neither action needs to imply higher credit risk-taking *per se*, as the net worth of non-prime borrowers also improved because of the lower short term rates and longer loan maturity entails more liquidity risk but not necessarily more credit risk.

Therefore, to isolate the changes in credit risk-taking, we employ duration models and analyze the impact of short-term interest rates prior to loan origination on the loan hazard rate, which is a loan default probability that is normalized per unit of time. This is possible as our dataset includes unique loan repayment information, i.e., not only *whether* the loan is overdue or not but also *when* it defaults.

We use the observed realizations of the time to default as our main measure of bank risk-taking *ex ante.*[16] However, we do observe all new and outstanding loans over a very

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13. The entire database contains more than 32,000,000 loans. We focus on the 22,470,900 commercial and financial loans (80% of total loans), excluding leasing, factoring and other specialized loans, granted by commercial banks, savings banks or credit cooperatives (95% of total credit market).

14. Given the way in which tax identification numbers are assigned, all firms with the same last digit for example would comprise a 10% random sample.

15. We randomly re-sample another 3% of the loans and re-run all specifications. We also sample 6% of the loans and run selected specifications. Results (available upon request) are virtually unchanged and illustrate the robustness of our results to the sampling procedure.

16. Internal or external credit ratings of loans or borrowers are not available. However, these measures are often criticized as coarse and unreliable. *Internal* credit ratings of banks in the U.S., Germany and Argentina for example are long time period and can control in our estimations for multiple bank characteristics and time-varying macroeconomic conditions, assuaging any concerns that the realizations of the time to default would systematically differ from the officers' expectations.

In addition, employing duration models, we can not only dynamically control for macroeconomic factors that influence credit risk, but also analyze at each point in time during the life of the loan what impact monetary policy has on its default probability. This possibility further helps in our econometric identification. Indeed, a testable prediction from theory implies that higher interest rates may lead to lower credit risk-taking at origination (as banks' net worth is lower), but results in higher credit risk once the loan is outstanding (as the borrowers' net worth is lower). We can actually test this prediction using duration models —i.e., on a loan-by-loan basis we can analyze how overnight rates before loan origination and how the path of overnight rates after loan origination affect the loan hazard rate.

Other potential measures that one could use as proxies for credit risk-taking are loan rates or collateral requirements. However, it is not clear what the expected impact of the short-term interest rates on loan rates or collateral requirements is.[17] Contractive monetary policy for example would imply higher loan spreads and collateral requirements if the banks' risk-appetite decreases. On the other hand, lower risk-appetite implies banks fleeing to quality, and consequently lower loan spreads and collateral requirements for the better average borrower.

3.3 Disentangling Supply of Credit to Risky Borrowers from its Demand

Detailed information in the CIR database allows us to disentangle the supply of credit to risky borrowers from its demand. The identification problem we face is that, when short-term interest rates change, the loan demand by the risky borrowers (or for risky projects) could be affected differently than the loan demand by the not-so-risky (henceforth, "safe") borrowers. Fortunately for our investigation, this identification problem may not be as severe as in the bank lending literature at large because four different steps assure us a proper identification.

First, lower short-term interest rates in general result in a higher loan demand [Kashyap and Stein (2000)], but not necessarily only from risky borrowers. Moreover, if their demand for loans would increase more (than the demand from the safe borrowers) and if the banks' appetite for risk would remain unaffected, we actually would expect observable lending standards to tighten and not to loosen. Therefore, controlling for lending standards such as collateral, maturity and loan amount therefore mitigates the identification challenge.

Second, we rely on a wide set of borrower characteristics, including borrower identity, to absorb the variation in the risk of the pool of the borrowers over the monetary policy cycle.

Third, as in Kashyap and Stein (2000), we exploit the cross-sectional implications of the sensitivity of bank risk-taking to monetary policy according to the strength of banks'

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partly based on subjective, non-financial factors [Treacy and Carey (2000), Grunert, Norden and Weber (2005) and Liberti (2004)]. Loan officers can therefore manipulate the ratings (Hertzberg, Liberti and Paravisini (2007)] and give better ratings when interest rates are low. *External* ratings provided by credit rating agencies were widely blamed during the financial crisis of 2007 as having been uninformative, even deceptive, in the years prior to the crisis.

17. The loan rate as a proxy for risk may additionally suffer from the variation over time in the price of risk. Evidence from equity prices [Bernanke and Kuttner (2005)], bond yields [Manganelli and Wolswijk (2007)], buyout pricing [Axelson, Jenkinson, Strömberg and Weisbach (2007)] and loan rates [Ioannidou, Ongena and Peydró (2007)] suggest this time variation is common across many financial assets.

balance sheet and moral hazard problems (proxied by bank size for example). At each point in time there are more than two hundred banks operational in Spain providing ample cross-sectional variation.

Finally, as in Khwaja and Mian (2008), we observe that many borrowers have multiple bank connections so that we can perform *within* borrower comparisons. We assess how for each borrower the proportion of financing provided by banks with a higher and lower appetite for risk (i.e., small versus large banks) depends on changes in the overnight interest rate. We complete this assessment by differentiating between riskier and safer borrowers (with and without a recent bad credit history). If following a monetary expansion, riskier borrowers connected to both types of banks start borrowing relatively more (than the safer borrowers) from those banks with a higher ability and incentive to increase risk when short-term rates change, one can argue that these banks offer the better deals or ration less the riskier borrowers. Consequently, it is also the banks that are adjusting their appetite for risk, not only the borrowers that are altering their demand for loans.

To conclude, given the nature of the identification problem we face, the range of borrower and bank characteristics we have access to, and the econometric strategies we mobilize, we surmise that making inferences on whether the stance of monetary policy affects the banks' appetite for credit risk is possible.

3.4 Exogenous Monetary Policy

If the level or variations of short-term interest rates were completely exogenous, the coefficient of the regression of credit risk-taking on short-term interest rates would indicate its causal impact. When monetary policy is not exogenous, there are two problems with econometric identification: (i) Reverse causality (e.g., future higher risk may imply current monetary expansion), and (ii) omitted variables (variables correlated with the stance of monetary policy that can also influence risk-taking). We can deal with these two problems relying on two key features of our empirical setting.

First, for the whole period analyzed, short-term interest rates in Spain were decided mostly in Frankfurt, not in Madrid. Implicitly from mid-1988 and explicitly from mid-1989 when Spain joined the European Monetary System and its exchange rate mechanism, the exchange rate target with the *Deutsche Mark* was the main objective of its monetary policy [Banco_de_España (1997)].[18] From 1999 onwards, Spain joined the Eurosystem as one of twelve countries, representing less than 15% of the total economic activity in this group.

Second, the mandate given to the *Bundesbank* and the ECB was primarily to preserve price stability, not to stimulate economic activity. Nevertheless, we control in the specifications for many macroeconomic variables such as Spanish (and German/ Euro Area) GDP growth and their forecasts, inflation, country risk, yield curve measures and other variables. In addition, we also track bank lending to borrowers with bad or no credit history.

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18. In 1986 Spain joined the European Union. Consequently, monetary policy started to pay more attention to the exchange rate and, in particular, to the Peseta / *Deutsche Mark* exchange rate. The monetary policy authorities in this way intended to incorporate more discipline and credibility in their fight against inflation. At the same time capital restrictions were being eliminated. As of mid-1988, Spanish monetary policy was no longer independent from the German monetary policy according to the textbook 'Mundell-Fleming trilemma' [see Blanchard (2006) or Krugman and Obstfeld (2006) for example]. It is therefore not entirely surprising that Boivin, Mojon and Giannoni (2008) finds that a shock to German monetary policy has a stronger impact in Spain than in Germany itself. Spain did devalue its currency three times between 1992 and 1993 and also had temporary credit controls the second half of 1989 and during 1990. In non-reported robustness regressions, we include time dummies for the quarters involved and results do not change significantly.

Indeed, if risk is expected to increase in the future and monetary policy reacts by being expansive today, low interest rates could still correspond to higher loan hazard rates even if banks flee to quality because of the looming crisis. However, observing that banks continue to grant loans to risky borrowers (for instance borrowers with no credit history) implies it is not monetary policy simply reacting to future risk but banks actually seeking it.

Our sample period spans more than a complete domestic business cycle as we extract quarterly loan records running from 1984:IV to 2006:IV to study the impact of monetary policy on bank credit risk-taking starting in 1988:II. We use the German and Euro overnight rates as a measure of the stance of monetary policy. While monetary policy was fairly exogenous, as we argued, and hence this measure is therefore appropriate, we also employ either the Spanish overnight interest rate directly or instrumented by the German rate. In addition, we also run all specifications for the pre-1999 period and for the euro period.

To conclude, given the degree of exogeneity of monetary policy in Spain, the macroeconomic controls and the combination of econometric strategies we employ, we are confident that making inferences on whether the stance of monetary policy affects the banks' appetite for credit risk is possible.

4 Results

Figure 1 summarizes the line-up of the models we will now discuss, including the indexing and timing of the variables. We say a loan *l* by bank *b* is granted to borrower *j* in quarter τ. Let T denote the time to maturity or the time to default in case of an overdue repayment; hence, repayment or default would occur in quarter $\tau + T$.

The *probit* models use monetary policy conditions present in the quarter prior to the origination of the loan (at $\tau - 1$) to explain the probability that the borrower that obtains the loan (at τ) has a bad or no credit history. The *within borrower comparisons* explain the difference in the change in the proportion of lending by small and large banks, to each individual borrower, between borrowers with and without a recent bad credit history (at τ) employing monetary policy conditions present in the quarter prior (at $\tau - 1$). *Duration models* differentiate between monetary policy conditions prior to origination ($\tau - 1$) and policy conditions prevailing during the life of the loan, either in the quarter prior to loan repayment or default ($\tau + T - 1$) or, in all the periods between the loan origination and the loan repayment or default ($\tau + t$, where *t=0, 1, …, T-1*).

Table 1 defines the main dependent (Panel A) and independent (Panel B) variables that are employed in the empirical specifications (including those that are used in the tabulated robustness exercises) as well as their descriptive statistics. As independent variables in the models we include measures of monetary policy conditions and an array of bank, borrower, loan, macroeconomic and provincial characteristics and controls. We measure monetary policy conditions using the quarterly average of nominal German and, from 1999:I onwards, Euro overnight interbank interest rates. We label the monetary policy measure prior to loan origination as INTEREST RATE.

Credit risk-taking and, in general, lending behavior may vary across banks. To control for differences in lending by the banks we introduce bank characteristics (coming from the CIR as well as from the banks' balance sheets). We include LN(TOTAL ASSETS) which equals the logarithm of the total assets of the bank, LIQUIDITY RATIO is the amount of liquid assets held by the bank over total assets, and OWN FUNDS/TOTAL ASSETS is the amount of bank equity over total bank assets.[19] We also control for the level of bank risk (i.e., an indicator of the bank's relative risk appetite and/or ability), measured by BANK NPL_b-NPL, which is the difference between the bank and the other banks' non-performing loan ratios. All bank characteristics are measured prior to the loan origination quarter. We further include the type of bank ownership using dummies that equal one if the bank is a commercial bank LISTED, a SAVINGS BANK, or a CREDIT COOPERATIVE and equal zero otherwise.[20] As savings banks and credit cooperatives are not listed, the benchmark category is the non-listed commercial bank.

We include borrower and loan characteristics as the composition of the pool of borrowers and loans may change over time and to disentangle supply from demand effects

19. Very few banks in certain periods record negative equity values. Removing these observations does not alter our results and, for consistency reasons, we decided to retain them.

20. Delgado, Salas and Saurina (2007) explain the main features of the Spanish banking system, focusing in particular on the differences in characteristics and behavior of commercial banks (both listed and non-listed), savings banks and credit cooperatives. All of them compete under the same rules although savings banks do not have shareholders.

(we also employ borrower identity in the duration analysis of individual loans).[21] We define LN(1+BORROWER BANK DEBT) to equal the logarithm of one plus the total amount of borrower bank debt and LN(1+NUMBER OF BANK RELATIONSHIPS) as the logarithm of one plus the number of bank relationships of the borrower. We do not have direct access to the actual date of registration of the firm, but we know when the firm borrowed for the first time since 1984:IV. The variable LN(2+AGE AS BORROWER) measures the age of the borrower in the CIR and for most firms will be highly correlated with actual age.[22] In addition to these borrower characteristics, our specifications include ten Industry dummies and fifty Province dummies.

