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# Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment*

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**Abstract.** We study the risk-taking channel of monetary policy in Bolivia, a dollarized country where monetary changes are transmitted exogenously from the USA. We find that a lower policy rate spurs the granting of riskier loans, to borrowers with worse credit histories, lower ex-ante internal ratings, and weaker ex-post performance (acutely so when the rate subsequently increases). Effects are stronger for small firms borrowing from multiple banks. To uniquely identify risk-taking, we assess collateral coverage,

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expected returns, and risk premia of the newly granted riskier loans, finding that their returns and premia are actually lower, especially at banks suffering from agency problems.

*JEL Classification:* E44, E5, G01, G21, G28, L14

> "The root cause of this credit correction was the Federal Reserve's willingness to keep money too easy for too long. The federal funds rate was probably negative in real terms for close to two years between 2003 and 2005. This led to a misallocation of capital."
>
> "The Bernanke Call – II," Review & Outlook, Editorial,
> *The Wall Street Journal*, August 11th, 2007

> "A rate cut does not just increase the supply of cash; it directly influences people's calculations about risk. Cheaper money makes other assets look more attractive."
>
> Monetary Policy—Hazardous times, Leaders, Opinion,
> *The Economist*, August 23rd, 2007

## 1. Introduction

The crisis in the credit markets started in August 2007 and has cast its long shadow until today. Many observers immediately argued—and continued to do so until today—that during the long period of very low levels of monetary policy rates that preceded the crisis, banks softened their lending standards and failed to price the extra risks they took.[1] Governor Jeremy C. Stein for example recently stressed once more that "a prolonged period of low interest rates, [...], can create incentives for agents to take on greater duration or

[1] Between 2001 and 2005, nominal short-term interest rates were the lowest in almost four decades and below Taylor rates in many countries, while real rates were negative (see Taylor (2007) and Rajan (2010)). Rajan (2006), Taylor (2008), Borio and Zhu (2008), Blanchard (2009), Brunnermeier (2009), Calomiris (2009), and Diamond and Rajan (2009), among others, and numerous contributions in *The Wall Street Journal*, *The Financial Times*, and *The Economist* conjecture that very low short-term interest rates may result in excessive risk-taking. Adrian and Shin (2009), Brunnermeier *et al.* (2009), and Shin (2009) discuss the importance of overnight rates for bank liquidity and leverage, affecting in turn risk-taking by banks. Short-term interest rates also affect the pricing of equity (Rigobon and Sack, 2004; Bernanke and Kuttner, 2005), bonds (Manganelli and Wolswijk, 2009), and buyouts (Axelson *et al.*, 2013).

credit risks, or to employ additional financial leverage, in an effort to 'reach for yield"' (Stein, 2013).[2]

In this article, we empirically analyze whether the level of the monetary policy rate affects bank loan risk-taking, expected returns, and pricing. To the best of our knowledge, this article and Jiménez *et al*. (2014) were the first papers to concurrently investigate the impact of monetary policy on bank risk-taking.[3] Exploiting the opportunities offered by their respective institutional settings and data, the two papers shed light on different key aspects of the "risk-taking channel"—as it has come to be known in the literature.[4] Both papers investigate how exogenous changes in the monetary policy rate affect the quality of new loans. Although the two papers draw from two entirely different financial systems in terms of development and economic conditions, that is, Bolivia and Spain, results are very similar: lower monetary policy rates are found to increase the likelihood that loans to lower quality borrowers are granted, particularly by banks with more acute agency problems.[5]

[2] See also the prescient speech in Jackson Hole by Raghuram Rajan, as IMF Chief Economist, on the impact of low monetary policy rates on excessive risk-taking (Rajan, 2006).

[3] The impact of monetary policy on the aggregate volume of credit in the economy has been widely analyzed. Bernanke and Gertler (1995) for example reviews the literature dealing with the general credit channel, while Bernanke and Blinder (1992), Kashyap and Stein (2000) and Jiménez *et al*. (2012) focus on the bank lending channel. Within the (*firm*) balance sheet channel, lower short-term interest rates improve borrowers' net worth and entice banks to grant loans to borrowers of lower quality in the past (Bernanke, Gertler, and Gilchrist, 1996) or with fewer pledgeable assets (Matsuyama, 2007).

[4] Allen and Gale (2000), Allen and Gale (2004), Borio and Zhu (2008), Allen and Rogoff (2011), Acharya and Naqvi (2012), Diamond and Rajan (2012), Dell'Ariccia, Laeven, and Marquez (2014), among others. Adrian and Shin (2011) discuss the risk-taking channel of monetary policy in the latest *Handbook of Monetary Economics*. They show that a lower monetary policy rate spurs risk-taking in lending by relaxing the bank capital constraint that is present due to bank moral hazard. The idea that the liquidity provided by central banks is important in driving excessive risk-taking is not new however: "Speculative manias gather speed through expansion of money and credit or perhaps, in some cases, get started because of an initial expansion of money and credit" (Kindleberger, 1978, p. 54).

[5] This similarity makes it less likely that the findings in this article are simply picking-up some uncontrolled peculiarity of the local system. Following this article and Jiménez *et al.* (2014), extant empirical work-in-progress and published further documents the existence and potency of a bank risk-taking channel of monetary policy across many countries and time periods. But none of these papers comes from a setting with exogenous monetary policy and/or has access to exhaustive information on banks, borrowers and loans, including individual loan rates, which is essential to uniquely identify the compositional changes in the supply of credit that take place. See, for example, for the USA (Altunbas, Gambacorta, and Marquez-Ibañez, 2010; Delis, Hasan, and Mylonidis, 2011; Paligorova

But this article—as compared to Jiménez *et al.* (2014)—takes a decisive step further by studying loan expected returns (pricing, collateral requirements and actual coverage, and default probabilities over the life of the loan) as risk-taking can only be identified with these measures. We rely on singular data from the Bolivian credit register, and study whether banks adjust key loan conditions, such as loan price and collateral values, to compensate for the extra risk taken. We find that banks do not.

Importantly also, as compared to Jiménez *et al.* (2014), this article analyzes the impact of changes in monetary policy rate on ex-post credit risk over the life of the loan. Our findings suggest that—though estimated within a sharply confined sample period—the time credit risk may crest when a period with a low monetary policy rate is followed by abrupt and strong increases in the policy rate (as was the case for example in the USA and Europe in 2002–07 before the start of the worst financial crisis since the 1930s, in Japan in the 1980s, or in the USA in the 1920s). Therefore, not only do monetary conditions at the start of the loan matter, but also throughout its life. Moreover, our findings have crucial implications for bank credit risk once the USA and Europe leave their current ultralow monetary policy rates (that have been in place since 2008) and return to normal historical levels. Finally, this article further explores robustness across time and industries and salient margins of bank risk-taking in terms of firm, relationship, loan and macro characteristics and conditions.

Analyzing the impact of the monetary policy rate on bank risk-taking involves three major identification challenges. First, the monetary policy rate is often endogenous to economic conditions and—in particular—is low when risks are high. Second, changes in the demand for loans need to be disentangled from the changes in the supply of loans. Third, banks could be adjusting other loan terms to compensate for the extra risk from loans with higher default probabilities. Consequently, exogenous monetary policy and exhaustive information on banks, borrowers, and loans—including loan prices, quantities and collateral requirements and values—are needed to understand if and how the policy rate affects banks' risk-taking.

Bolivia during the period 1999–2003 provides us with an excellent—almost experimental—setting to identify the impact of the monetary policy rate on bank risk-taking, which is closer to a Mundell–Fleming setting than the one offered in Spain. During this period, Bolivia's banking system was

and Santos, 2012; Dell'Ariccia, Laeven, and Suarez, 2013; Buch, Eickmeier, and Prieto, 2014a, 2014b), Austria (Gaggl and Valderrama, 2010), Colombia (López, Tenjo, and Zárate, 2010a, 2010b), the Czech Republic (Geršl *et al.*, 2012), Portugal (Bonfim and Soares, 2013), and Sweden (Apel and Claussen, 2012).

almost fully dollarized, its currency followed a crawling peg with the US dollar, and there were hardly any restrictions in its capital account. But its small economy was not synchronized with the US economy. Consequently, changes in the US federal funds rate, which from the USA are transmitted into the Bolivian liquidity markets, provide exogenous variation in the relevant monetary policy rate.

The Bolivian credit register contains very detailed contract information at a monthly frequency on all bank loans granted to firms in Bolivia. Each loan is observed from origination till repayment or default on a monthly frequency, which is important for disentangling the impact of monetary policy on the quality of newly granted loans to its impact on outstanding loans. Moreover, crucially for identifying credit supply and excessive bank risk-taking, the Bolivian credit register contains loan prices, which is not the case in the large majority of the credit registers around the world, as well as collateral requirements and values. All this information is necessary to study loan expected returns, which are crucial to identify risk-taking in lending. Moreover, matched with bank balance sheet information and key firm characteristics such as identity, industry, debt levels, credit rating, and borrower credit histories, the register allows us to study bank risk-taking eliminating alternative hypotheses. We analyze many different loan-specific measures of loan risk-taking that fit into three categories: (i) the likelihood of granting loans to borrowers with ex-ante observable past nonperformance or weak internal credit ratings at origination; (ii) the ex-post likelihood of individual loan default or the time to such default; and crucially, (iii) the pricing of credit risk and the expected return of loans (calculated using both the loan interest rate and the value of the pledged assets).