As loan characteristics we include the log of the total loan amount, LN(SIZE OF THE LOAN) and time-invariant loan dummies that equal one if the loan requires COLLATERAL or is a FINANCIAL CREDIT and equal zero otherwise. Four MATURITY dummies stand for the 0 to 3 month, 3 month to 1 year, 1 to 3 year, and 3 to 5 year maturity classes, the benchmark being long-term loans over 5 years. All borrower characteristics are dated in the quarter prior to the origination of the loan and all loan characteristics are naturally dated in the quarter of the origination itself.

To capture general economic and market developments related to business cycle conditions and country risk, we include the growth in real gross domestic product, GPDG, in the quarter prior to the origination of the loan, and at origination itself the Spanish INFLATION rate, a COUNTRY RISK measure (the spread between the ten year Spanish and German government bond rate), and a TIME TREND and TIME TREND^2 [as in Kashyap and Stein (2000)].[23]

4.1 Borrowers with a Bad or without Credit History

We start analyzing measures of credit risk-taking that proxy for risk at the borrower level. We estimate probit models with two different discrete dependent variables. RECENT BAD CREDIT HISTORY is a dummy that equals one if any loan of the borrower was overdue during the previous six months, and equals zero otherwise, and NO CREDIT HISTORY is a dummy that equals one if the borrower receives its first bank loan ever, and equals zero otherwise (i.e., the borrower has or had another loan). Through the CIR database bank loan officers can find out whether loans of potential borrowers were overdue during the last six months and they also have access to the total exposure of the potential borrower.

Table 2 shows the results. We report the coefficients in the first column and the significance levels represented by stars in the second column.[24] In the third column (and in italics between parentheses) we tabulate the robust standard errors that are corrected for clustering at the borrower level.[25]

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21. Introducing borrower fixed effects in the probit models leaves the results unchanged.

22. This variable is therefore by construction left censored but removing it or limiting its backward looking horizon does not alter our results.

23. Replacing the spread with the time-varying International Country Risk Guide index does not alter results. We also include measures of banking system efficiency or credit growth, individual bank credit growth, German / Euro inflation and GDP growth, GDP growth forecasts, the volatility of GDP, yield curve measures and house prices. Results are unaffected and we opted to report the more parsimonious models. We revisit the inclusion of these variables in our duration analysis.

24. *** Significant at 1%, ** significant at 5%, and * significant at 10%. For convenience we also indicate the significance levels of the coefficients in the text.

25. Loan default may be correlated at the borrower level, an issue we revisit in robustness. We alternatively cluster at the bank or quarter level but results are mostly unaffected.

The dependent variable in Model I is RECENT BAD CREDIT HISTORY. The probit regression shows that low interest rates imply that banks grant more loans to borrowers thathad a recent bad credit history, i.e., a non-performance of a loan during the last six months. This is one of our key findings. The possibility that we are observing the evergreening of loans by banks can be discarded; this activity should decrease —not increase— when interest rates are low (we further drop individual loan renewals in robustness later in the paper). The effect of the interest rate on engaging risky borrowers (i.e., borrowers with a recent bad credit history) is also economically relevant. A two-standard deviation cut in interest rates from 5% to 1% for example would increase the probability of lending to a risky borrower by a 16%.

The coefficients on the other variables are mostly as expected. Banks with relatively more than average non-performing loans already on their books, fewer own funds and that are non-listed commercial banks or that are credit cooperatives seem more likely to engage borrowers that were overdue during the last six months. Younger firms with fewer bank relationships are also less likely to have been non-performing recently.[26] Observing a lower amount of credit and higher collateral requirements also makes it more likely that the borrower was recently non-performing. This is to be expected if banks adjust loan conditions when demand from those risky borrowers is higher. Not including loan or borrower characteristics or, alternatively, including borrower fixed effects leaves the results unaffected.

On the basis of a commonly shared reading of Spanish monetary history we argued earlier that the German/Euro overnight interest rate is the proper and fairly exogenous monetary policy rate. Nevertheless, we replace the INTEREST RATE by the INTEREST RATE in SPAIN instrumented by the German overnight interest rate. The first stage regression of the INTEREST RATE in SPAIN on the German INTEREST RATE, reported in Table 2B, shows that controlling for Spanish macro conditions the German rate is a strong instrument [Staiger and Stock (1997)], with a t-statistic on its coefficient that is larger than eight. Jointly the variables explain 97% of the variation in the Spanish interest rate (the correlation between the two countries' GDP growth rates is only 36%). The effect of the instrumented Spanish interest rate on the likelihood a risky borrower is granted a loan is, as expected, even larger and statistically significant at the 1% level (Model II in Table 2). A cut in interest rates from 5% to 1% in this case increases the probability of lending to a risky borrower by 21%.

Finally, as in Kashyap and Stein (2000) and using cross-sectional variation in bank characteristics to further identify the supply effect, we add the interaction of the INTEREST RATE with LN(TOTAL ASSETS). Small banks may react more strongly in their risk-taking to changes in the interest rate since they may have worse access to liquidity for example [Diamond and Rajan (2006)]. The coefficient on the interaction term in Model III shows this is indeed the case.

To account for the unlikely possibility that banks evergreen and also for the general interpretation of the results, Models IV to VI show that low interest rates also correspond to banks granting more loans to borrowers that have NO CREDIT HISTORY. New borrowers have in general more uncertain cash flows and are therefore riskier. Results are similar to the results on borrowers with a bad credit history. Note that these results reinforce the

26. Firms with bilateral bank relationships may perform better. Badly performing firms may also initiate more bank relationships [Bhattacharya and Chiesa (1995) and Yosha (1995); for evidence see Degryse and Ongena (2001), Farinha and Santos (2002) and Fok, Chang and Lee (2004), among others]. The result on age is overturned in the duration analysis.

interpretation that lenders take on higher credit risk when short-term interest rates are lower and not that lower interest rates and high credit risk are just a consequence of worse economic fundamentals in the economy.

All in all, banks seem to lend to riskier borrowers when interest rates are low prior to loan origination, and given the controls for GDP growth, inflation, country risk and other variables, the results further suggest that when stance of monetary policy is more expansive, credit risk-taking is higher.[27] Therefore, we find support for H1.

4.2 Within Borrower Comparison

Despite the inclusion of borrower characteristics and loan conditions, and the fact that our estimates so far suggest that small banks react more to interest rate changes than large banks, concerns may linger whether our findings pick up supply side effects. We therefore turn to a within borrower comparison to take our additional and final identification step.

As in Khwaja and Mian (2008) we observe that many borrowers in our sample have multiple bank connections. Using the entire CIR database we select the 769,222 borrowers with loans from more than one bank. We do so for each quarter between 1988:II and 2006:IV. We are left with 13,265,830 firm-quarters. In each quarter we classify all borrowers into two groups, "risky" and "safe", according to their RECENT BAD CREDIT HISTORY (the dummy equals one for risky and zero for safe borrowers). Similarly in each quarter we classify all banks into small and large according to their TOTAL ASSETS (small banks are below and large banks are above the quarter median, respectively), as theory surmises small banks may be more affected by the stance of monetary policy in their ability and incentive to take on more credit risk.

For each borrower-quarter, we then calculate the difference between the percentages of the loan amounts that are obtained from either the borrower's small or large banks, a difference we surmise that will remain unaltered if a borrower's demand for financing changes.[28] We label this difference SMALL – LARGE BANK BORROWING. We first-difference this variable and regress it on the lagged INTEREST RATE, RECENT BAD CREDIT HISTORY, and their interaction. We further include level of borrower's debt, borrower unobservable effects and macro controls. We report the results of this regression in Table 3, Model I.

The negative and significant coefficient on INTEREST RATE suggests that following a monetary expansion small banks provide relatively more financing to *all* borrowers than large banks. More importantly, the negative and significant coefficient on the interaction term INTEREST RATE * RECENT BAD CREDIT HISTORY (i.e., –0.038**) suggests that following a monetary expansion small banks provide more loans to *risky* borrowers than large banks *vis-à-vis* loans to safer borrowers. The results suggest that, when interest rates are lower, large banks loosen their lending standards for risky firms less than small banks, suggesting that it is the *banks* that also *adjust* their credit risk-taking following changes in monetary policy (and not the risky borrowers that alter their demand).

Next we select only those borrowers that simultaneously have relationships with both small and large banks, leaving 6,844,387 firm-quarters. In consequence, in this

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27. Similarly Jiménez and Saurina (2006) find that lending standards worsen during good times. They consequently argue for countercyclical prudential norms.

28. Following monetary changes, small banks are more affected in their risk-taking than large banks [see for example Stiglitz and Greenwald (2003) and Diamond and Rajan (2006)].

case borrowers have access to bank finance from both banks with high and low appetite for credit risk. Results in Model II (Table 3) strongly suggest that following lower interest rate small banks lend relatively more to borrowers with a bad credit history than large banks (the coefficient in this case equals –0.091***). We also replace the macro controls with 74 quarterly dummies. Results are unaffected and not reported.

4.3 Duration Analysis

While the results of the probit models and within borrower comparisons so far are suggestive *per se*, a number of additional steps are vital to reach firmer conclusions. First, banks may lend more to risky borrowers because they think that economic fundamentals are strong enough that the probability of default is reduced when rates are low (as low rates imply high borrowers' net worth for example). Hence, to analyze whether monetary policy influences credit-risk appetite we need to assess whether individual loans have a higher default probability or not.

Second, average loan maturity may change over time; worse, the stance of monetary policy may affect liquidity risk and hence loan maturity (more risk-taking would entail lending at longer maturities). Consequently, we need to have a measure of credit risk-taking that is normalized per period of time. Therefore, we need to analyze credit risk-taking employing duration models to assess how the hazard rate is affected by monetary policy.

4.4 Methodology

We analyze the time to default of the individual bank loan, or "loan spell", as a measure of risk.[29] We define default to occur if three months after the date of maturity or the date of an interest payment, the debt balance remains unpaid.[30] The hazard function in duration analysis provides us with a suitable method for summarizing the relationship between the time to default and the likelihood of default.[31] The hazard rate effectively is a per-period measure of credit risk-taking and has an intuitive interpretation as the per-period probability of loan default provided the loan 'survives' up to that period. We rely on a parametric Weibull specification to determine the shape of the hazard function with respect to time. The Weibull distribution allows for monotonically positive or negative duration dependence, i.e., loans may be more or less likely to default as the time since their origination increases. As almost 80% of the loans in the sample are four quarters or shorter in maturity, we focus on the results for the standard Weibull parameterization with non-time varying covariates.[32]

Repayment of a loan may prevent us from ever observing a default on this loan. Such a loan spell can be considered right censored. Not knowing when the default would occur means we are unable to observe the "true" time to default for these loan spells. With no adjustment to account for censoring, maximum likelihood estimation of the proportional hazard models produces biased and inconsistent estimates of model

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29. As in McDonald and Van de Gucht (1999) for example. Loans to small firms typically carry a relatively short maturity, often without early repayment possibilities; hence, we choose to ignore early repayment behavior captured in their competing risk model.

30. We use "default" in the common sense of "a failure to pay financial debts" *(Merriam-Webster Dictionary)*. Ninety days overdue is a standard period to classify a loan as non-performing but some countries use different overdue dates depending on the credit product [see for example Beattie, Casson, Dale, McKenzie, Sutcliffe and Turner (1995)].

31. Cameron and Trivedi (2005), Heckman and Singer (1984), Kiefer (1988), Kalbfleisch and Prentice (2002) and Greene (2003) provide comprehensive treatments of duration analysis. Shumway (2001), Chava and Jarrow (2004) and Duffie, Saita and Wang (2007) discuss and employ empirical bankruptcy models.

32. Our main results are unaffected either if we use a log-logistic specification which allows for a non-monotonic duration dependence or a Cox (1972) proportional hazard model for which the baseline hazard is a loan-specific constant. We find weak evidence for non-monotonicity at longer maturities. We return to estimation with time-varying covariates in the robustness subsection.

parameters. Accounting for right-censored observations will be accomplished in duration analysis by expressing the log-likelihood function as a weighted average of the sample density of completed loan spells and the survivor function of uncompleted spells. We return to the independence of the censoring scheme itself in the robustness subsection. As our sample consists out of *new* loans granted from 1988:II onwards, there is no left censoring problem.

4.5 First Results

The estimates in Table 4 are based on the maximum likelihood estimation of a duration model with a Weibull distribution. A positive coefficient indicates that an increase in the independent variable increases the hazard rate. All estimates are adjusted for right censoring and standard errors are clustered at the borrower level.

Model I controls for key macroeconomic conditions (specifically for the growth in real gross domestic product, the inflation rate, a measure of country risk, and two time trends, in level and squared), and also includes bank random effects to control for unobservable heterogeneity related to different bank lending behavior ("frailty model"). The estimated coefficient on INTEREST $RATE_{\tau-1}$ in Model I equals –0.099***. Hence, a lower short-term interest rate prior to loan origination implies that banks grant loans with a *higher* hazard rate, i.e., with a higher probability of default per quarter. Therefore, we find support for H2. On the other hand, the coefficient on INTEREST $RATE_{\tau+T-1}$ equals 0.344*** indicating that a lower short-term rate during the life of the loan implies a *lower* loan hazard rate.

While lower short-term interest rates in the economy increase the hazard rate on new loans but decrease the hazard rate on the outstanding loans, higher GDP growth decreases the hazard rate on both new and outstanding loans (the coefficients on GDP growth are –0.201*** and –0.045***, respectively). These estimated coefficients also benchmark the effects of monetary policy on credit risk: A one percentage point change in the interest rate for example has similar sized effects as one percentage point change in GDP growth, though its standard deviation is almost double the size of the standard deviation of GDP growth one (more on economic relevancy later). All in all, these results suggest that expansive monetary policy, in contrast to economic growth, whets the appetite for credit risk.[33]

Both higher inflation and country risk at origination entail as expected a higher loan hazard rate, while the positive coefficients on both time trends indicates a secular increase in Spanish bank risk-taking. The latter finding clearly demonstrates that more risk-taking need not be excessive *per se* and that only intertemporal variation in risk-taking across borrowers and banks can provide evidence in this regard.

Finally, the estimate of $\ln(\alpha)$, which is the logarithm of the parameter of duration dependence in the Weibull distribution, equals 0.620***. As α equals 1.859 and is larger than one, the positive duration dependence we find implies that default becomes conditionally more likely over the life of the loan.

4.6 Bank, Borrower and Loan Characteristics

Bank characteristics have significantly changed during the entire sample period. We therefore add time variant bank characteristics in Model II. The key results we already discussed are basically unchanged. The coefficients on most bank characteristics are statistically significant,

33. GDP growth also has an opposite effect than short-term rates on the selection of borrowers' quality of credit history (see Table 2).

except the coefficient on total assets. The coefficients on the own funds and liquidity ratio for example are negative, indicating that banks with more own funds at stake or with more liquidity grant loans with lower hazard rates. More own funds at stake may lower the incentive to take risk as in Keeley (1990) for example and, banks may hoard liquidity and therefore not grant risky loans as in Diamond and Rajan (2006). The coefficient on the bank's non-performing loan ratio (compared to the sector's average) is positive suggesting that banks seemingly persist in hazardous lending. Listed commercial banks, and more intensely savings banks and cooperatives grant more risky loans (0.154***; 0.422*** and 0.371***, respectively).

We further add borrower and loan characteristics in Model III of Table 4 to control for changes over time in the borrowers and loans and to disentangle supply from demand effects. A higher demand from risky borrowers or a deterioration in the quality of the marginal new borrower and/or project for example may lead banks with a constant risk-appetite to lower the amount of credit, to demand more collateral and/or to shorten maturity. Including these proxies for lending standards, and the borrower characteristics, leaves the main results basically unchanged.

With regard to the borrower characteristics, we observe that the coefficient on the proxy of the size of the firm is insignificant, whereas as the borrower ages the likelihood to default decreases. The risk profile of a firm, measured by its credit history, shows that firms with bad credit records in the past are more likely to default in the future. Finally, we observe that borrowers with a large number of bank relationships are more risky. Loan characteristics play also an important role explaining the time to default of a loan. Model III shows that smaller, more collateralized and short-term loans are riskier than the other [as in Jiménez, Salas and Saurina (2006)].

Controlling also for unobservable borrower heterogeneity employing random effects (corresponding to 39,963 individual firms) in Model IV, again does not alter our findings. All these results suggest that banks do *adjust* their credit risk-taking in response to changes in short-term rates. The coefficients on most borrower and loan characteristics are statistically significant in Model IV, except the coefficient on collateral.[34] Younger firms with more bank relationships are more likely to default and so are smaller loans with a shorter maturity. Once we control for unobservable firm heterogeneity the coefficient on the size of the borrower turns negative, showing that loans to smaller firms are riskier. Banks seem to adjust loan amount and maturity when the demand from risky borrowers is higher (again not including loan characteristics leaves the results unaffected).[35]

Finally, in Model V we introduce interactions between the interest-rate-at-origination variable and a borrower bad credit history dummy and borrower age. Remember that one of our two main motivations to employ duration analysis was that more lending to borrowers with a bad or no credit history not necessarily implied more bank credit risk-taking if lower interest rates significantly bolstered borrowers' net worth for example. However, the estimates reported in Model V suggest that borrowers with a bad or shorter credit history fail even more when monetary policy is expansive. This is a key finding providing our

34. The coefficient on collateral turns statistically significant when we do not control for unobservable borrower heterogeneity (as in Model III for example). Collateral may be set for the borrower in beginning of the relationship and may be only infrequently adjusted.

35. For credit lines we take the total amount that is made available to the borrower. Dropping credit lines that are not drawn or dropping all credit lines does not alter the results. Some loans are also flagged as renewals. Dropping renewals does not change the results.

results on borrower selection in Tables 2 and 3 with a clearer interpretation: When interest rates are lower, there is more credit risk-taking. Therefore, we find support for H2.

4.7 Economic Relevancy and Dynamics

In this section we investigate how the stance and dynamic path of monetary policy affect credit risk. We employ the coefficients of the Model IV in Table 4 to calculate a quarterly probability of default for a loan with a mean maturity of five quarters,[36] and other mean characteristics, for different combinations of INTEREST RATE$_{\tau-1}$ and INTEREST RATE$_{\tau+T-1}$. Figure 2 displays these combinations.

For example, if the short-term interest rate in the economy is equal to 4.1% (the sample mean) at loan origination and maturity, the quarterly probability of loan default is estimated to equal 0.6% (which equals the sample quarterly probability of loan default). In contrast, if the interest rate at origination equals 2.0% (the sample mean minus one standard deviation), but increases over the life of the loan to 6.2% (the sample mean plus one standard deviation), the default rate of the loan more than doubles to 1.4%. On the other hand, if the "path is reversed" and the funds rate drops from 6.2% to 2.0%, the default rate more than halves to 0.2%.

These results suggest that during long periods of low interest rates banks may take on more credit risk and relax lending standards. Exposing the "hazardous" cohort of loans, granted when rates were low, to swiftly increasing policy rates dramatically exacerbates their risk, these estimates suggest (an effect which is more muted when rates were high at origination).[37] Therefore, we also find support for H3.

To further assess the dynamics of credit risk-taking, we first-difference the interest rate and GDP growth variables and include additional lags of the interest rate in Model VI of Table 4. The effect of a change in the interest rate on the hazard rate is immediate. Coefficients on the quarterly change in the interest rate one and two quarters prior to origination are equal to –0.601*** and –0.152**, respectively, while the coefficient on its third lag is small and not significant. The coefficient on the change in the interest rate over the life of a loan equals +0.201***. These estimates again vividly illustrate the conundrum central banks may face when changing policy rates: On the one hand, lowering rates reduces on the short-run the credit risk of outstanding loans and increases the credit risk-taking of banks; on the other hand, there will be more defaults in the medium term.

Finally, we report the results for a duration model that allows the short-term interest rate, GDP growth rate, country risk and inflation to vary over the life of the loan (indexed $\tau+t-1$, with $t:1\rightarrow T$). We focus on the time variation in only these variables as a number of bank and borrower characteristics do not vary much over time (bank ownership, number of borrower relationships, and bad credit history for example) or are deterministically "defined" with respect to the duration of the loan (age for example).

36. The choice of maturity matters also because the estimated parameter of duration dependence is significantly larger than one: In Model IV it equals $e^{0.816}$ = 2.261. The hazard rate will therefore increase over the life of the loan. Integrating the hazard rate over the life of the loan yields the probability of default of the loan.

37. While suggestive of the impact of changes in monetary policy on the loan hazard rates, the estimates are calculated for one loan cohort only. To obtain a correct assessment of a monetary policy path on the aggregate hazard rate, cohort size and timing needs to be properly accounted for (loans granted during the period of the increase in the policy interest rate will have a lower and lower hazard rate for example). We leave such an exercise for future work.

In addition, the loan characteristics if allowed to vary may *not* be longer "ancillary" (or exogenous) with respect to loan duration![38]

Models VII and VIII report the estimates employing 1,989,170 loan-quarter observations. The coefficient on the interest rate prior to origination remains negative and significant, but the coefficient on the newly introduced time-varying interest rate covariate is small in Model VII. However, also the two trend variables strikingly loose significance in that model thus suggesting multicollinearity. Therefore, we drop the two time trend variables in Model VIII and the coefficient on the time-varying interest rate as expected returns to a value closer to previous specifications (i.e., non-time-varying).

Note also in Model VIII that when we allow inflation to vary over the life of the loan, higher inflation implies lower hazard rate. Higher inflation reduces the real value of the debt thus reducing default risk [see Allen and Gale (2004) and Diamond and Rajan (2006)]. However, higher inflation at origination implied more risk in Model I for instance.[39]

4.8 Interactions with Bank Characteristics

Next we introduce interactions of the overnight rates with bank characteristics. Theory suggests banks' propensity to adjust credit risk-taking in response to monetary policy conditions may depend upon bank size, liquidity, type of ownership, and local market characteristics. Interactions can further assist us in addressing identification problems. We report the estimates in Table 5. To focus and conserve space, the coefficients on borrower and loan characteristics and the macro controls are no longer reported. These coefficients remain virtually unaffected from Table 4.

Smaller banks not only take more credit risk but also change their credit risk-taking more in response to changes in the stance of monetary policy (Model I in Table 5). Their lower net worth, lack of diversification, and more difficulties in accessing liquidity may provide an explanation [Diamond and Rajan (2006)]. On the other hand, banks with more liquidity take more risks and respond more to a lowering of interest rates in their risk-taking than other banks (Model II). Banks may hoard liquidity (possibly because they take higher risk). Hence when short-term interest rates are lower, banks with high levels of liquidity may finance more risky long-term projects [Diamond and Rajan (2006)], as they no longer need this level of liquidity since their cost / access to liquidity improves. Liquid bank assets may also worsen the moral hazard problem as these assets can be easily directed towards risky ventures [Myers and Rajan (1998)]. When monetary policy is expansive and bank return on assets is low, the banks that can increase credit risk-taking more are those with many liquid assets at hand.[40]

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38. To obtain interpretable estimates it is required that the variables be either "defined" or "ancillary" with respect to the duration of the loan. A defined variable follows a deterministic path. *Age* is an example of a defined variable because its path is set in advance of the loan and varies deterministically with loan duration. An ancillary variable has a stochastic path but the path cannot be influenced by the duration of the loan. *Collateralization* for example is probably not ancillary as banks may eventually tighten collateral requirements when hazard rates increase.

39. Higher inflation may amplify the standard deviation of the spread between bank loan and deposit rates, yet cut bank profitability and lead to banking instability (Boyd and Champ (2003)]. The evidence seems sometimes mixed though. In Beck, Demirgüç-Kunt and Levine (2003) for example lower inflation eases financing obstacles faced by borrowing firms, while in Demirgüç-Kunt and Detragiache (2002) inflation does not help predict the occurrence of banking crises [in contrast to Demirgüç-Kunt and Detragiache (1998)].

40. The measure for bank liquidity we employ is often used in the literature that investigates the credit channel of monetary policy [see Kashyap and Stein (2000) for example]. In a previous version of this paper and in non-reported regressions, we explore other measures of liquidity such as the ratios of loans to deposits and interbank deposits

Banks with a relatively higher ratio of non-performing loans seem to continue in their ways by granting loans with a higher hazard rate (Model III). However monetary policy does not affect their credit risk-taking in a statistically significant way.[41] While credit cooperatives grant loans with a higher hazard rate than private commercial banks, their risk-taking is not significantly affected by monetary policy (Model IV). Savings banks increase less their risk-taking when rates are lower, which suggests that bank managers seem to be more cautious. That might be the result of a more limited upside potential in their pay packages since savings banks have no shares. Alternatively, they might try to rein more on credit risk since their portfolios are, *ceteris paribus*, always more risky (the SAVINGS BANK parameter is always positive, significant and the largest one among type of ownership dummy variables in specifications without interaction terms).