We find robust evidence that a lower federal funds rate increases banks' appetite for risk: banks grant new loans to ex-ante less creditworthy borrowers and with a higher ex-post default rate, yet with both lower expected returns and lower loan spreads. In particular, controlling for numerous bank, firm, bank–firm relationship, loan, banking market characteristics, and macroeconomic conditions (as well as loading in eventually both bank and firm fixed effects), we observe that a decrease in the US federal funds rate prior to loan origination: (i) increases the likelihood that loans are granted to observably riskier borrowers with observable past nonperformance or to borrowers with weak internal credit ratings; (ii) leads to the origination of more loans with a higher probability of default yet lower expected returns and lower price per unit of risk implying that this extra risk-taking is supply (and not demand) driven. In pointed contrast, a decrease in the federal funds rate at repayment or over the life of the loan is also found to lower the default rate of outstanding loans, suggesting that the credit risk taking channel is more toxic when monetary policy rates increase following a period of low interest rates.

We also document that, when the federal funds rate is low, banks with more liquid assets and fewer funds from foreign financial institutions take more risk. Banks with a higher ratio of nonperforming loans or a lower capital ratio also take more risk. The additional risk that is taken is mispriced even more by these banks than by the other banks. Banks dealing with small firms, in multiple relationships or after the introduction of explicit deposit insurance engage in stronger risk-taking. Both the pricing, the expected returns, and the stronger risk-taking for banks with more acute agency problems suggest that low short-term interest rates create excessive bank risk-taking.[6]

The rest of the article proceeds as follows. Section 2 describes the data and our empirical strategy. Section 3 presents the results. Section 4 concludes.

## 2. Data and Empirical Strategy

### 2.1 SETTING AND DATA

To econometrically identify changes in the banks' appetite for risk ideally one would like to have: (i) variation in short-term interest rates which is not driven by local economic conditions; and (ii) detailed loan-level information, including loan rates, volume, maturity, and collateral. Bolivia offers one of the closest settings—that we know of—to this ideal econometric environment. In this section we explain why.

During the sample period, the Bolivian peso was pegged to the US dollar and the banking sector was almost completely dollarized. More than 90% of deposits and credits were in US dollars, which made Bolivia one of the most dollarized economies among those that have stopped short of full dollarization. The exchange rate regime, the absence of restrictions on movements in

[6] Similar to the free cash flow hypothesis (Jensen, 1986), more liquidity exacerbates agency problems between the banks, their debt-holders, the supervisors, and the deposit insurance scheme because of the resulting flexibility to alter risk (Myers and Rajan, 1998). Foreign depositors, who are large, more sophisticated, and not covered by the domestic deposit insurance scheme, may be better able and have more incentives to monitor bank managers and limit moral hazard. Low levels of bank capital (and higher *NPLs*), by giving less "skin in the game" for example, also sharpen agency problems (see Dewatripont and Tirole (1994) and Freixas and Rochet (2008) for reviews). Our findings, therefore, link higher loan risk-taking in an environment with low short-term interest rates to more severe agency problems in banks (Allen and Gale, 2007) further increasing confidence that our empirical testing strategy identifies supply effects.

the capital account, and the dollarization imply that the federal funds rate is the proper measure of monetary policy rates in Bolivia. In fact, during the sample period the correlation between the US federal funds rate and other short-term interest rates in Bolivia is very high, suggesting that changes in the US monetary policy rates are transmitted into the Bolivian liquidity markets. For example, the correlation coefficients between the US federal funds rare and the rates on savings deposits, T-Bills, and interbank loans are equal to 0.92, 0.88, and 0.74, respectively. Instead, the correlation between the US federal funds rate and measures of economic activity in Bolivia is negligible and equal to −0.14.[7]

Our main data source is the Central de Información de Riesgos Crediticios (CIRC), the public credit registry of Bolivia. The database is managed by the Bolivian Superintendent and all banks are required to participate. It contains detailed information, on a monthly basis, on all outstanding loans granted by any bank operating in the country. The Register was first studied by Ioannidou and Ongena (2010) and Berger, Frame, and Ioannidou (2011). We have access to information from 1999 to 2003 on a monthly frequency.

For each loan, we have detailed contract information (e.g., date of initiation, maturity, amount, interest rate, rating, currency denomination, value of collateral, type of loan), information about the borrower (e.g., identity, region, industry, legal status, number and scope of relationships, total bank debt, the borrower's credit history), as well as information on ex-post performance. For each month, we know whether and when a loan has overdue payments and whether it defaults. Being able to observe the entire loan spell on a monthly frequency is what allows us to employ a duration model to disentangle the impact of changes in the monetary policy rates on the quality of new loan originations from their impact on the quality of outstanding loans. We complement this dataset with bank characteristics (e.g., size, capital ratios, nonperforming loans, liquid assets, and foreign financing) from publicly available bank balance sheet and income statements.

## 2.2 MEASURES OF BANK RISK-TAKING

The richness of the Register allows us to construct several complementary measures of bank risk-taking. We start with ex-ante measures of risk that were directly available to the banks when making their loan decisions

[7] By way of comparison, the correlation coefficient between the US federal funds rate and the US growth rate of real GDP is instead positive and equal to 0.34, as the Federal Reserve typically raises its monetary policy rate when the growth rate GDP is higher (Taylor, 1993).

(e.g., the borrowers' credit history and their own internal ratings on the borrowers' repayment capacity) and examine whether the short-term interest rate affects the probability of initiating new loans to borrowers with ex-ante observable credit history problems (i.e., past delinquencies) or with a subprime rating.

The next step in our empirical strategy consists in assessing within the framework of a simple probit model the ex-post default probability (of all individual loans that were newly granted) as a measure of risk. Using an ex-post measure allows us to differentiate between the effects of monetary policy at the time of loan origination and at the time of repayment (or default). We define default (the event of interest) to occur when the bank downgrades a loan to the default status (a rating of 5) and estimate how the monetary policy rate—at loan origination and repayment (or default)—affects the probability of default.[8] Controlling for other factors that affect the probability of default, the effect of the short-term interest rate at loan origination on the ex-post nonperformance is attributable to risk-taking. Ex-post defaults are necessary to analyze risk-taking as loan officers use information on firm risk which is not available to us (econometricians), thus complementing the above risk-taking measures based on ex-ante observable information.

Using the estimates from this probit model (and crucial information as loan prices and collateral values), we then calculate the ex-ante expected default probability and the (net) expected return for each newly granted loan. If bad borrowers demand more loans when interest rates are low,[9] and more loans flow to these subprime borrowers, then loans should exhibit higher expected default rates. Yet, banks may try to adjust the loan terms to keep loan expected returns constant in this case. However, if the increase in riskier loans is supply-driven (i.e., it is the banks that are willing to take more risk, and not the bad borrowers that seek more credit), then loan expected returns may drop, and may drop more for banks with more acute moral hazard problems.[10]

[8] Small loans are downgraded to a rating of 5 if there are overdue payments for at least a certain period of time (91 days for collateralized loans and 121 days for loans that are not collateralized). Large loans, instead, are downgraded to 5 when the borrower is considered insolvent (i.e., borrowers' net worth is close to 0).

[9] In Stiglitz and Weiss (1981), the demand for funds from risky borrowers increases when interest rates are higher. The empirical evidence on this account seems mixed (Berger and Udell, 1992).

[10] In the interactions with bank characteristics that proxy for bank moral hazard, we can control for firm fixed effects.

Within the framework of a fully specified duration model, we next use the time to default as a dynamic measure of risk that allows us to better account for possible changes in loan maturity (duration). In particular, we analyze the determinants of the hazard rate in each period, that is, the probability that a loan defaults in period $t$, conditional on surviving until period $t$. A duration model also allows us to further differentiate between the effects of monetary policy at the time of loan origination and over the life of the loan to disentangle the differential effects of monetary policy on new and outstanding loans.

Exploiting the cross-sectional implications of recent theory regarding the sensitivity of bank risk-taking to monetary policy according to the strength of banks' balance sheets (Diamond and Rajan, 2006; Diamond and Rajan, 2009; Adrian and Shin, 2011; Diamond and Rajan, 2012) and moral hazard problems (Rajan, 2006; Allen and Gale, 2007), we further include in the duration model interactions between the federal funds rate and key bank characteristics.

The final step of our empirical investigation is to study the loan rate as the most salient loan condition, which is often either the only one or the last one to be adjusted across borrowers and loans, and which is also an easily interpretable *numéraire* of risk. *Ceteris paribus* (i.e., mopping up the changes in credit demand from riskier borrowers with an array of controls), the average price per unit of risk should drop if the granting of more riskier loans is supply-driven (i.e., if banks chase riskier borrowers), and again it should drop more for banks beset more severely by moral hazard problems. To control for possible contemporaneous changes in loan demand from riskier borrowers, we use an array of firm, bank–firm relationship, banking market, and macroeconomic conditions (in the likely case risky demand expands when the policy rate is low, loan premia should *ceteris paribus* increase, not decrease as we find). In even more conservative specifications, we also employ firm fixed effects as to wipe out any observable and unobservable firm fundamentals. In robustness checks we also control for loan terms.[11]

[11] Because a lower interest spread may be driven for example by a higher value of collateral, it is important that we also control for these loan terms. We do so in robustness because loan terms are endogenous, even though not necessarily to an equal degree and in all instances. For example, borrowers are commonly known to request a certain amount of credit with a certain maturity and currency (Kirschenmann, 2012; Brown, Kirschenmann, and Ongena, 2014); the bank may then require a certain preset minimum level of collateral coverage (Berger and Udell, 1995); only the interest rate paid on the loan may be the outcome of a bargaining process in the end (Mosk (2013); see also Degryse, Kim, and Ongena (2009)).