Having more new borrowers in the province increases the hazard rate on new loans (Model V), as the adverse selection problem among banks stemming from bank relationships with old borrowers is alleviated thereby weakening the bank incentives to screen. When monetary policy is more expansionary, the relative cost of screening versus non-screening increases, providing incentives to banks to soften their lending standards [Dell'Ariccia and Marquez (2006)]. We find that the presence of more new borrowers in the province reinforces the impact of short-term rates on credit risk-taking.

Finally, with more banking competition (proxied by a lower Herfindahl-Hirschman Index), banks have more incentives to take risk because the franchise value of the bank is lower [as in Keeley (1990)]. Thus, with easy access to liquidity during monetary expansions, a very competitive environment for banks may enhance risk taking [Dell'Ariccia and Márquez (2006), Sengupta (2007)].

Overall, we find that the impact of the stance of monetary policy on credit risk-taking depends on bank size, liquidity, and ownership. Local banking conditions, at the province level, like the percentage of new borrowers and the banking market concentration also matter. Therefore, the evidence is consistent with H4.

4.9 Robustness

Finally, in Table 6 we run through a number of additional robustness checks. To conserve space we now also suppress the coefficients on the bank characteristics. These coefficients remain virtually unaffected from Table 5.

4.9.1 CENSORING SCHEME INDEPENDENCE: LOAN MATURITY AND MULTIPLICITY

Banks may not only change loan risk, but also alter other loan terms according to monetary conditions. For instance, expansive monetary policy could make banks more willing to bear liquidity risk [Diamond and Rajan (2006)]. Changes in observed loan maturity in particular are a fundamental reason to rely on duration and not on probit models when assessing loan risk on the basis of observed loan default. But even if the loan maturity (at origination) would be directly affected by monetary policy (the conditional correlation coefficient of –0.08 actually suggests it is *not*),[42] or borrowers would repay early to benefit from a lower interest

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(a measure for the importance of wholesale depositors). We find that the impact of interest rates on credit risk-taking also depends on the structure of the deposits.

41. The insignificant coefficient on the interaction term is positive, possibly because banking supervisors face a capacity constraint (when low interest rates spur risk-taking by many banks) and focus on curtailing risk-taking by banks with high NPL ratios.

42. The correlation is even weaker when we consider the Euro period (i.e., it equals 0.01).

rate on a new loan, the censoring scheme would remain independent and the basic methods of survival analysis would remain valid.[43]

However, schemes in which the failure times of loans are censored because of an unusually high (or low) risk of failure are not independent and the basic methods of survival analysis are then not valid. Early repayments of individual loans for example that would follow from their lower failure rates do not constitute an independent censoring mechanism. However this problem should be limited as most loans have a short maturity and do not have early repayment clauses, nor adjustable rates.

Nevertheless, we conservatively remove all loans with maturity longer than one year in Model I in Table 6. Despite losing more than 20% of all observations (with 536,571 observations remaining), results are mostly unaffected. For selected specifications we also check the results for loans with maturity shorter than three months. Again results are unaltered. Note again that these loans with short maturities do not have adjustable interest rates. Therefore, our findings related to the effect of overnight rates on credit risk seem not driven by the higher direct financing costs resulting from the adjustable loan rates. We also remove all loans with maturity shorter than one year. Results (unreported) do not change qualitatively despite working again with a much smaller number of loans (137,556 observations). In sum, overnight rates influence the hazard rate across the maturity spectrum.

Repayments by the same borrower may also not be independent *across* loans. If successful in servicing other loans, borrowers may strive to avoid defaulting on the “last” loan for example. Alternatively, a default on one loan may increase the probability of default on the other loans. Our earlier borrower random effects model and clustering at the borrower level throughout all other exercises should have accounted for this dependence. Nevertheless, next we also remove all the loans from borrowers that have multiple loans outstanding. Only 234,338 “single” loans remain. This rather drastic loan selection, however, does not alter the results (Model II of Table 6). Hence, H2 seems again supported, irrespective of the maturity and multiplicity of the loans.

4.9.2 EXOGENEITY OF MONETARY POLICY

Model III in Table 6 focuses on the 1988-1998 period during which the Spanish peseta was pegged to the German mark. In this earlier period most sample borrowers also had no access to bond financing while securitization of loans was almost inexistent. In fact, if we consider all the loans that were securitized (and most of them were mortgages, not business loans), securitized loans represented less than 1% of the total number of loans in 1998 (but already 15.3% of all loans in 2006). In consequence, borrowers in Spain in this earlier period were almost entirely dependent on bank credit and banks did not transfer the credit risk. While the number of loan observations drops to 292,346 once we consider the 1988-1898 period, the results are mostly unaffected however.

Next, we replace again both interest rate variables by the interest rate in Spain, instrumented by the German interest rate, but do not detrend. As in Table 2, in a first stage we regress the INTEREST RATE in SPAIN on all predetermined variables including

43. A censoring scheme is said to be independent if the probability of censoring at each time *t* depends only on random processes that are independent of the failure times in the trial, the observed pattern of failures and censoring up to time *t* in the trial, or (as in our case) on a covariate [Kalbfleisch and Prentice (2002), p.13].

the German overnight interest rates (see Table 2B). The estimated coefficients on the instrumented INTEREST RATE SPAIN are similar to the estimates in the duration models using the INTEREST RATE variables.[44] All in all, Model IV in Table 6 shows that using the (instrumented) Spanish interest rate does not alter the results.

In Model V we report the equivalent results for the 1999-2006 Euro period (381,781 loans). Results for both periods are strikingly similar. It is interesting to notice that nominal rates were in some sub-periods very low compared to a Taylor rule, since in these sub-periods the three largest Euro area economies had significant lower levels of GDP growth and inflation than Spain. In addition, this period of time is more homogenous: Inside this period the Spanish economy in general, and the banking system in particular, did not experience any significant structural change. Therefore, H2 seems supported either for the whole period or for each of the two subperiods separated by the inception of the Euro, which further helps in giving the results a causal interpretation.

4.9.3 DEFINITIONS OF INDEPENDENT VARIABLES AND OMITTED VARIABLES

The time trends we included so far may capture improvements in the efficiency in the Spanish banking sector during the last 20 years. The efficiency of the banking sector has dramatically improved in Spain, potentially biasing our results if we would not control for this effect. Consequently, we also replace the trend variables once with the variables EFFICIENCY RATIO and FINANCIAL INCOME/ATA, respectively. The EFFICIENCY RATIO, a direct measure of efficiency, is defined as expenses over gross operating margin of all banks. FINANCIAL INCOME/ATA equals the interest income plus dividends received over average total assets of all banks (i.e., asset profitability), thus, reflecting a more indirect measure of efficiency. Alternatively, it controls for the risk profile of the bank (on average, riskier banks should have a higher FINANCIAL INCOME/ATA ratio). Results are virtually unaffected and we choose not to report them. Time trends may also capture the volatility of GDP growth. Replacing the time trends with these variables again does not affect our findings.

Changes in credit composition [with respect to risk for example) not necessarily affect the volume of credit (Matsuyama (2007)]. However, in the banking lending channel, monetary policy stance affects the volume of lending, maybe implying more credit-risk if the marginal borrowers were of a lower quality. In Table 6, Model VI we control for the annual growth rate in business loans for each individual bank at the time of the origination of the loans.[45] We find that results are very similar suggesting that the stance of monetary policy may imply a change in credit risk-taking and an optimal change in credit composition in addition to changing the credit volume (which has a positive and significant parameter, as expected).[46]

Note that this regression is also related to the demand *versus* supply identification issue. If banks would want to keep their level of credit risk constant, then more credit volume

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44. The required adjustment of the standard errors on the estimated coefficients is not immediately available. The difference in fit of the models estimated with the actual and the projected Spanish interest rate, however, suggests that the adjustment factor is likely to be close to one. We further calculate the adjustment factor for a model estimated using ordinary least squares for which the dependent variable equals the logarithm of the time to default (censored observations are set equal to their maximum, i.e., 48 months). Again the adjustment factor is close to one and the estimated coefficients themselves in this linear model are very similar to those of the duration model.

45. For comparability reasons we use the annual growth rate. Using the more noisy quarterly growth leaves results virtually unaffected.

46. As in Jiménez and Saurina (2006) who find that “excess” credit growth has a positive impact on future *ex post* credit losses.

would imply (if the marginal projects were riskier) a tightening of lending standards or maybe a different pool of borrowers. In Tables 4 to 6 we control for loan characteristics such as collateral, maturity and loan amount, and we also control for some borrower characteristics including identity. Hence, our results suggest that the stance of monetary policy in general and in particular the level of overnight rates also influence the appetite of banks for credit risk.

Lower interest rates may increase real estate prices and the value of collateral. This may imply more lending as in Kyotaki and Moore (1997), but defaults may occur once liquidity evaporates.[47] Model VII controls for the changes in house prices. The results suggest the other mechanisms we identified so far are at work besides this channel.[48]

Monetary policy may further react to lower expected GDP growth, even if determined by central banks in which price stability is the main objective of monetary policy. Lower forecasted GDP growth (that is, potentially higher risk in the future) would result in lower central bank policy rates in this case – a reverse causality problem. We introduce expected GDP growth in Model VIII to further deal with this problem. We focus on the Euro period for two reasons: (1) we have access to the ECB's own quarterly predictions and the predictions by the Organization for Economic Co-operation and Development (OECD) for the entire period only come at a semiannual frequency; and (2) the business cycle conditions in the Euro area are more relevant (than the German conditions in the earlier period) as the now opened Spanish economy is more connected to the larger Euro area. In addition, by including expected GDP growth in the Euro Area, we control as well for the possibility that the results were driven by changes in Euro Area GDP growth rather than by ECB rates. However we find very similar results.[49]

Finally, in Model IX we introduce Spanish long-term interest rates prior to loan origination, in particular the interest rate on the SPANISH TEN YEAR BOND, which is the most liquid one. Long-term rates may also matter for credit risk-taking. However, results are again unaffected, maybe because banks finance themselves more through short maturity debt that is more affected by short-term rates.

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47. While we cannot control for loss given default, empirical evidence actually shows a negative correlation between default probabilities and average recovery rates [Altman, Brady, Resti and Sironi (2005) and Acharya, Bharath and Srinivasan (2007)]. In addition to house prices, industry, province and borrower effects may have absorbed differences in recovery rates.

48. We control at the firm level for the level of debt. This is important as lower interest rates make debt cheaper, which may increase debt levels and make firm defaults more likely. However, comparing the results in Models I and II in Table 4 (no debt level variable) with all subsequent models suggest that the level of debt is not the only channel through which the stance of monetary policy influences the hazard rate.

49. In a non-reported regression we also use OECD forecasts for the whole period and control for German GDP growth. Results are virtually the same.

5 Conclusions and Policy Implications

This paper is the first to empirically investigate four questions that tie overnight rates and the stance of monetary policy to credit risk-taking and that are relevant for both academics and policy makers (central bankers and supervisors alike). Do lower short-term interest rates lead to more lending to borrowers that in the past were riskier? Do lower interest rates increase the credit risk-taking by banks? Are default rates the highest when after a period of low interest rates, which boosted credit risk-taking, a significant monetary tightening devalues the net worth of the borrowers? Do the answers to the former questions vary across types of banks, borrowers and banking markets?

We employ the Spanish Credit Register, a unique and comprehensive dataset that contains almost all business loan contracts from the last twenty-three years, and rely on the short-term interest rates set by the *Bundesbank* and then the ECB as the proper, yet fairly exogenous, measure of the stance of monetary policy. Therefore we can identify the effect of short-term interest rates on credit risk-taking. We are able to tackle the pernicious endogeneity problem that arises if monetary policy is determined domestically, disentangle demand of risky credit from supply and control for alternative hypotheses.

Controlling for macroeconomic conditions and for bank, loan, and borrower characteristics, we find robust evidence that suggests that prior to loan origination lower short-term interest rates motivate banks to soften their lending standards and grant more loans to borrowers with a bad or no credit history. More importantly, banks grant loans with a higher hazard rate (default probability normalized per time, a desirable normalization since monetary policy may also affect liquidity risks and hence maturity). In consequence, these results suggest that following a monetary expansion better borrowers' net worth and a higher appetite for liquidity risk are not the only motives for the banks' new engagements]see Bernanke, Gertler and Gilchrist (1996), Diamond and Rajan (2006) and Matsuyama (2007)]. Following a monetary expansion banks want to take more credit risk as well [see Smith (2002), Stiglitz and Greenwald (2003), Diamond and Rajan (2006), Dell'Ariccia and Marquez (2006), Rajan (2006), and Borio and Zhu (2007)].

Conditioning on the loan being granted, lower interest rates imply lower credit risk —i.e., lower interest rates reduce the credit risk of outstanding loans. This is possibly the case because refinancing costs are lower and borrower net worth is higher and, therefore, credit risk is lower. Consequently there is a completely different impact of lower interest rates on the credit risk of new *vis-à-vis* outstanding loans.

In sum, in the short-run lower interest rates reduce total credit risk of banks since the volume of outstanding loans is larger than the volume of new loans. In the medium term, lower interest rates, however, may increase credit risk in the economy. In particular, a period of low interest rates followed by a severe monetary contraction maximizes credit risk, as the already "hazardous" cohort of new loans gets exposed to higher interest rates as outstanding loans. On the other hand, steep declines in interest rates minimize total credit risk thus possibly reducing a credit crunch.

The impact of monetary policy on risk-taking is not equal for all banks: Small banks, banks that are flush with liquidity and commercial banks take on more extra risk when interest rates are low. Therefore, balance-sheet strength, investment opportunities, moral hazard and type of bank ownership shape the impact of monetary policy on bank credit risk-taking. In addition, more new firms and fiercer competition in the market enhance the impact of interest rates on bank credit risk-taking [see Dell'Ariccia and Marquez (2006) and Keeley (1990)].

We also find that higher GDP growth reduces credit risk for new and outstanding loans alike and for loans to borrowers with bad credit history. Higher GDP growth or lower short-term interest rates imply higher borrower net worth and, therefore, fewer agency problems between lenders and borrowers. However, the effect of GDP growth on credit risk-taking is different from the effect of short-term interest rates. This implies that there may be other financial inefficiencies [Rajan (2006) and Diamond and Rajan (2006)] that explain the results of this paper. Finally, higher inflation during the life of the loan reduces credit risk, maybe because it reduces the real value of debt [Allen and Gale (2004) and Diamond and Rajan (2006)]. In contrast higher inflation before loan origination implies higher risk taking. Finally, we find that long-term interest rates have a weaker effect on credit risk-taking than short-term rates. Short-term rates possibly affect bank risk-taking more because banks finance themselves mainly through short-term debt [Diamond and Rajan (2006)].

There are a number of natural extensions to our study. First, we currently focus on the impact of monetary policy on the hazard rate of individual bank loans but overlook the correlations between loan default and the impact on each individual bank's portfolio or the correlations between all the banks' portfolios and the resulting systemic impact of monetary policy. Second, given the cohorts of loans and initial and ending policy rates for a time period, one can calculate on the basis of the estimated coefficients the path of monetary policy rates that would minimize the total amount of credit risk. It would be interesting to compare this path to the actual path that was followed. Third, we have studied the effects of monetary policy on the composition of credit in only one dimension, i.e., risk. Industry affiliation or portfolio distribution between mortgages, consumer loans and commercial and industrial loans for example may also change. Fourth, we focus on one of the possible causes of the current credit crisis, but we were silent on whether the risk-taking we observe was excessive. In credit channel models banks are usually too conservative due to agency problems with their borrowers and expansive monetary policy can therefore not result in excessive risk-taking. However, in Rajan (2006) or in banking models with agency problems between shareholders and debtholders and/or banking regulators [Freixas and Rochet (2008)], banks will take excessive risk. The structure of bank deposits, debt, ownership and control —in particular, for listed banks, *board independence* and *ownership dispersion* and, for non-listed commercial banks, savings banks and credit cooperatives, *stakeholders' relationships*— may therefore determine the impact of monetary policy on credit risk-taking. Finally, the impact of monetary policy on credit risk-taking by banks may be amplified by certain types of financial innovation, for example loan securitization. Given space constraints we leave these extensions for future work.

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FIGURE 1. EMPIRICAL STRATEGY

The figure summarizes the empirical strategy we follow.

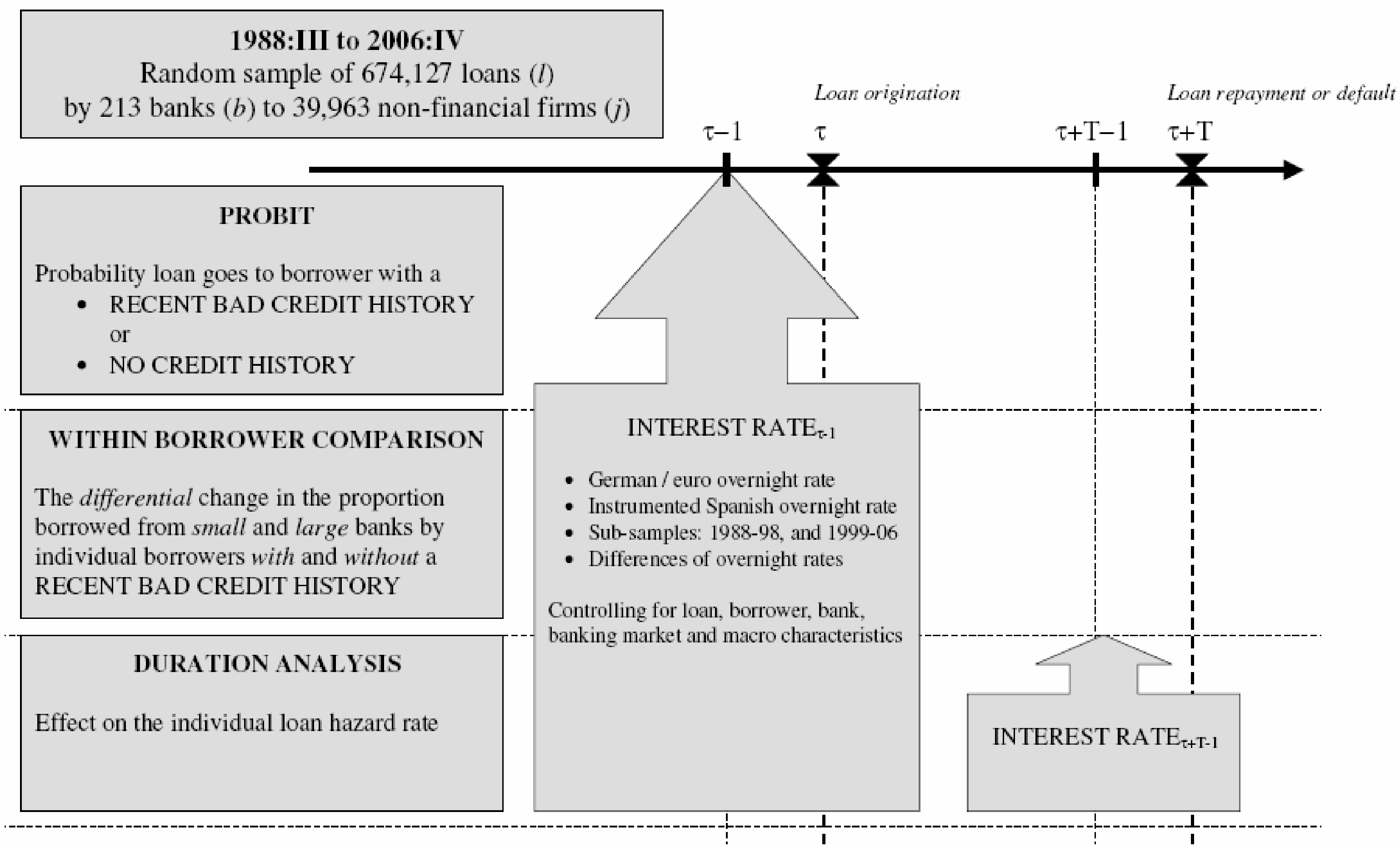

FIGURE 2. MONETARY POLICY PATHS AND LOAN HAZARD RATE

The figure displays on the vertical axis the quarterly probability of *Default* (in percent) calculated for a loan with a mean maturity of five quarters, and other mean characteristics, based on the coefficients of Model IV in Table 4. On the horizontal axes are the *Policy Rate prior to Origination* (INTEREST $RATE_{t-1}$) and the *Policy Rate until Maturity* (INTEREST $RATE_{t+T-1}$).

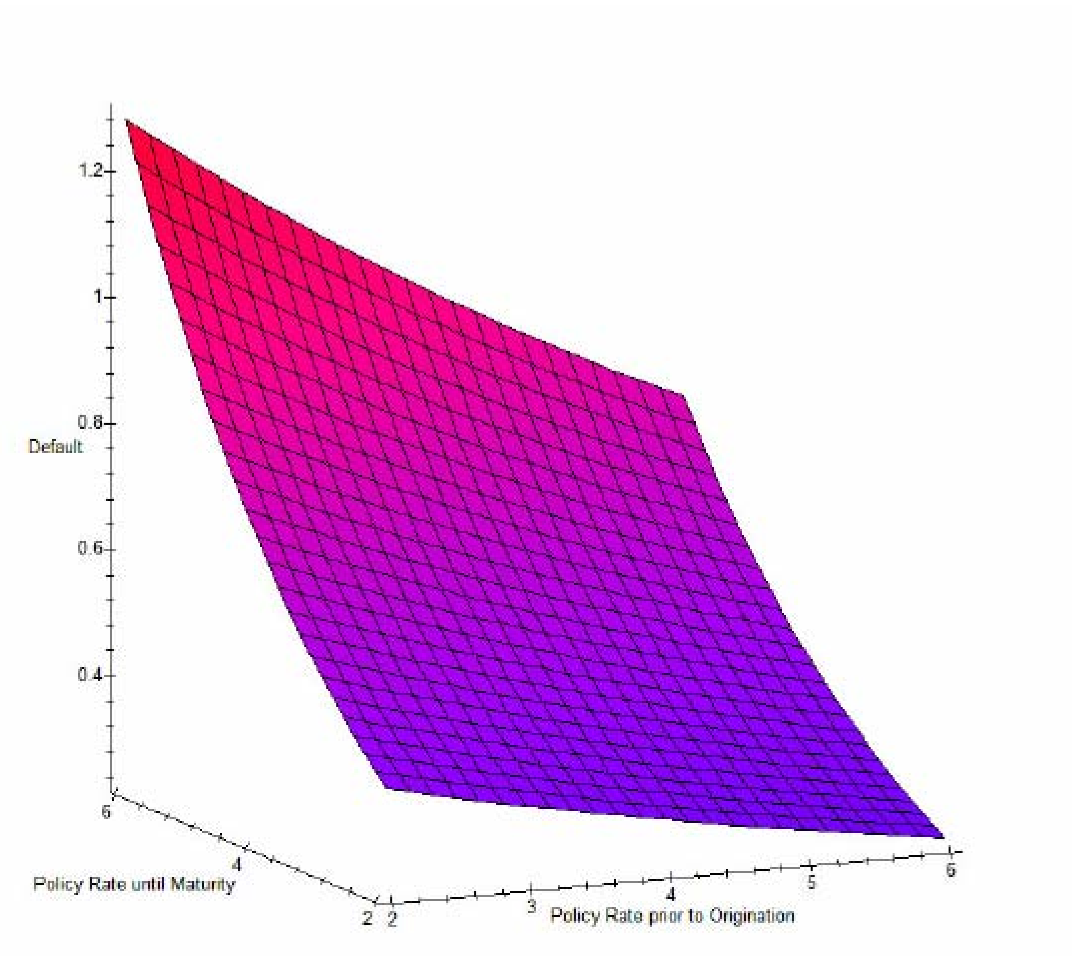

TABLE 1. DESCRIPTIVE STATISTICS

The table defines the variables employed in the empirical specifications, including their unit, and provides their mean, standard deviation, minimum and maximum. Panel A reports the dependent variables and Panel B the independent variables. All variables are measured in the quarter before the loan was granted, except the loan characteristics and the first three robust variables that are measured in the quarter the loan was granted. All country specific variables pertain to Spain unless otherwise indicated. EUR: amount in Euros, QTR: number of quarters, %: in percent. The number of observations equals 674,127 for all variables (based on a 3% random sample), except for ΔSMALL – LARGE BANK where it equals 13,265,830 (based on the full sample of firms with multiple loans).