More generally, throughout our empirical investigation we report basic and parsimonious models that nevertheless field wide arrays of bank, firm, bank–firm relationship, loan and banking market characteristics and macroeconomic conditions, supplemented with comprehensive sets of individual bank, firm type, firm industry, region, and month dummies. The results are further robust to many wide-ranging alterations. For example, we assess various functional forms for all our specifications, employ the US federal funds rate as an instrument for the Bolivian interbank rate (instead of using the federal funds rate directly in the specifications), introduce firm fixed effects and include more macro controls such as additional country risk measures, cross-border financial linkages, the Bolivian peso–US dollar exchange rate, and various other short-term or long-term interest rates, and spreads. Finally, we also study the subperiod stability of our findings. We discuss these and other robustness checks in more detail when reporting our results.

## 3. Results

### 3.1 BORROWER AND LOAN DEFAULT

#### 3.1.a *Dependent variables in the probit models*

Table I defines all the variables employed in the empirical specifications, and provides their mean, standard deviation, minimum, median, and maximum values.

The first four dependent variables we employ are binary. Hence, we mainly estimate probit models. A dummy variable *Past NPL* equals 1 if any of the borrower's outstanding loans in the month prior to the initiation of the loan is nonperforming (i.e., the loan had an overdue payment of 30 days or more),[12] and equals 0 otherwise. A dummy *Past Default* equals 1 if in the month prior to the loan initiation the borrower had a loan that had defaulted ever before (i.e., was given the worst credit rating of 5), and equals 0 otherwise.[13] Both of these past repayment problems are observable

[12] The available data does not allow us to distinguish nonperforming loans with past due payments of 90 days or more (an often used definition of nonperformance) or loans that are still accruing interest.

[13] Hence both measures not only differ in the timing of past loan delinquency, that is, the month prior to the loan initiation versus the time before the month prior to the loan initiation, but also in the technical definition of delinquency, that is, nonperformance (i.e., overdue payment of 30 days or more) versus default (i.e., worst credit rating of 5). We therefore use *Past NPL* and *Past Default* as variable names. Notice that the Bolivian

*Table I.* Descriptive statistics

The table defines the variables employed in the empirical specifications and provides their mean, standard deviation, minimum, median, and maximum. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. The timing of the variables in this table is set similar to the empirical models: $\tau - 1$ is the month prior to the month the loan was granted and $\tau + t$ is during the life of the loan. The number of loan – month observations equals 157,955 and the number of loan observations equals 27,213.

| Variables | Definition | Unit | Mean | St.Dev. | Min. | Med. | Max. |
|---|---|---|---|---|---|---|---|
| *Dependent variables* | | | | | | | |
| (Borrower) Past NPL | = 1 if any of the borrower's outstanding loans in the month prior to the loan initiation is nonperforming (i.e., the loan had an overdue payment of 30 days or more); = 0 otherwise | 0/1 | 0.05 | 0.22 | 0 | 0 | 1 |
| (Borrower) Past Default | = 1 if in the month prior to the loan initiation the borrower had defaulted on a loan ever before (i.e., the loan was given the worst credit rating of 5); = 0 otherwise | 0/1 | 0.00 | 0.04 | 0 | 0 | 1 |
| Subprime (Loan) | = 1 if the bank's own internal credit rating indicated that at the time of loan origination the borrower had financial weaknesses that rendered the loan repayment doubtful and, therefore, was subprime (i.e., had a rating equal to 3 or higher); = 0 otherwise | 0/1 | 0.03 | 0.17 | 0 | 0 | 1 |
| (Loan) Default | = 1 if the granted loan defaults (i.e., is given the worst credit rating of 5); = 0 otherwise | 0/1 | 0.02 | 0.13 | 0 | 0 | 1 |
| Time to Loan Default or Repayment | Time to loan default (i.e., the loan is given the worst credit rating of 5) or repayment | Months | 6.27 | 6.01 | 1 | 4 | 52 |
| *Monetary conditions* | | | | | | | |
| Federal Funds$_{\tau-1}$ | US federal funds rate in the month prior to loan origination | % | 4.29 | 1.81 | 1.01 | 4.81 | 6.54 |
| Federal Funds$_{\tau+t}$ | US federal funds rate during the life of the loan until default or repayment | % | 4.03 | 1.80 | 1.01 | 4.81 | 6.54 |

*(continued)*

*Table I.* (Continued)

| Variables | Definition | Unit | Mean | St.Dev. | Min. | Med. | Max. |
|---|---|---|---|---|---|---|---|
| *Bank characteristics* | Includes 13 bank dummies | | | | | | |
| $\ln(\text{Assets})_{\tau-1}$ | The log of total bank assets | mln. US$ | 6.27 | 0.73 | 2.79 | 6.43 | 7.27 |
| $(\text{Loans/Assets})_{\tau-1}$ | Ratio of bank loans over total assets | % | 71.01 | 6.71 | 9.91 | 71.16 | 86.16 |
| $(\text{Non-Performing Loans/Assets})_{\tau-1}$ | Ratio of nonperforming bank loans over total assets | % | 7.68 | 4.57 | 0.60 | 6.13 | 41.60 |
| $(\text{Capital/Assets})_{\tau-1}$ | Ratio of bank equity over total assets | % | 10.36 | 4.32 | 5.34 | 9.26 | 54.22 |
| $(\text{Liquid Assets/Assets})_{\tau-1}$ | Ratio of bank liquid assets over total assets | % | 12.60 | 6.49 | 1.43 | 11.03 | 47.93 |
| $(\text{Foreign Funds/Assets})_{\tau-1}$ | Ratio of financing by foreign institutions over total assets | % | 10.50 | 8.11 | 0.00 | 9.05 | 46.43 |
| *Firm characteristics* | Includes 18 industry dummies and 2,725 firm fixed effects | | | | | | |
| Bank $\text{borrowing}_{\tau-1}$ | The firm's total outstanding bank loans | mln. US$ | 1.85 | 3.58 | 0.00 | 0.47 | 45.11 |
| Sole proprietorship | = 1 if the firm is a sole proprietorship; = 0 otherwise | 0/1 | 0.11 | 0.32 | 0 | 0 | 1 |
| Partnership | = 1 if the firm is a partnership; = 0 otherwise | 0/1 | 0.16 | 0.37 | 0 | 0 | 1 |
| Corporation | = 1 if the firm is a corporation; = 0 otherwise | 0/1 | 0.70 | 0.46 | 0 | 1 | 1 |
| Other | = 1 if the firm is a public company, a municipality, or a cultural, sport, or religious association; = 0 otherwise | 0/1 | 0.02 | 0.15 | 0 | 0 | 1 |
| *Bank–firm relationship characteristics* | | | | | | | |
| Multiple $\text{Banks}_{\tau-1}$ | = 1 if the firm has outstanding loans with more than one bank; = 0 otherwise | 0/1 | 0.54 | 0.50 | 0 | 1 | 1 |
| Main $\text{Bank}_{\tau-1}$ | = 1 if the value of loans from a bank is at least 50% of the firm's loans; = 0 otherwise | 0/1 | 0.72 | 0.45 | 0 | 1 | 1 |
| $\text{Scope}_{\tau-1}$ | = 1 if the firm has additional products (i.e., credit card used or not used, overdraft used or not used, and discount documents) with a bank; = 0 otherwise | 0/1 | 0.25 | 0.43 | 0 | 0 | 1 |

*(continued)*

*Table I.* (Continued)

| Variables | Definition | Unit | Mean | St.Dev. | Min. | Med. | Max. |
|---|---|---|---|---|---|---|---|
| *Loan characteristics* | | | | | | | |
| $\text{Amount}_{\tau}$ | Loan amount at origination | mln. US$ | 0.17 | 0.49 | 0.00 | 0.05 | 12.21 |
| $\text{Interest Rate}_{\tau}$ | Annual contractual interest rate at origination | % | 13.96 | 2.64 | 0.16 | 14.5 | 35 |
| $\text{Collateral Value}_{\tau}$ | The value of collateral to the loan amount at origination | % | 0.84 | 11.42 | 0 | 0 | 1,240.73 |
| $\text{Maturity}_{\tau}$ | Loan maturity at origination | months | 19.96 | 22.54 | 0 | 11.83 | 180.43 |
| $\text{Installment}_{\tau}$ | = 1 if loan is an installment loan; = 0 if a single-payment loan | 0/1 | 0.71 | 0.45 | 0 | 1 | 1 |
| *Banking market characteristics* | Includes 12 region dummies | | | | | | |
| Herfindahl Hirschman $\text{Index}_{\tau-1}$ | The sum of squared bank shares of outstanding loans calculated per month for each region | – | 0.18 | 0.11 | 0.12 | 0.16 | 1 |
| *Macroeconomic conditions* | Includes 11 Month and Deposit Insurance Dummies | | | | | | |
| Δ GDP $\text{Bolivia}_{\tau-1}$ | Growth in the gross domestic product in Bolivia | % | 1.87 | 0.80 | 0.42 | 2.04 | 3.60 |
| Inflation $\text{US}_{\tau-1}$ | Monthly change in the US consumer price index | % | 2.62 | 0.74 | 1.07 | 2.65 | 3.70 |
| Inflation $\text{Bolivia}_{\tau-1}$ | Monthly change in the Bolivian consumer price index | % | 2.71 | 1.66 | −1.23 | 2.71 | 6.42 |
| ICRG Country Risk $\text{Measure}_{\tau-1}$ | = 100 if low risk; = 0 if high risk. Composite country risk indicator encompassing political, financial, and economic risk | – | 67.49 | 1.13 | 64.80 | 67.50 | 69.80 |
| Exchange Rate Peso – $\text{Dollar}_{\tau-1}$ | The exchange rate between the peso and the US dollar | – | 6.60 | 0.60 | 5.71 | 6.41 | 7.73 |
| Price of $\text{Tin}_{\tau-1}$ | The price of tin (a major export product of Bolivia) | US$ | 3,363 | 457 | 1,236 | 3,554 | 4,000 |
| Net Exports Bolivia/GDP $\text{Bolivia}_{\tau-1}$ | Ratio of net exports of Bolivia and GDP in Bolvia | % | 0.85 | 2.09 | −1.74 | 0.35 | 9.86 |
| Δ Real GDP $\text{US}_{\tau-1}$ | Growth in the real gross domestic product in the USA | % | 2.56 | 1.45 | 0.22 | 2.22 | 4.85 |

to all banks through the credit registry.[14] A dummy *Subprime* equals 1 if the bank's own internal credit rating indicated that at the time of loan origination that the borrower had financial weaknesses rendering the loan repayment doubtful (i.e., had a rating equal to 3 or higher), and equals 0 otherwise.[15] All three variables measure risks ex-ante that are directly available to banks when making their loan decisions.

A fourth dummy *Default* equals 1 if the granted loan defaults (i.e., is given the worst rating of 5) and equals 0 otherwise. This variable measures risks ex-post. We believe that using a combination of ex-ante and ex-post measures is important. Higher ex-post default rates could be due to "bad luck". It is possible banks never intended to take these risks and were just caught off guard during difficult times. Hence, the ex-ante risk measures and banks' intensity to moral hazard problems allow distinguishing whether higher ex-post loan defaults are due to "bad luck" or to higher ex-ante risk-taking appetite. At the same time, it is also important to examine whether any higher ex-ante risk materializes into higher ex-post risk and defaults.

### 3.1.b *Independent variables*

*Monetary policy conditions.* To measure monetary policy conditions, we use the monthly average of the nominal US federal funds rate. We label the monetary policy measure in the month prior to loan origination ($\tau - 1$) as $Federal\,Funds_{\tau-1}$,[16] the measure at loan default or maturity ($\tau + T$) as $Federal\,Funds_{\tau+T}$ (to include, the latter variable makes sense only when *Default* is the dependent variable). During the sample period, the US federal funds rate averaged around 4.25%, but varied substantially throughout (Figure 1).

During an initial period of monetary policy tightening, the rate climbed from 4.75% in March 1999 to 6.5% in May 2000. The rate remained at this

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credit registry is a "black" credit registry where default is "never" erased from memory (hence this variable for all practical purposes does not suffer from left censoring introduced by the start of the studied sample period as the credit registry started recording defaults since its creation in 1989). Loan nonperformance on the other hand is erased after it ends.

[14] Ioannidou and Ongena (2010) and Berger, Frame, and Ioannidou (2011) provide a detailed description of the information sharing regime in place. See also Beck, Ioannidou, and Schäfer (2012).

[15] Also on this account, we complement the study by Jiménez *et al.* (2014) because they did not employ the banks' own internal rating as a measure of credit risk.

[16] We also employ the federal funds rate as an instrument for the Bolivian interbank rate. We run first-stage regressions with and without controlling for macro conditions either at the individual loan-level or at the year-month level. Using the US federal funds rate as instrument for the Bolivian interbank rate yields results that are very similar to those reported.

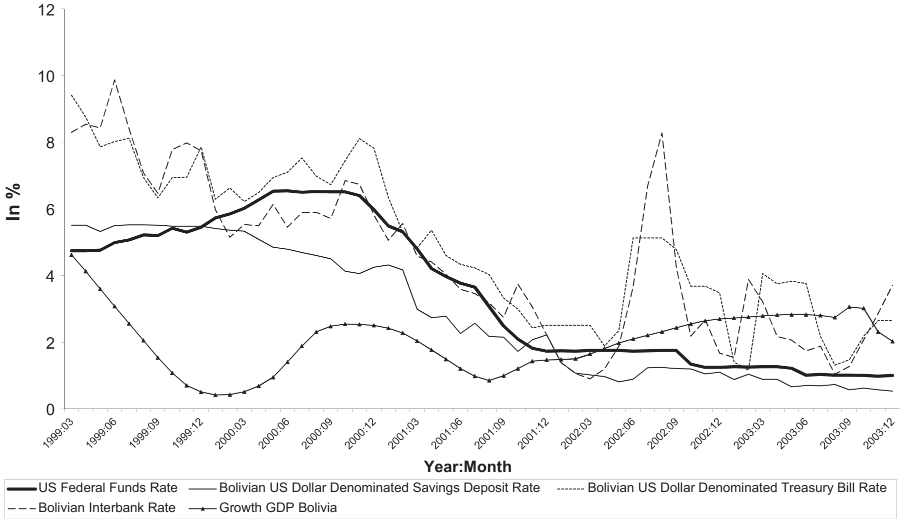


*Figure 1.* The US federal funds rate, Bolivian interest rates, and the growth in Bolivian gross domestic product. The figure displays monthly values of the US federal funds rate, the Bolivian US dollar denominated savings deposit rate, the Bolivian US dollar denominated Treasury bill rate, the Bolivian interbank rate, and the growth in Bolivian gross domestic product.

plateau of 6.5% until October 2000, followed by a steep decline during a period of monetary expansion to 1.75% in December 2001 and to 1% by December 2003. As mentioned earlier, this variation in the US federal funds rate was transmitted to Bolivian liquidity markets. For example, the rate on US dollar denominated savings deposits, the rate on the 3-month US dollar denominated Bolivian Treasury Bills, and the interbank rates follow a similar pattern.[17]

*Bank, firm, and relationship characteristics.* In addition to the measures of monetary policy conditions, an array of bank, firm, relationship, loan, market, and macroeconomic controls are included in the specifications. Bank characteristics are all taken in the month prior to the loan origination. As a measure of bank size, we use the natural log of total bank assets in millions of US dollars, $\ln(Assets)_{\tau-1}$. Better possibilities for diversification or

[17] The spread between the Bolivian Treasury Bill rate and the US federal funds rate reflects country risk. Episodes of political instability occurring during the sample period coincide with increases in the spread. The empirical analysis includes the International Country Risk Guide country risk indicator as a control variable, but results are robust to the inclusion of the spread as well.

"too big to fail" perceptions (Boyd and Runkle, 1993) for example may entice large banks to initiate riskier loans. The median bank granting loans recorded in the register has around 625 million US dollar in assets.[18]

We also include the ratio of loans to total assets, $(Loans/Assets)_{\tau-1}$, to control for the effect that a bank's financial and asset structure might affect risk management. A backlog of nonperforming loans may increase a bank's appetite for more risk, as the charter value is decreased; hence, we include the ratio of nonperforming loans to total loans, $(Non-Performing\,Loans/Assets)_{\tau-1}$. On average almost 8% of the loan volume is nonperforming, with substantial variation across banks and time. All specifications also include the ratio of bank equity over total assets, $(Capital/Assets)_{\tau-1}$, a key measure of bank agency problems. Finally, more liquid assets, $(Liquid\,Assets/Assets)_{\tau-1}$, and less foreign financing (and therefore less monitoring), $(Foreign\,Funds/Assets)_{\tau-1}$, may allow banks to indulge in risk-taking. This effect may be reinforced by monetary conditions (an issue we address later by introducing interactions). The mean and median of both ratios equal around 10%. We also include twelve individual bank dummies to capture the possibly time-invariant bank characteristics such as ownership, the choice of bank business model, its lending technology, and the credit scoring models that are employed (e.g., Berger and Udell, 2006; Berger *et al.*, 2008; Degryse, Laeven, and Ongena, 2009).

For firm characteristics, we include three dummy variables to control for the firm's legal structure and eighteen industry dummies to capture possible differences in loan demand.[19] Using the information in the Register, we also compute a firm's total outstanding bank debt, $Bank\,Borrowing_{\tau-1}$, in millions of US dollars as a measure of firm leverage and riskiness. The average (median) firm borrows around 1.85 (0.47) millions of US dollars in bank loans. Unfortunately, we cannot match the loans with firm accounting information to provide additional controls since for confidentiality

[18] We translate all Bolivian peso amounts into US dollars at the prevailing exchange rate. We report nominal US dollars but include both US and Bolivian inflation rates in all specifications. The mean annualized monthly US inflation rate for the loans in the sample equals 2.62%.