Panel A **Dependent Variables**	**Definition**	**Unit**	**Mean**	**St. Dev.**	**Min.**	**Max.**
Probit						
RECENT BAD CREDIT HISTORY (0/1)	=1 if the borrower was overdue during the last six months on another loan; =0 otherwise. This information is known to the loan granting officer.	-	0.047	0.212	0	1
NO CREDIT HISTORY (0/1)	=1 if the borrower receives its first loan ever; =0 otherwise. This information is known to the loan granting officer.	-	0.053	0.224	0	1
Within Borrower Comparison						
Δ SMALL - LARGE BANK	The quarterly change in the difference between the percentages of the loan amounts that are obtained from either the borrower's small or large banks.	%	-0.084	34.170	-200.000	200.000
Duration Analysis						
DEFAULT (0/1)	=1 if there is default, i.e, if three months after the date of maturity or the date of an interest payment, the debt balance remains unpaid; =0 otherwise.	-	0.006	0.080	0	1
TIME TO DEFAULT	The number of quarters to default.	QRT	4.371	3.815	1	48

Panel B **Independent Variables**	**Definition**	**Unit**	**Mean**	**St. Dev.**	**Min.**	**Max.**
Monetary Policy Rates						
INTEREST RATE	Quarterly averages of German and Euro overnight interest rates (the Euro interest rate starts in 1999:I), dated in the quarter prior to loan origination.	%	4.135	2.166	2.023	9.619
Δ INTEREST RATE	The change in the INTEREST RATE	%	-0.037	0.702	-7.540	6.390
INTEREST RATE SPAIN	Quarterly average of Spanish overnight interest rate.	%	6.086	4.330	2.023	15.512
Bank Characteristics	*including bank identity (213 banks)*					
LN(TOTAL ASSETS)	The logarithm of the total assets of the bank.	EUR	16.859	1.626	8.595	19.484
LIQUIDITY RATIO	The amount of liquid assets (cash and balances with central banks, loans and advances to credit institutions, and loans and advances to general government) held by the bank over total assets.	%	29.270	12.422	0.222	95.902
BANK NPL_b-NPL	The difference between the bank and the average bank's level of non performing loans over total assets.	%	-0.013	1.793	-4.784	68.969
OWN FUNDS/TOTAL ASSETS	The amount of bank equity over total bank assets.	%	6.324	2.470	-11.226	80.945
LISTED (0/1)	=1 if the commercial bank is publicly listed; =0 otherwise.	-	0.456	0.498	0	1
SAVINGS BANK (0/1)	=1 if the bank is a saving bank; =0 otherwise.	-	0.319	0.466	0	1
CREDIT COOPERATIVE (0/1)	=1 if the bank is a credit cooperative; =0 otherwise.	-	0.050	0.218	0	1
Borrower Characteristics	*including borrower identity (39,963 borrowers)*					
LN(1+BORROWER BANK DEBT)	The logarithm of one plus the total amount of borrower bank debt.	EUR	5.609	2.380	0	14.401
LN(1+NUMBER OF BANK RELATIONSHIPS)	The logarithm of one plus the number of bank relationships of the borrower.	-	1.385	0.710	0	4.369
BAD CREDIT HISTORY (0/1)	=1 if the borrower was overdue any time before on another loan; =0 otherwise.	-	0.111	0.314	0	1
LN(2+AGE AS BORROWER)	The logarithm of two plus the age of the borrower. Age is the number of quarters from the first time the firm borrowed from a bank.	QRT	2.874	1.102	0.693	4.477
Loan Characteristics	*including a loan identifier (674,127 loans)*					
LN(SIZE OF THE LOAN)	The logarithm of the total loan amount granted.	-	4.175	1.376	1.792	15.061
COLLATERAL (0/1)	=1 if the loan is collateralized; =0 otherwise.	-	0.077	0.267	0	1
FINANCIAL CREDIT (0/1)	=1 if the loan is a financial credit; =0 otherwise. Financial credit includes all loans that are not used to finance either the production of commercialization of goods or services.	-	0.457	0.498	0	1
MATURITY 0m.-3m. (0/1)	=1 if the loan matures before 3 months; =0 otherwise.	-	0.421	0.494	0	1
MATURITY 3m.-1y. (0/1)	=1 if the loan matures between 3 months and 1 year; =0 otherwise.	-	0.375	0.484	0	1
MATURITY 1y.-3y. (0/1)	=1 if the loan matures between 1 year and 3 years; =0 otherwise.	-	0.099	0.298	0	1
MATURITY 3y.-5y. (0/1)	=1 if the loan matures between 3 year and 5 years; =0 otherwise.	-	0.035	0.185	0	1
Macro Controls						
GPDG	Growth in real gross domestic product.	%	3.032	1.312	-1.833	6.193
INFLATION	CPI Inflation rate.	%	3.755	1.368	1.490	7.100
COUNTRY RISK	The spread between the ten year Spanish and German government bond rate.	%	1.526	2.064	0.010	6.700
Province Characteristics						
NEW FIRMS/TOTAL FIRMS	The number of new firms over the total number of firms in the province.	%	4.551	1.530	1.148	21.781
HERFINDAHL-HIRSCHMAN INDEX	The Herfindahl Hirschman Index is hundred times the sum of squared bank market shares in total bank loans in each province (0 to 100).	-	6.950	3.001	2.578	39.420
Robustness						
CREDIT GROWTH	Growth of loans to firms at bank level.	%	1.922	30.636	-77.839	43.679
HOUSE PRICE GROWTH	The growth in house prices.	%	11.449	7.370	-7.415	27.335
FORECAST EURO AREA GDPG	ECB forecast for 1 year ahead euro area GDP growth.	%	2.210	0.526	1.200	3.400
SPANISH TEN YEAR BOND	The interest rate on a Spanish ten year Governement bond	%	6.877	3.483	3.180	14.750

TABLE 2. PROBIT MODELS

The estimates this table lists are based on probit models. The dependent variable is indicated in the table. In Panel A RECENT BAD CREDIT HISTORY equals one if the borrower was overdue during the last six months on another loan and equals zero otherwise. NO CREDIT HISTORY equals one if the borrower never received another recorded loan before and equals zero otherwise. In Panel B INTEREST RATE SPAIN is the quarterly average of the Spanish overnight interest rate. The definition of the other variables can be found in Table 1. Subscripts indicate the time of measurement of each variable. t is the quarter the loan was granted. Coefficients are listed in the first column, significance levels in the second column, and robust standard errors that are corrected for clustering at the borrower level are reported in italics between parentheses in the third column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Panel A	**I**			**II**			**III**			**IV**			**V**			**VI**		
Model	**Probit**			**IV Probit 1988-1998**			**Probit**			**Probit**			**IV Probit 1988-1998**			**Probit**		
Dependent Variable	**RECENT BAD CREDIT HISTORY$_{ft}$ (0/1)**			**RECENT BAD CREDIT HISTORY$_{ft}$ (0/1)**			**RECENT BAD CREDIT HISTORY$_{ft}$ (0/1)**			**NO CREDIT HISTORY$_{ft}$ (0/1)**			**NO CREDIT HISTORY$_{ft}$ (0/1)**			**NO CREDIT HISTORY$_{ft}$ (0/1)**		
Independent Variables	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*
Monetary Policy Rates																		
INTEREST RATE$_{t-1}$	-0.017	**	*(0.008)*				-0.133	***	*(0.027)*	-0.019	***	*(0.027)*				-0.066	***	*(0.017)*
INTEREST RATE SPAIN$_{t-1}$				-0.048	***	*(0.014)*							-0.033	***	*(0.008)*			
Monetary Policy Rate and Bank Characteristics																		
INTEREST RATE$_{t-1}$ * LN(TOTAL ASSETS$_{bt-1}$)							0.007	***	*(0.002)*							0.003	***	*(0.001)*

Bank Characteristics												
LN(TOTAL ASSETS$_{b\tau-1}$)	-0.006	*(0.005)*	0.010 *	*(0.006)*	-0.041 ***	*(0.010)*	0.013 ***	*(0.010)*	0.022 ***	*(0.004)*	0.001	*(0.005)*
LIQUIDITY RATIO$_{b\tau-1}$	-0.014	*(0.074)*	-0.241 ***	*(0.086)*	0.007	*(0.074)*	0.132 ***	*(0.074)*	0.207 ***	*(0.054)*	0.138 ***	*(0.040)*
BANK NPL$_{b\tau-1}$-NPL$_{\tau-1}$	0.009 ***	*(0.002)*	0.006 ***	*(0.002)*	0.009 ***	*(0.002)*	-0.006 ***	*(0.002)*	-0.004 **	*(0.002)*	-0.006 ***	*(0.002)*
OWN FUNDS/TOTAL ASSETS$_{b\tau-1}$	-1.124 ***	*(0.257)*	-0.962 ***	*(0.305)*	-1.118 ***	*(0.260)*	0.367 **	*(0.260)*	0.886 ***	*(0.208)*	0.372 **	*(0.150)*
LISTED$_{b\tau-1}$ (0/1)	-0.043 ***	*(0.016)*	-0.005	*(0.019)*	-0.048 ***	*(0.016)*	0.018 *	*(0.016)*	0.003	*(0.013)*	0.017 *	*(0.010)*
SAVINGS BANK$_{b\tau-1}$ (0/1)	0.008	*(0.017)*	0.043 **	*(0.020)*	0.008	*(0.017)*	0.249 ***	*(0.017)*	0.240 ***	*(0.013)*	0.249 ***	*(0.010)*
CREDIT COOPERATIVE$_{b\tau-1}$ (0/1)	0.109 ***	*(0.036)*	0.121 **	*(0.054)*	0.087 **	*(0.036)*	0.235 ***	*(0.036)*	0.267 ***	*(0.027)*	0.229 ***	*(0.017)*
Borrower Characteristics												
LN(1+BORROWER BANK DEBT$_{j\tau-1}$)	0.002	*(0.010)*	0.033 **	*(0.013)*	0.002	*(0.010)*						
LN(1+NUMBER OF BANK RELATIONSHIPS$_{j\tau-1}$)	0.619 ***	*(0.035)*	0.627 ***	*(0.042)*	0.618 ***	*(0.035)*						
LN(2+AGE AS BORROWER$_{j\tau-1}$)	0.025 *	*(0.015)*	0.045 **	*(0.019)*	0.025 *	*(0.015)*						
Loan Characteristics												
LN(SIZE OF THE LOAN$_{l\tau}$)	-0.090 ***	*(0.006)*	-0.100 ***	*(0.007)*	-0.090 ***	*(0.006)*	-0.186 ***	*(0.006)*	-0.230 ***	*(0.005)*	-0.186 ***	*(0.003)*
COLLATERAL$_{l\tau}$ (0/1)	0.342 ***	*(0.023)*	0.314 ***	*(0.026)*	0.342 ***	*(0.023)*	0.230 ***	*(0.023)*	0.100 ***	*(0.017)*	0.230 ***	*(0.012)*
FINANCIAL CREDIT$_{l\tau}$ (0/1)	-0.030 **	*(0.013)*	0.006	*(0.015)*	-0.030 **	*(0.013)*	0.281 ***	*(0.013)*	0.233 ***	*(0.009)*	0.282 ***	*(0.007)*
MATURITY$_{l\tau}$ 0m.-3m. (0/1)	-0.118 ***	*(0.027)*	-0.158 ***	*(0.032)*	-0.116 ***	*(0.027)*	-0.512 ***	*(0.027)*	-0.565 ***	*(0.020)*	-0.512 ***	*(0.013)*
MATURITY$_{l\tau}$ 3m.-1y. (0/1)	-0.046 *	*(0.026)*	-0.068 **	*(0.030)*	-0.045 *	*(0.026)*	-0.379 ***	*(0.026)*	-0.408 ***	*(0.019)*	-0.379 ***	*(0.013)*
MATURITY$_{l\tau}$ 1y.-3y. (0/1)	-0.009	*(0.027)*	-0.019	*(0.032)*	-0.009	*(0.027)*	-0.311 ***	*(0.027)*	-0.325 ***	*(0.020)*	-0.311 ***	*(0.013)*
MATURITY$_{l\tau}$ 3y.-5y. (0/1)	0.038	*(0.027)*	0.068 *	*(0.036)*	0.040	*(0.027)*	-0.151 ***	*(0.027)*	-0.181 ***	*(0.024)*	-0.150 ***	*(0.015)*
Macro Controls												
GPDG$_{\tau-1}$	-0.088 ***	*(0.007)*	-0.049 ***	*(0.010)*	-0.088 ***	*(0.007)*	-0.007 *	*(0.007)*	-0.034 ***	*(0.007)*	-0.008 **	*(0.004)*
INFLATION$_{\tau}$	0.028 **	*(0.011)*	-0.028 *	*(0.015)*	0.028 **	*(0.011)*	0.000	*(0.011)*	0.000	*(0.012)*	0.000	*(0.007)*
COUNTRY RISK$_{\tau}$	0.022 ***	*(0.008)*	0.011	*(0.010)*	0.022 ***	*(0.008)*	0.042 ***	*(0.008)*	0.053 ***	*(0.006)*	0.042 ***	*(0.006)*
TIME TREND	0.029 ***	*(0.010)*	0.306 ***	*(0.042)*	0.026 **	*(0.011)*	-0.006	*(0.011)*	-0.045 *	*(0.024)*	-0.007	*(0.004)*
TIME TREND^2	0.000 ***	*(0.000)*	-0.001 ***	*(0.000)*	0.000 ***	*(0.000)*	0.000	*(0.000)*	0.000	*(0.000)*	0.000	*(0.000)*
Other												
CONSTANT	-2.751 ***	*(0.854)*	-20.240 ***	*(2.743)*	-2.000 **	*(0.876)*	-0.089	*(0.876)*	3.038 *	*(1.564)*	0.184	*(0.377)*
Industry dummies (9)	yes		yes		yes		yes		yes		yes	
Province dummies (49)	yes		yes		yes		yes		yes		yes	
No. of Observations (Loans)	674,127		292,346		674,127		674,127		292,346		674,127	
Log pseudolikelihood	-106,821		-430,131		-106,821		-125,635		-419,901		-125,629	
χ^2 (p-value)	0.000		0.000		0.000		0.000		0.000		0.000	