[19] The list of the industries is: (i) Agriculture and cattle and Farming; (ii) Forestry and fishery; (iii) Extraction of oil and gas; (iv) Minerals; (v) Manufacturing; (vi) Electricity, gas, and water; (vii) Construction; (viii) Wholesale and retail trade; (ix) Hotels and restaurants; (x) Transport, storage, and communications; (xi) Financial Intermediation; (xii) Real estate activities; (xiii) Public administration defense and social security; (xiv) Education; (xv) Communal and personal social services; (xvi) Activities of households as employees of domestic personnel; (xvii) Activities of extraterritorial organizations and bodies; and (xviii) Other activities.

reasons the borrower's identities have been altered before the data were given to us. Hence, to control for possible unobserved firm heterogeneity we introduce firm fixed effects in corresponding linear regressions.

As the database contains the universe of Bolivian bank loans, we can construct three indicators of bank–firm relationship characteristics. $Multiple\ Banks_{\tau-1}$ equals 1 if the firm has outstanding loans with more than 1 bank, and equals 0 otherwise; $Main\ Bank_{\tau-1}$ equals 1 if the value of loans from a bank is at least 50% of the firm's loans, and equals 0 otherwise; and, $Scope_{\tau-1}$ equals 1 if the firm has additional products (i.e., used or unused credit cards, used or unused overdrafts, and discount documents) with the bank, and equals 0 otherwise. While more than half of the loans are taken by firms that have multiple bank relationships, almost 75% of these firms borrow at least 50% from 1 bank.[20] Only 25% of the loans are obtained jointly with additional bank products.

*Loan characteristics.* For loan characteristics, we include $Amount_{\tau}$, $Interest\ Rate_{\tau}$, $Collateral_{\tau}$, $Maturity_{\tau}$, and $Installment_{\tau}$. Most loans are small to medium-sized. The average and median loan equals 170,000 US dollars and 50,000 US dollars, respectively, but have a high loan rate of around 14%; well above the average federal funds rate of 4%. Only 27% of loans are collateralized. The median loan maturity is 12 months, while the median time to default or repayment is 4 months. Defaults and early repayments explain the difference between the loan maturity and its observed duration (i.e., the time between $\tau$ and $\tau + T$). We ignore early repayment behavior as lenders may have foresight about early repayment. Finally, 71% of the loans are installment loans, while the remaining 29% of the loans are single-payment loans.

*Banking market and macroeconomic conditions.* To capture banking market characteristics, we use the Herfindahl–Hirschman Index (HHI) of market concentration, $HHI_{\tau-1}$, which is equal to the sum of the squared bank shares of outstanding loans, calculated per month for each region. The mean HHI equals 0.18, comparable to levels for the USA and other countries (see, e.g., Table I in Degryse and Ongena (2008)). We also include twelve region dummies to capture other possible structural differences in the banking markets and regions at large.

[20] These statistics are provided per loan. Only around one-fifth of our sample firms have multiple bank relationships and there is a positive correlation between firm size and the number of relationships. This pattern is consistent with findings from other countries (Ongena and Smith, 2000). See also Guiso and Minetti (2010) and Ongena, Tümer-Alkan, and von Westernhagen (2012) on borrower concentration.

We include eight variables to control for changes in macroeconomic conditions at loan origination. The growth rate in the real gross domestic product in Bolivia, $GDP\ Bolivia_{\tau-1}$, is included to control for variations in the demand for bank loans over the Bolivian business cycle. The average growth rate during the sample period was 1.87%,[21] varying between 0.42% and 3.60%.

We further include the USA and the Bolivian inflation rates, $Inflation\ US_{\tau-1}$ and $Inflation\ Bolivia_{\tau-1}$, respectively. Both inflation rates are calculated using the corresponding consumer price indexes. During the sample period, the average Bolivian inflation rate was 2.72%, slightly higher than the average US inflation rate of 2.62%, though with more than double its variation.

We also control for changes in country risk, using the composite country risk indicator from the International Country Risk Guide published by the PRS Group, $Country\ Risk_{\tau-1}$. This indicator is available on a monthly frequency and encompasses three types of risk, that is, political, financial, and economic. According to the Guide, a value of 0 indicates high risk, while a value between 80 and 100 indicates very low risk. During the sample period, the country risk of Bolivia varied between 65 and 70.

We further include the exchange rate between the Bolivian peso and the US dollar, $Exchange\ Rate\ Peso-Dollar_{\tau-1}$, the price of its main export product to the US,[22] the $Price\ of\ Tin_{\tau-1}$, and the ratio of net exports to its GDP, $Net\ Exports\ Bolivia/GDP\ Bolivia_{\tau-1}$, to capture changes in external monetary conditions and commodity prices that would affect economic growth and inflationary expectations in Bolivia concurrently with its interest rates. We also include the change in real US GDP growth, $\Delta\ REAL\ GDP\ US_{\tau-1}$. Finally, we include 11 month dummies to absorb any seasonality in bank activity and a deposit insurance dummy that equals 1 once deposit insurance is introduced in December 2001, and equals 0 otherwise (Ioannidou and Penas, 2010).[23]

### 3.1.c *Estimated coefficients on the federal funds rate variables*

As indicated earlier, the estimates in Table II are (mainly) based on probit estimations.[24] For the first model, we report the estimated coefficients and

[21] All statistics in Table I are computed by loan. The mean growth rate by month equals 2.04%, slightly higher as the number of outstanding loans and the growth rate are not perfectly correlated.

[22] The tin industry continues to have a discernible effect on the level of economic activity in general (e.g., Bojanic (2009)).

[23] In later robustness we split the sample by this date.

[24] The number of loans employed for the estimation varies because either some information is missing or the binary dependent variable outcome is perfectly

*Table II.* The impact of monetary conditions on measures of bank risk-taking in probit and OLS models

The estimates this table lists are based on probit or OLS estimations. The definition of the variables can be found in Table I. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. $T$ is the time to default or maturity. For the first dependent variable, the first column reports the estimated coefficients of a probit model, the second column the marginal effects for a change of one unit in the respective independent variable, and in the third column the estimated coefficients from an ordinary least squares regression; for the other dependent variables the estimated coefficients are reported. Within their respective column, the coefficients or marginal effects are listed on the first row and the standard errors that are clustered at the bank-month level are reported between parentheses on the second row. Significance levels are indicated adjacent to the coefficients. In Model (5), the variable Exchange Rate Peso – $\text{Dollar}_{\tau+T}$ cannot be included because of collinearity with the other independent variables. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

| Model | (1) | | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| Dependent variable | Past NPL | | | Past default | Subprime | Default |
| Estimated model | Probit | | OLS | Probit | Probit | Probit |
| Variables | Coefficients | *Marg.Effect* | Coefficients | Coefficients | Coefficients | Coefficients |
| *Monetary conditions* | | | | | | |
| Federal Funds$_{\tau-1}$ | –0.206*** | *–1.1%* | –0.01225*** | –0.193* | –0.080** | –0.168* |
| | [0.044] | | [0.00337] | [0.113] | [0.040] | [0.086] |
| Federal Funds$_{\tau+T}$ | | | | | | 0.263*** |
| | | | | | | [0.071] |
| *Bank characteristics* | | | | | | |
| ln(Assets)$_{\tau-1}$ | 0.700*** | *3.7%* | 0.06103*** | –0.747 | 0.201 | 1.116*** |
| | [0.271] | | [0.01873] | [0.912] | [0.195] | [0.313] |
| (Loans/Assets)$_{\tau-1}$ | 0.013 | *0.1%* | 0.00041 | 0.000 | –0.001 | 0.039** |
| | [0.009] | | [0.00085] | [0.024] | [0.013] | [0.016] |
| (Non-Performing Loans/Assets)$_{\tau-1}$ | 0.003 | *0.0%* | 0.00166* | –0.006 | 0.042*** | 0.011 |
| | [0.011] | | [0.00098] | [0.036] | [0.010] | [0.014] |

*(continued)*

*Table II.* (Continued)

| Variables | | (1) | | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|---|
| | Model | (1) | | (2) | (3) | (4) | (5) |
| | Dependent variable | Past NPL | | | Past default | Subprime | Default |
| | Estimated model | Probit | | OLS | Probit | Probit | Probit |
| Variables | | Coefficients | *Marg.Effect* | Coefficients | Coefficients | Coefficients | Coefficients |
| $(\text{Capital/Assets})_{\tau-1}$ | | 0.033*** | *0.2%* | 0.00328*** | 0.030 | −0.011 | 0.044** |
| | | [0.013] | | [0.00121] | [0.055] | [0.013] | [0.020] |
| $(\text{Liquid Assets/Assets})_{\tau-1}$ | | −0.01 | *−0.1%* | −0.0004 | −0.041* | 0.001 | 0.001 |
| | | [0.008] | | [0.00063] | [0.024] | [0.012] | [0.017] |
| $(\text{Foreign Funds/Assets})_{\tau-1}$ | | 0.01 | *0.1%* | 0.00153** | −0.001 | −0.010 | 0.005 |
| | | [0.007] | | [0.00063] | [0.022] | [0.008] | [0.008] |
| Individual Bank (12) Dummies | | Included | | Included | Included | Included | Included |
| *Firm characteristics* | | | | | | | |
| $\text{Bank Borrowing}_{\tau-1}$ | | 0.011** | *0.1%* | −0.00033 | −0.168*** | −0.007 | −0.095*** |
| | | [0.005] | | [0.00168] | [0.054] | [0.007] | [0.026] |
| Legal Structure (3) and Industry (18) Dummies | | Included | | Subsumed | Included | Included | Included |
| Firm (2,716) Dummies | | Not included | | Included | Not included | Not included | Not included |
| *Bank–firm relationship characteristics* | | | | | | | |
| $\text{Multiple Banks}_{\tau-1}$ | | 0.810*** | *4.3%* | 0.04445*** | −0.354* | −0.012 | −0.119 |
| | | [0.058] | | [0.00697] | [0.200] | [0.056] | [0.077] |
| $\text{Main Bank}_{\tau-1}$ | | −0.233*** | *−1.4%* | −0.0024 | −0.594*** | −0.270*** | −0.301*** |
| | | [0.049] | | [0.00663] | [0.218] | [0.058] | [0.073] |
| $\text{Scope}_{\tau-1}$ | | 0.484*** | *3.3%* | 0.03219*** | 0.208* | 0.223*** | 0.295*** |
| | | [0.049] | | [0.00822] | [0.125] | [0.045] | [0.062] |
| *Loan characteristics* | | | | | | | |
| $\text{Amount}_{\tau}$ | | 0.03 | *0.2%* | 0.00095 | 0.329*** | 0.194*** | 0.126 |
| | | [0.036] | | [0.00348] | [0.069] | [0.026] | [0.112] |
| $\text{Interest Rate}_{\tau}$ | | 0.169*** | *0.9%* | 0.00766*** | 0.103*** | 0.202*** | 0.221*** |

*(continued)*

*Table II.* (Continued)

| Variables | (1) | | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| Model | (1) | | (2) | (3) | (4) | (5) |
| Dependent variable | Past NPL | | | Past default | Subprime | Default |
| Estimated model | Probit | | OLS | Probit | Probit | Probit |
| Variables | Coefficients | *Marg.Effect* | Coefficients | Coefficients | Coefficients | Coefficients |
| | [0.015] | | [0.00149] | [0.024] | [0.015] | [0.028] |
| Collateral $Value_{\tau}$ | 0.004*** | *0.0%* | 0.00045*** | 0.001* | 0.004*** | 0.005*** |
| | [0.001] | | [0.00015] | [0.001] | [0.001] | [0.001] |
| $Maturity_{\tau}$ | 0.004*** | *0.0%* | −0.00005 | 0.007*** | 0.009*** | − 0.003 |
| | [0.001] | | [0.00013] | [0.002] | [0.001] | [0.003] |
| $Installment_{\tau}$ | −0.123*** | *−0.6%* | −0.00825* | −0.042 | −0.189*** | 0.125* |
| | [0.039] | | [0.00438] | [0.095] | [0.051] | [0.069] |
| *Banking market characteristics* | | | | | | |
| Herfindahl Hirschman $Index_{\tau-1}$ | −3.899*** | *−20.6%* | −0.29730*** | −4.150* | −5.621*** | −3.171*** |
| | [0.674] | | [0.08924] | [2.125] | [1.235] | [0.801] |
| Region (9) Dummies | Included | | Subsumed | Included | Included | Included |
| *Macroeconomic conditions* | | | | | | |
| Δ GDP $Bolivia_{\tau-1}$ | 0.060* | *0.3%* | 0.00520* | −0.230*** | −0.041 | −0.063 |
| | [0.034] | | [0.00298] | [0.078] | [0.037] | [0.050] |
| Δ GDP $Bolivia_{\tau+T}$ | | | | | | 0.062 |
| | | | | | | [0.049] |
| Inflation $Bolivia_{\tau-1}$ | 0.061* | *0.3%* | 0.00354 | 0.102 | 0.030 | 0.061 |
| | [0.031] | | [0.00224] | [0.064] | [0.026] | [0.052] |
| Inflation $Bolivia_{\tau+T}$ | | | | | | −0.164*** |
| | | | | | | [0.043] |
| ICRG Country Risk $Measure_{\tau-1}$ | −0.02 | *−0.1%* | 0.00013 | −0.074 | 0.042 | −0.057 |
| | [0.031] | | [0.00261] | [0.078] | [0.033] | [0.048] |

*(continued)*

*Table II*. (Continued)

| Variables | (1) | | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| Model | | | | | | |
| Dependent variable | Past NPL | | | Past default | Subprime | Default |
| Estimated model | Probit | | OLS | Probit | Probit | Probit |
| | Coefficients | *Marg.Effect* | Coefficients | Coefficients | Coefficients | Coefficients |
| ICRG Country Risk Measure$_{\tau+T}$ | | | | | | −0.019 |
| | | | | | | [0.041] |
| Exchange Rate Peso − Dollar$_{\tau-1}$ | −0.12 | *−0.6%* | 0.00372 | −0.108 | 0.105 | −0.768** |
| | [0.167] | | [0.01249] | [0.435] | [0.161] | [0.299] |
| Price of Tin$_{\tau-1}$ | 0.000 | *0.0%* | 0.00001 | 0.001 | 0.000 | 0.000 |
| | [0.000] | | [0.00001] | [0.000] | [0.000] | [0.000] |
| Price of Tin$_{\tau+T}$ | | | | | | 2.345*** |
| | | | | | | [0.255] |
| Net Exports Bolivia/GDP Bolivia$_{\tau-1}$ | 0.027* | *0.1%* | 0.00141 | −0.031 | 0.027** | 0.034 |
| | [0.014] | | [0.00113] | [0.039] | [0.013] | [0.024] |
| Net Exports Bolivia/GDP Bolivia$_{\tau+T}$ | | | | | | −0.035* |
| | | | | | | [0.018] |
| Δ Real GDP US$_{\tau-1}$ | 0.057 | *0.3%* | −0.00337 | −0.044 | −0.001 | 0.140** |
| | [0.035] | | [0.00232] | [0.089] | [0.035] | [0.055] |
| Δ Real GDP US$_{\tau+T}$ | | | | | | 0.038 |
| | | | | | | [0.038] |
| Month (11) and Deposit Insurance Dummies | Included | | Included | Included | Included | Included |
| Constant | −7.749** | | −7.749** | 8.068 | −9.623*** | −21.703*** |
| | [3.200] | | [3.200] | [7.990] | [3.093] | [5.510] |
| Pseudo $R^2$ (Adjusted $R^2$) | 0.23 | | 0.33 | 0.27 | 0.25 | 0.40 |
| Number of bank-month clusters | 624 | | 624 | 382 | 623 | 597 |
| Number of loan observations | 31,811 | | 31,896 | 19,158 | 31,346 | 29,027 |

adjacent to them the estimated marginal effects in italics; for the other models we report only the estimated coefficients. Standard errors that are clustered at the bank-month level are always reported between parentheses on the second row below the estimated coefficients.

In Model (1), we find that a lower federal funds rate prior to loan origination implies that banks give more loans to borrowers with past nonperformance. This impact is not only statistically significant, but also economically relevant. A 100 basis points decrease in the funds rate, for example, increases the probability that a loan is granted to a borrower with nonperforming loans by 1.1 percentage points, a semi-elasticity of almost 20% (as the mean Past NPL is 5%).

While controlling for an array of factors, the estimates could still result from a relative increase in the demand for credit from riskier borrowers (though a lower interest rate actually decreases the demand from risky borrowers in Stiglitz and Weiss (1981)). In Model (2), we therefore introduce firm fixed effects. For technical reasons we estimate the model linearly, but results are virtually unaffected. Indeed, the estimated coefficient equals −0.012***,[25] which can be assessed on sight to imply an almost equal economic relevancy as in the preceding probit model.

Next we replace the dependent dummy variable *Past NPL* by the *Number of Past NPL*, which equals the number of the borrower's outstanding loans in the month prior to the initiation of the loan that is nonperforming (i.e., the loans had an overdue payment of 30 days or more). In linear models (which are further left untabulated) without and with firm fixed effects, the estimated coefficients on the federal funds rate equal −0.087*** and −0.045**, respectively.[26] For a 100 basis points decrease in the funds rate for example these estimated coefficients imply an increase in the number of nonperforming loans by 0.08 and 0.05, or a semi-elasticity of 45% and 23%, respectively (as the mean number of non-performing loans equals 0.194).

Similar results in terms of statistical significance and economic relevancy are found for loans to borrowers with defaults in Model (3) and for loans to borrowers with subprime credit scores in Model (4).[27] All these results are

predicted by bank identity, firm type, industry, and/or region (or some combination of these variables).

[25] As in the tables, we use stars next to the coefficients to indicate their significance levels: ***significant at 1%, **significant at 5%, and *significant at 10%.

[26] For easy comparison we rely on linear models rather than on count data models. Results are mostly unaffected if we do.

[27] If in linear models we use the *Number of Past Default* rather than *Past Default* (recall that the registry keeps loan default indefinitely on record), the estimated coefficients of the federal funds rate are not statistically significant possibly due to the fact that some defaults

consistent with the different models by Allen and Gale and Diamond and Rajan on risk-taking and risk-shifting that we summarized in Section 1.