Panel B	**I**			**II**		
Model	**OLS**			**OLS**		
Sample Period	**1988-II to 1998-IV**			**1988-II to 1998-IV**		
Dependent Variable	**INTEREST RATE SPAIN$_{\tau}$**			**INTEREST RATE SPAIN$_{\tau}$**		
	All Variables in Level			**All Variables in Differences**		
Independent Variables	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*
Monetary Policy Rates						
INTEREST RATE$_{\tau}$	0.921	***	*(0.110)*	0.634	***	*(0.221)*
Macro Controls						
GPDG$_{\tau}$	0.167	**	*(0.064)*	-0.129		*(0.111)*
INFLATION$_{\tau}$	-0.201		*(0.194)*	-0.070		*(0.177)*
COUNTRY RISK$_{\tau}$	1.287	***	*(0.105)*	0.995	***	*(0.105)*
Other						
CONSTANT	0.780	*	*(0.410)*	-0.075		*(0.070)*
No. of Observations (Quarters)	43			43		
Adjusted R-squared	0.97			0.77		

TABLE 3. WITHIN BORROWER COMPARISON

The estimates this table lists are based on ordinary least square models. The dependent variable is Δ SMALL – LARGE BANK BORROWING$_t$, which is the quarterly change (between t-1 and t) in the percentages of the loan amounts that are obtained by each individual borrower from either the borrower's small or large banks (small/large banks are below/above the quarter median in total assets). The definition of the other variables can be found in Table 1. Model I analyzes per quarter all borrowers that have multiple bank relationships. Model II studies per quarter all borrowers with at least one relationship with a small and one relationship with a large bank. Subscripts indicate the time of measurement of each variable. t is the quarter the loan was granted. Coefficients are listed in the first column, significance levels in the second column, and robust standard errors that are corrected for clustering at the borrower level are reported in italics between parentheses in the third column.

*** Significant at 1%, ** significant at 5%, * significant at 10%.

Model	I			II		
	OLS			OLS		
Independent Variables	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*
Monetary Policy Rates						
INTEREST RATE$_{t-1}$	-0.071	***	*(0.010)*	-0.010		*(0.012)*
INTEREST RATE$_{t-1}$* RECENT BAD CREDIT HISTORY (0/1)$_{jt-1}$	-0.038	**	*(0.019)*	-0.091	***	*(0.022)*
Borrower Characteristics						
RECENT BAD CREDIT HISTORY (0/1)$_{j\tau-1}$	-0.036		*(0.105)*	0.342	***	*(0.119)*
LN(1+BORROWER BANK DEBT$_{j\tau-1}$)	0.396	***	*(0.014)*	0.435	***	*(0.020)*
Macro Controls						
GPDG$_{\tau-1}$	0.064	***	*(0.010)*	0.056	***	*(0.012)*
TIME TREND	-0.057	***	*(0.010)*	-0.045	***	*(0.012)*
TIME TREND^2	0.000	***	*(0.000)*	0.000	**	*(0.000)*
Other						
CONSTANT	4.291	***	*(0.820)*	2.368	**	*(0.991)*
Borrower Fixed Effects (769,222)	yes			yes		
No. of Observations (Quarters)	13,265,830			6,844,387		
R-squared	0.03			0.05		

TABLE 4. DURATION MODELS

The estimates in this table are based on maximum likelihood estimation of the proportional hazard model using the Weibull distribution as baseline hazard rate. The parameter ln(α) measures the degree of duration dependence. The dependent variable is the hazard rate. The definition of the other variables can be found in Table 1. Subscripts indicate the time of measurement of each variable. t is the quarter the loan was granted. *T* is the time to repayment or default of the loan. *t* which indexes the time over the life of the loan, replaces *T* in Models VII and VIII in the subscripts of INTEREST RATE, GDPG, INLATION and COUNTRY RISK. All estimates are adjusted for right censoring. Coefficients are listed in the first column, significance levels in the second column, and robust standard errors that are corrected for clustering at the borrower level are reported in italics between parentheses in the third column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Model	I Weibull Bank Heterogeneity			II Weibull Bank Characteristics			III Weibull Borrower/Loan Characteristics			IV Weibull Borrower Heterogeneity			V Weibull Borrower Risk Interactions			VI Weibull Differences			VII Weibull Time-Varying			VIII Weibull Time-Varying Without Trends		
Independent Variables	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*
Monetary Policy Rates																								
INTEREST RATE$_{\tau-1}$	-0.099	***	*(0.019)*	-0.084	***	*(0.021)*	-0.072	***	*(0.021)*	-0.127	***	*(0.023)*	-0.100	***	*(0.025)*				-0.114	***	*(0.014)*	-0.052	***	*(0.014)*
INTEREST RATE$_{\tau+T-1}$	0.344	***	*(0.014)*	0.350	***	*(0.015)*	0.323	***	*(0.016)*	0.293	***	*(0.017)*	0.324	***	*(0.016)*				0.044	**	*(0.021)*	0.191	***	*(0.019)*
INTEREST RATE$_{\tau-1}$ * BAD CREDIT HISTORY$_{j\tau-1}$ (0/1)													-0.093	***	*(0.021)*									
INTEREST RATE$_{\tau-1}$ * LN(2+AGE AS BORROWER$_{j\tau-1}$)													0.021	***	*(0.006)*									
ΔINTEREST RATE$_{\tau-1}$																-0.601	***	*(0.067)*						
ΔINTEREST RATE$_{\tau-2}$																-0.152	***	*(0.058)*						
ΔINTEREST RATE$_{\tau-3}$																0.011		*(0.063)*						
INTEREST RATE$_{\tau+T-1}$ - INTEREST RATE$_{\tau-1}$																0.201	***	*(0.012)*						

Bank Characteristics								
LN(TOTAL ASSETS$_{b\tau-1}$)		0.018 *(0.014)*	0.022 *(0.015)*	0.017 *(0.015)*	0.022 *(0.015)*	0.032 ** *(0.015)*	0.073 *** *(0.015)*	0.033 ** *(0.014)*
LIQUIDITY RATIO$_{b\tau-1}$		-0.573 *** *(0.215)*	-0.358 *(0.230)*	-0.182 *(0.218)*	-0.362 *(0.230)*	-0.671 *** *(0.233)*	-1.804 *** *(0.234)*	-0.594 *** *(0.198)*
BANK NPL$_{b\tau-1}$-NPL$_{\tau-1}$		0.061 *** *(0.005)*	0.055 *** *(0.006)*	0.069 *** *(0.007)*	0.055 *** *(0.006)*	0.053 *** *(0.006)*	0.051 *** *(0.006)*	0.055 *** *(0.006)*
OWN FUNDS/TOTAL ASSETS$_{b\tau-1}$		-5.042 *** *(0.922)*	-5.360 *** *(0.953)*	-5.996 *** *(0.922)*	-5.449 *** *(0.954)*	-5.026 *** *(0.948)*	-5.543 *** *(0.938)*	-5.028 *** *(0.928)*
LISTED$_{b\tau-1}$ (0/1)		0.154 *** *(0.059)*	0.146 ** *(0.060)*	0.079 *(0.060)*	0.148 ** *(0.060)*	0.184 *** *(0.060)*	0.215 *** *(0.062)*	0.154 ** *(0.060)*
SAVINGS BANK$_{b\tau-1}$ (0/1)		0.422 *** *(0.058)*	0.469 *** *(0.059)*	0.479 *** *(0.059)*	0.471 *** *(0.059)*	0.495 *** *(0.059)*	0.505 *** *(0.061)*	0.455 *** *(0.059)*
CREDIT COOPERATIVE$_{b\tau-1}$ (0/1)		0.371 *** *(0.099)*	0.521 *** *(0.103)*	0.417 *** *(0.105)*	0.524 *** *(0.103)*	0.564 *** *(0.103)*	0.742 *** *(0.104)*	0.547 *** *(0.101)*
Borrower Characteristics								
LN(1+BORROWER BANK DEBT$_{j\tau-1}$)			0.025 *(0.018)*	-0.043 ** *(0.018)*	0.023 *(0.018)*	0.027 *(0.018)*	0.014 *(0.019)*	0.019 *(0.018)*
LN(1+NUMBER OF BANK RELATIONSHIPS$_{j\tau-1}$)			0.529 *** *(0.070)*	1.013 *** *(0.065)*	0.538 *** *(0.070)*	0.540 *** *(0.071)*	0.540 *** *(0.072)*	0.537 *** *(0.071)*
BAD CREDIT HISTORY$_{j\tau-1}$ (0/1)			1.110 *** *(0.063)*	0.777 *** *(0.061)*	1.608 *** *(0.136)*	1.132 *** *(0.064)*	1.093 *** *(0.064)*	1.118 *** *(0.064)*
LN(2+AGE AS BORROWER$_{j\tau-1}$)			-0.406 *** *(0.026)*	-0.264 *** *(0.027)*	-0.512 *** *(0.039)*	-0.411 *** *(0.026)*	-0.367 *** *(0.028)*	-0.392 *** *(0.027)*
Loan Characteristics								
LN(SIZE OF THE LOAN$_{l\tau}$)			-0.231 *** *(0.016)*	-0.104 *** *(0.018)*	-0.235 *** *(0.016)*	-0.234 *** *(0.016)*	-0.238 *** *(0.016)*	-0.239 *** *(0.016)*
COLLATERAL$_{l\tau}$ (0/1)			0.225 *** *(0.061)*	0.076 *(0.064)*	0.227 *** *(0.061)*	0.240 *** *(0.062)*	0.237 *** *(0.061)*	0.227 *** *(0.061)*
FINANCIAL CREDIT$_{l\tau}$ (0/1)			0.665 *** *(0.056)*	0.834 *** *(0.055)*	0.672 *** *(0.056)*	0.660 *** *(0.056)*	0.650 *** *(0.057)*	0.637 *** *(0.057)*
MATURITY$_{l\tau}$ 0m.-3m. (0/1)			0.906 *** *(0.082)*	1.182 *** *(0.086)*	0.912 *** *(0.082)*	0.976 *** *(0.082)*	0.950 *** *(0.081)*	0.947 *** *(0.081)*
MATURITY$_{l\tau}$ 3m.-1y. (0/1)			0.886 *** *(0.068)*	0.987 *** *(0.071)*	0.890 *** *(0.068)*	0.945 *** *(0.069)*	0.915 *** *(0.068)*	0.923 *** *(0.068)*
MATURITY$_{l\tau}$ 1y.-3y. (0/1)			0.527 *** *(0.070)*	0.495 *** *(0.073)*	0.530 *** *(0.070)*	0.565 *** *(0.071)*	0.520 *** *(0.070)*	0.549 *** *(0.069)*
MATURITY$_{l\tau}$ 3y.-5y. (0/1)			0.158 ** *(0.075)*	0.111 *(0.080)*	0.159 ** *(0.075)*	0.173 ** *(0.076)*	0.139 * *(0.076)*	0.164 ** *(0.075)*
Macro Controls								
GPDG$_{\tau-1}$	-0.201 *** *(0.014)*	-0.202 *** *(0.016)*	-0.199 *** *(0.017)*	-0.240 *** *(0.016)*	-0.201 *** *(0.017)*		-0.162 *** *(0.014)*	-0.154 *** *(0.014)*
GPDG$_{\tau+T-1}$	-0.045 *** *(0.016)*	-0.048 *** *(0.018)*	-0.052 *** *(0.018)*	-0.057 *** *(0.019)*	0.227 *** *(0.061)*		-0.121 *** 0.017	-0.040 ** *(0.016)*
ΔGPDG$_{\tau-1}$						-0.296 *** *(0.047)*		
GPDG$_{\tau+T-1}$ - GPDG$_{\tau-1}$						0.026 * *(0.015)*		
INFLATION$_{\tau}$	0.067 ** *(0.027)*	0.055 * *(0.031)*	0.050 *(0.031)*	0.088 *** *(0.030)*	0.049 *(0.031)*	0.412 *** *(0.033)*	0.036 *(0.029)*	-0.094 *** *(0.027)*
COUNTRY RISK$_{\tau}$	0.090 *** *(0.021)*	0.107 *** *(0.023)*	0.108 *** *(0.023)*	0.139 *** *(0.023)*	0.109 *** *(0.023)*	-0.058 ** *(0.022)*	0.033 *(0.023)*	0.222 *** *(0.018)*
TIME TREND	0.133 *** *(0.021)*	0.173 *** *(0.028)*	0.159 *** *(0.028)*	0.211 *** *(0.026)*	0.155 *** *(0.028)*	0.181 *** *(0.023)*	0.007 *(0.024)*	
TIME TREND^2	0.000 *** *(0.000)*	-0.001 *** *(0.000)*	0.000 *** *(0.000)*	-0.001 *** *(0.000)*	0.000 *** *(0.000)*	-0.001 *** *(0.000)*	0.000 * *(0.000)*	
Other	1.859							
CONSTANT	-19.04 *** *(1.770)*	-22.13 *** *(2.276)*	-21.89 *** *(2.336)*	-26.43 *** *(2.158)*	-21.48 *** *(2.351)*	-22.55 *** *(1.839)*	-5.684 *** *(1.981)*	-8.649 *** *(0.430)*
ln(α) (duration dependence)	0.620 *** *(0.008)*	0.619 *** *(0.008)*	0.671 *** *(0.008)*	0.816 *** *(0.009)*	0.672 *** *(0.008)*	0.624 *** *(0.008)*	0.705 *** *(0.009)*	0.671 *** *(0.008)*
Industry dummies (9)	no	no	yes	yes	yes	yes	yes	yes
Province dummies (49)	no	no	yes	yes	yes	yes	yes	yes
Year dummies (18)	no	no	no	yes	no	no	no	no
Bank Random Effects (213 Banks)	yes	no	no	no	no	no	no	no
Borrower Random Effects (39,963 Borrowers)	no	no	no	yes	no	no	no	no
No. of Observations (Loans or Loan Quarters)	674,127	674,127	674,127	674,127	674,127	674,127	1,989,170	1,989,170
Log pseudolikelihood	-21,895	-21,682	-20,598	-19,199	-20,580	-20,842	-20,599	-20,719
χ^2 (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 5. DURATION MODELS INCLUDING INTERACTIONS WITH BANK CHARACTERISTICS