In Model (5), we feature the loan-specific, ex-post measure of bank risk-taking, that is, the dummy*Default* that equals 1 if the granted loan defaults, and equals 0 otherwise. This specification not only includes the federal funds rate and the macroeconomic variables in the month prior to the origination of the loan ($\tau$), but also in the month of default or maturity ($\tau + T$).[28]

Results are most interesting. The estimated coefficient on the funds rate at origination remains negative and statistically significant, while the estimated coefficient on the funds rate at loan default or maturity is estimated to be positive. This is one of our main findings. A decrease in the US federal funds rate, which under the exchange rate regime renders monetary conditions in Bolivia more expansionary, corresponds to a higher loan default rate at origination, but "at the same time" to a lower default rate at maturity. Hence expansionary monetary policy seems to encourage the initiation of riskier loans, but it also diminishes the default rate on outstanding bank loans! These results are fully consistent with the model in Adrian and Shin (2011), as the reduction in credit risk for existing loans due to an expansionary shock of monetary policy reduces the capital constraints for banks, thus allowing them to take on higher risk. In later specifications, we confirm this finding using a duration model that additionally controls for changes in other loan and macroeconomic conditions over the life of the loan.

However, all our findings so far do not necessarily imply that banks take more (or excessive) risk when the funds rate is low, as the loan terms at origination (notably loan prices and collateral) may be altered to offset the higher expected default rate. For example, in the models by Allen and Gale, banks enter into loans with negative expected returns when they have higher liquidity due to their moral hazard problems, as they do not suffer fully the loan losses. In the next sections, we therefore investigate the impact of the funds rate on the (net) expected return of the newly granted loans and on the loan prices.

### 3.1.d *Estimated coefficients on the control variables*

But before turning to such an investigation and a deeper interpretation of the estimated coefficients on the federal funds rate, we briefly review the estimated coefficients on the other (control) variables across all

occur a long time ago and may not be that informative about the borrower's current financial condition.

[28] The variable *Exchange Rate Peso – Dollar* at $\tau + T$ cannot be included in this specification because of collinearity with the other independent variables.

specifications (in this Table and already for the duration models in Table V as well). Most of these coefficients are fairly stable in magnitude and statistical significance throughout most specifications.

Large banks grant more loans to risky borrowers (Table II) and grant more risky loans (Table V).[29] Banks that have more loans on their books grant more risky loans.[30] Banks with stronger balance sheets in terms of capital are more likely to grant loans with a higher credit risk.[31] On the other hand, banks with a higher rate of nonperformance in their loan portfolio continue to engage subprime borrowers (the estimated coefficient in the other specifications is not statistically significant). Firms with more debt are more likely to repay their outstanding loans. And that is also the case if firms borrow from the same (main) bank,[32] but take no extra products.

The loan rate, collateral, and maturity are also relevant for the risk that is taken by the bank. *Ceteris paribus*, loans with higher loan rates, secured loans,[33] or loans with longer maturities and balloon payments, involve a higher probability that the borrowers are more risky, crucially suggesting that banks may adjust loan conditions when they take on more risk (an issue we return to shortly). The coefficients on the $\mathit{Federal\,Funds}_{\tau-1}$, however, suggest that these adjustments do not account fully for the extra risk they are taking when interest rates are low.

Banks in less concentrated markets lend to riskier borrowers and grant riskier loans, possibly because more intense competition lowers lending standards by reducing bank charter value (Keeley, 1990). The estimated coefficients on the eight macro-economic variables are mostly insignificant in the probit models, possibly also because of collinearity, making the significance and magnitude of the estimated coefficients on the federal funds

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29 The estimated coefficient on bank size in Model (2) is not significant. The definition of the dependent variable precludes new borrowers from being included in this specifications (reducing the number of observations to 19,158) suggesting that especially large banks may engage new risky borrowers.

30 Replacing this variable with bank loan growth or dropping all bank characteristics leaves results unaltered.

31 We also replace bank equity with Tier 1 plus Tier 2 capital and run the two measures of bank capital stand-alone or concurrently in Tables II and V, and in interactions in Table V, but estimates are mostly unaffected (and therefore not reported).

32 If we exclude unused credit cards and overdrafts from the definition of the *Scope* variable results are mostly unaffected.

33 Replacing our collateral dummy variable with the loan-to-value ratio (equal to the estimated market value of the collateralized assets at the time of the loan origination to the loan amount) leaves results unaltered.

rate particularly noteworthy.[34] We return to the estimates of the other macroeconomic coefficients when we estimate time-varying duration models.

### 3.2 LOAN (NET) EXPECTED RETURN

Banks likely adjust loan terms when turning to riskier lending. In this section, we therefore investigate the impact of the federal funds rate on the (net) expected return of the newly granted loans. We define the Net Expected Return (NER) of a 1 dollar loan to equal (*à la* Saunders and Cornett, 2012):

$$\text{NER} = [(1 - P) * (1 + \text{InterestRate}) + (P * \text{Collateral Value})] \\ -(1 + \text{InterbankRate}).$$

$P$ is the estimated probability of default of the loan based on Model (4) in Table II. The Interest Rate is the annual contractual interest rate at origination and the Collateral Value is the value of collateral to the loan amount at origination. The Interbank Rate is the interest rate the bank pays on an interbank loan in the month prior to origination (which is the deposit rate for the marginal funds that the bank obtains). When calculating the Expected Return (ER), we simply set the (1 + Interbank Rate) equal to 0 (in this way removing the almost direct effect that changes in the monetary policy rate would have on the value of the loan).

In Table III we regress, using ordinary least squares, the NER or ER of each loan on the federal funds rate and (in Models (2) and (4) in Table III) on the array of bank, firm, bank–firm relationship, loan (excluding those used to calculate the expected returns), banking market, and macro variables that were also present in Model (4) of Table II.[35]

The results are again interesting and strongly suggest that a decrease in the federal funds rate reduces the (net) expected return of the loan. For example, when controls are included, a 100 basis points drop in the federal funds rate

[34] Results are further robust to the inclusion in a variety of specifications of: (i) The total amount of loans granted to Bolivia by BIS countries (which includes the USA); (ii) the 1-year US Treasury Bill rate; (iii) the 10-year US Government Bond rate; and (iv) the yield curve defined as the spread between the 10-year US Government Bond rate and the 1-year US Treasury Bill rate. All interest rates and spreads can be introduced either at origination, or at origination and at default or maturity of the loan. Results are further robust to splitting the sample period in two almost equal halves in December 2001, which is the month deposit insurance was introduced.

[35] We can also include firm fixed effects in these regressions if we include interactions with bank characteristics proxying for bank moral hazard, as the NER is at the bank-firm (loan) level.

*Table III*. Monetary conditions and the (net) expected return of a one dollar loan

The estimates this table lists are based on ordinary least squares estimations. The Net Expected Return of a one dollar loan equals: $[(1-P) * (1+\mathit{Interest\ Rate})+(P * \mathit{Collateral\ Value})]-(1+\mathit{Interbank\ Rate})$; the Expected Return of a one dollar loan equals: $(1-P) * (1+\mathit{Interest\ Rate})+(P * \mathit{Collateral\ Value})$. $P$ is the estimated probability of default of the loan based on specification Table II Model (4). The *Interbank Rate* is the interest rate the bank pays on an interbank loan at $\tau-1$. The definition of the other variables can be found in Table I. The set of controls from Table II include Bank, Firm, Bank–Firm Relationship, Loan and Banking Market Characteristics, and Macroeconomic Conditions. A constant is always included. The number of loan observations equals 13,366. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. The estimated coefficients are reported in the first row and the standard errors are reported between parentheses in the second row. Significance levels are indicated adjacent to the coefficients. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

| | | Net expected return | | Expected return | |
|---|---|---|---|---|---|
| Variables | Model | (1) | (2) | (3) | (4) |
| Federal Funds$_{\tau-1}$ | | 0.925*** | 3.307** | 1.491*** | 3.496** |
| | | [0.238] | [1.528] | [0.238] | [1.530] |
| *Set of Controls from Table II* | | Not included | Included | Not included | Included |
| $R^2$ | | 0.00 | 0.04 | 0.00 | 0.04 |

reduces the mean expected return of newly granted loans by 350 basis points in Model (4), implying a semi-elasticity for an otherwise mean loan with a zero default probability that equals 25% (= 350/1,396). Hence, following a decrease in the federal funds rate, banks not only are more likely to grant loans to borrowers that are observably risky, but the (net) expected return of these newly granted loans (which is assessed on the basis of their overall ex-post performance) is substantially lower.

Weak creditor rights in Bolivia raise the possibility that collateral values may not be that informative. Indeed collateral values are often higher than the amounts banks are able to recover in the event of bankruptcy. Though the incidence of collateral in our sample is comparable to reports from Belgium for example (26% in Degryse and Van Cayseele (2000)), it is much lower than the incidence reported in the US Small Business Survey (53% in Berger and Udell (1995)), which is possibly indicative of the substantial difficulties in seizing and liquidating pledged assets in Bolivia.