The estimates in this table are based on maximum likelihood estimation of the proportional hazard model using the Weibull distribution as baseline hazard rate. The parameter ln(α) measures the degree of duration dependence. The dependent variable is the hazard rate. The definition of the other variables can be found in Table 1. Subscripts indicate the time of measurement of each variable. t is the quarter the loan was granted. *T* is the time to repayment or default of the loan. All estimates are adjusted for right censoring. Coefficients are listed in the first column, significance levels in the second column, and robust standard errors that are corrected for clustering at the borrower level are reported in italics between parentheses in the third column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Model	I Weibull Size			II Weibull Liquidity			III Weibull NPL			IV Weibull Type of Ownership			V Weibull Local Markets		
Independent Variables	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*	Coeff.	Sig.	*(S.E.)*
Monetary Policy Rates															
INTEREST RATE$_{\tau-1}$	-0.482	***	*(0.077)*	-0.456	***	*(0.078)*	-0.462	***	*(0.079)*	-0.563	***	*(0.090)*	-0.412	***	*(0.082)*
INTEREST RATE$_{\tau+T-1}$	0.322	***	*(0.016)*	0.325	***	*(0.016)*	0.324	***	*(0.016)*	0.332	***	*(0.016)*	0.328	***	*(0.016)*
Monetary Policy Rate and Bank or Province Characteristics															
INTEREST RATE$_{\tau-1}$ * LN(TOTAL ASSETS$_{b\tau-1}$)	0.025	***	*(0.005)*	0.031	***	*(0.005)*	0.031	***	*(0.005)*	0.032	***	*(0.006)*	0.030	***	*(0.005)*
INTEREST RATE$_{\tau-1}$ * LIQUIDITY RATIO$_{b\tau-1}$				-0.304	***	*(0.078)*	-0.302	***	*(0.078)*	-0.271	***	*(0.078)*	-0.311	***	*(0.078)*
INTEREST RATE$_{\tau-1}$ * BANK NPL$_{b\tau-1}$-NPL$_{\tau-1}$							0.119		*(0.295)*						
INTEREST RATE$_{\tau-1}$ * LISTED$_{b\tau-1}$ (0/1)										0.037		*(0.025)*			
INTEREST RATE$_{\tau-1}$ * SAVINGS BANK$_{b\tau-1}$ (0/1)										0.090	***	*(0.024)*			
INTEREST RATE$_{\tau-1}$ * CREDIT COOPERATIVE$_{b\tau-1}$ (0/1)										0.024		*(0.047)*			
INTEREST RATE$_{\tau-1}$ * NEW FIRMS/TOTAL FIRMS$_{p\tau-1}$													-1.309	***	*(0.451)*
INTEREST RATE$_{\tau-1}$ * HERFINDAHL HIRSCHMAN INDEX$_{p\tau-1}$													0.664	*	*(0.343)*
Bank Characteristics															
LN(TOTAL ASSETS$_{b\tau-1}$)	-0.111	***	*(0.028)*	-0.134	***	*(0.029)*	-0.136	***	*(0.029)*	-0.142	***	*(0.032)*	-0.126	***	*(0.029)*
LIQUIDITY RATIO$_{b\tau-1}$	-0.357		*(0.229)*	1.267	***	*(0.459)*	1.258	***	*(0.458)*	0.992	**	*(0.456)*	1.039	**	*(0.463)*
BANK NPL$_{b\tau-1}$-NPL$_{\tau-1}$	0.058	***	*(0.006)*	0.057	***	*(0.006)*	0.050	***	*(0.019)*	0.057	***	*(0.006)*	0.065	***	*(0.006)*
OWN FUNDS/TOTAL ASSETS$_{b\tau-1}$	-5.819	***	*(0.983)*	-5.760	***	*(0.984)*	-5.745	***	*(0.985)*	-5.601	***	*(0.982)*	-4.956	***	*(0.955)*
LISTED$_{b\tau-1}$ (0/1)	0.126	**	*(0.060)*	0.125	**	*(0.060)*	0.126	**	*(0.060)*	-0.063		*(0.140)*	0.138	**	*(0.059)*
SAVINGS BANK$_{b\tau-1}$ (0/1)	0.459	***	*(0.059)*	0.477	***	*(0.059)*	0.478	***	*(0.059)*	0.014		*(0.133)*	0.468	***	*(0.059)*
CREDIT COOPERATIVE$_{b\tau-1}$ (0/1)	0.448	***	*(0.103)*	0.462	***	*(0.104)*	0.462	***	*(0.104)*	0.280		*(0.223)*	0.434	***	*(0.102)*
Borrower, Loan, and Macro Controls, and Constant	*yes*			*yes*			*yes*			*yes*			*yes*		
Province Characteristics															
NEW FIRMS/TOTAL FIRMS$_{p\tau-1}$													0.086	***	*(0.027)*
HERFINDAHL HIRSCHMAN INDEX$_{p\tau-1}$													-0.018		*(0.017)*
Other															
ln(α) (duration dependence)	0.671	***	*(0.008)*	0.671	***	*(0.008)*	0.671	***	*(0.008)*	0.673	***	*(0.008)*	0.669	***	*(0.008)*
Industry dummies (9)	yes			yes			yes			yes			yes		
Province dummies (49)	yes			yes			yes			yes			no		
No. of Observations (Loans)	674,127			674,127			674,127			674,127			674,127		
Log pseudolikelihood	-20,580			-20,570			-20,570			-20,558			-20,692		
χ^2 (p-value)	0.000			0.000			0.000			0.000			0.000		

TABLE 6. DURATION MODELS – ROBUSTNESS

The estimates in this table are based on maximum likelihood estimation of the proportional hazard model using the Weibull distribution as baseline hazard rate. The dependent variable is the hazard rate. The definition of the other variables can be found in Table 1. Subscripts indicate the time of measurement of each variable. t is the quarter the loan was granted. *T* is the time to repayment or default of the loan. None of the variables vary over time. All estimates are adjusted for right censoring. Coefficients are listed in the first column, significance levels in the second column, and robust standard errors that are corrected for clustering at the borrower level are reported in italics between parentheses in the third column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Model	I	II	III	IV	V	VI	VII	VIII	IX
	Weibull	Weibull	Weibull	Weibull	Weibull	Weibull	Weibull	Weibull	Weibull
	Maturity <= 1 Yr	Single Loans	1988-1998	1988-1998	1999-2006	Credit Growth	House Prices	Forecast GDPG	Ten Yr Bond
Independent Variables	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)	Coeff. Sig. (S.E.)
Monetary Policy Rates									
INTEREST RATE$_{\tau-1}$	-0.104 *** (0.029)	-0.081 *** (0.030)	-0.111 *** (0.026)		-0.178 ** (0.071)	-0.081 *** (0.021)	-0.077 *** (0.021)	-0.197 *** (0.072)	-0.066 *** (0.023)
INTEREST RATE SPAIN$_{\tau-1}$				-0.098 *** (0.019)					
INTEREST RATE$_{\tau+T-1}$	0.320 *** (0.022)	0.307 *** (0.024)	0.397 *** (0.018)		0.266 *** (0.052)	0.322 *** (0.016)	0.324 *** (0.016)	0.268 *** (0.052)	0.324 *** (0.016)
INTEREST RATE SPAIN$_{\tau+T-1}$				0.325 *** (0.010)					
Bank, Borrower, and Loan Controls *Macro Controls and Constant*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Additional Variables									
CREDIT GROWTH$_{b\tau}$						0.399 *** (0.067)			
HOUSE PRICE GROWTH$_{\tau}$							-0.009 * (0.005)		
FORECAST EURO AREA GDPG$_{\tau}$								-0.121 (0.085)	
SPANISH TEN YEAR BOND$_{\tau-1}$									-0.029 (0.035)
Other									
ln(α) (duration dependence)	0.766 *** (0.009)	0.597 *** (0.012)	0.645 *** (0.010)	0.731 *** (0.010)	0.802 *** (0.017)	0.670 *** (0.008)	0.672 *** (0.008)	0.804 *** (0.017)	0.671 (0.008)
Industry dummies (9)	yes	yes	yes	yes	yes	yes	yes	yes	yes
Province dummies (49)	yes	yes	yes	yes	yes	yes	yes	yes	yes
No. of Observations (Loans)	536,571	234,338	292,346	292,346	381,781	674,127	674,127	381,781	674,127
Log pseudolikelihood	-8,398	-8,359	-12,606	-12,319	-7,671	-20,575	-20,595	-7,574	-20,597
χ^2 (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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