In Table IV (Panel A), we therefore focus our analysis on the 9,452 loans that are uncollateralized. Results are mostly unaffected. In Panel B, we investigate if the pricing of these uncollateralized loans that are risky, that is, those with Past NPL, Past Default or that are Subprime, is more aggressive. In Panel B, we find it indeed is, by 14% in Model (2) for example (= 0.204/1.463). For collateralized loans this is not the case (not reported), possibly because banks may expect for these loans (and despite some difficulties) to claim the collateral when needed, which may absorb some of the price effects. Finally, in Panel C we single out the loans with the simplest return structure in our sample, that is, those loans with a 1-Year Maturity that are also Single-Payment. We are left with only 124 loans; yet again results are most similar, if not stronger!

### 3.3 TIME TO LOAN DEFAULT

Next, we analyze the time to default or repayment of an individual loan as a measure of its risk. As reported in Table I, the mean time to default or repayment is 6 months, but varies between 1 and 52 months. Analyzing the time to default or repayment with a time-varying duration model has a number of advantages over the analysis of loan default with a probit model (as in Model (4) of Table II).[36]

First, earlier loan default clearly implies more risk-taking than later loan default. The probit model disregards this difference in the timing of default. Second, the maturity of the granted loans may change over the monetary cycle. In a probit model, the apparent shortening of maturity following a decrease in the federal funds rate may lead to a fallacious inference of more risk-taking (short-maturity loans likely have a shorter "duration", and hence the inability of the firm to repay the loan will be revealed earlier). In contrast, a duration model aims to explain the changes in the hazard rate which has the intuitive interpretation as the probability of default in period $t$ conditional on surviving until this period. The hazard rate is therefore effectively a per-period measure of risk and, hence, comparable between loans with different durations. Third, and more importantly for disentangling the impact of monetary policy on new and outstanding loans, the federal funds rate and other macroeconomic conditions may also vary over the life of

[36] Heckman and Singer (1984), Kiefer (1988), Kalbfleisch and Prentice (2002), Greene (2003) and Cameron and Trivedi (2005) provide comprehensive treatments of duration analysis, while Shumway (2001), Chava and Jarrow (2004) and Duffie, Saita, and Wang (2007) for example employ duration analysis to study the time to firm bankruptcy. The spell in our application is the duration of time that passes before the loan defaults (as in McDonald and Van de Gucht, 1999). Repayment prevents us from ever observing a default on the loan, right-censoring the spell, and necessitating the use of a right-censored robust estimator. We study only newly granted loans, effectively removing the left-censoring problem.

*Table IV*. Monetary conditions and the (net) expected return of a one dollar loan by loan type, collateralization, and risk

The estimates this table lists are based on ordinary least squares estimations. The net expected return of a one dollar loan equals: $[(1-P) * (1+\textit{Interest Rate}) + (P * \textit{Collateral Value})] - (1+\textit{Interbank Rate})$; the Expected Return of a one dollar loan equals: $(1-P) * (1+\textit{Interest Rate}) + (P * \textit{Collateral Value})$. *P* is the estimated probability of default of the loan based on specification Table II Model (4). The *Interbank Rate* is the interest rate the bank pays on an interbank loan at $\tau-1$. *Risky Loan* is a dummy variable that equals 1 if any of our ex-ante measures of risky loans in Table II are equal to one (*Past NPL*, *Past Default,* or *Subprime*), and equals 0 otherwise. The definition of the other variables can be found in Table I. The set of controls from Table II include Bank, Firm, Bank–Firm Relationship, Loan and Banking Market Characteristics, and Macroeconomic Conditions. A constant is always included. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. The number of observations equals 9,452, 9,452, and 124, in Panels A, B, and C, respectively. The estimated coefficients are reported in the first row and the standard errors are reported between parentheses in the second row. Significance levels are indicated adjacent to the coefficients. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

| | | Net expected return | | Expected return | |
|---|---|---|---|---|---|
| Variables | Model | (1) | (2) | (3) | (4) |
| *Panel A: uncollateralized loans* | | | | | |
| Federal Funds$_{\tau-1}$ | | 1.831*** | 1.474*** | 2.394*** | 1.559*** |
| | | [0.029] | [0.102] | [0.028] | [0.099] |
| *Panel B: uncollateralized risky loans* | | | | | |
| Federal Funds$_{\tau-1}$ | | 1.792*** | 1.463*** | 2.352*** | 1.542*** |
| | | [0.030] | [0.102] | [0.028] | [0.099] |
| Risky Loan$_{\tau-1}$ | | −2.910*** | −0.278 | −3.041*** | −0.547 |
| | | [0.532] | [0.356] | [0.484] | [0.335] |
| Federal Funds$_{\tau-1}$ * | Risky Loan$_{\tau-1}$ | 0.762*** | 0.204** | 0.804*** | 0.279*** |
| | | [0.131] | [0.095] | [0.121] | [0.090] |
| *Panel C: 1-year maturity and single-payment loans* | | | | | |
| Federal Funds$_{\tau-1}$ | | 1.446*** | 5.052*** | 2.020*** | 4.337** |
| | | [0.223] | [1.882] | [0.204] | [1.997] |
| *In Panels A to C:* Set of Controls from Table II | | Not included | Included | Not included | Included |

the loan. The probit model only accounts for the variation at the time of loan origination and of repayment (or default), but not for the entire loan spell.

We rely on the maximum likelihood estimation of the proportional hazard model using the commonly used Weibull distribution as the baseline hazard rate.[37] We report the estimated coefficients, standard errors, and significance levels in Table V. Model (1) features only the federal funds rate in the month

[37] This baseline hazard includes a parameter of duration dependence. If this parameter is estimated to be larger (smaller) than 1, the hazard rate is positively (negatively) duration

prior to the loan origination, while Model (2) also includes the time-varying changes of the US federal funds rate after loan origination until default or repayment, that is, $Federal\,Funds_{\tau+t}$.

The duration model estimates confirm our findings so far. The coefficients of $Federal\,Funds_{\tau-1}$ in Models (1) and (2) are negative, statistically significant, and equal to −0.159** and −0.151**, respectively. The coefficient of the $Federal\,Funds_{\tau+t}$ in Model (2) is positive and significant at the 5% level and equals 0.667**. In Model (3), we use the monthly changes in the federal funds rate over the lifetime of the loan, $\Delta\,Federal\,Funds_{\tau+t}$, instead of the level, which yields qualitatively similar results.

To account for the demand for credit from riskier borrowers, we at once introduce firm fixed effects in Model (4). For technical reasons, we again turn to a linear regression model with a dependent variable *Time to Default*, which equals the number of months before a loan is downgraded to the default status and equals the value 98 if no downgrade is observed during the sample period (98 is the number of months in the sample period and therefore the maximum number possible). The estimated coefficients of 0.579* and −1.128***—which have the opposite signs as now the time to default and not the hazard rate is the dependent variable—confirm the earlier estimates.

All estimated effects are also economically relevant. A 100 basis points decrease in the $Federal\,Funds_{\tau-1}$ for example in Model (2) increases the hazard rate by a sixth, while a similar increase in the $Federal\,Funds_{\tau+t}$ almost doubles the hazard rate. In sum, during periods of low interest rates banks take on more risk and relax lending standards. Exposing a risky cohort of loans, granted when rates were low (or even before such a period), to increasing policy rates dramatically exacerbates their “toxicity”.

Some estimated coefficients on the time-varying macroeconomic conditions in the duration models are also statistically significant. Higher inflation in Bolivia corresponds to a lower hazard rate (possibly because it reduces the real level of debt), while a higher price of tin and lower net exports correspond to a higher hazard rate (possibly because most Bolivian exporters then face difficulties in repaying loans). The coefficients on the growth rate of real GDP in Bolivia and the USA, the exchange rate Peso-Dollar, and the ICRG Country Risk measure are mostly not statistically significant.[38]

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dependent. In unreported exercises, we also allow for nonmonotonic duration dependency by assessing log-logistic and semi-parametric Cox specifications but results are unaltered.

[38] Results are robust to the replacement of the country risk measure by its three components (economic and political country risk matter more than financial country risk).

*Table V*. The impact of monetary conditions on an ex post measure of bank risk-taking in time-varying duration and OLS models

The estimates this table lists are based on ML estimation of the proportional hazard model using the Weibull distribution as the baseline hazard rate, or are based on ordinary least squares estimation. Time to Default equals the number of months before a loan is downgraded to the default status and equals the value 98 if no downgrade is observed during the sample period. The linear model is completed with the change in GDP growth in Bolivia and the USA, inflation and country risk. The definition of the other variables can be found in Table I. In the duration models the number of loan – month observations equals 157,955. The number of loan observations equals 27,213. In the OLS model, the number of observations equals 29,326. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. Variables that vary over time have a subscript that includes $t$. All estimates are adjusted for right censoring. Coefficients are listed in the first row and the standard errors that are clustered at the bank-month level are reported between parentheses in the second row. Significance levels are indicated adjacent to the coefficients. For the estimated parameter of duration dependence the difference from one is tested. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

| Variables | Model | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|---|
| | Dependent variable | Default | Default | Default | Time to Default | Default | Default | Default | Default |
| | Estimated model | Duration | Duration | Duration | OLS | Duration | Duration | Duration | Duration |
| *Monetary conditions* | | | | | | | | | |
| Federal $\text{Funds}_{\tau-1}$ | | −0.159** | −0.151** | −0.157** | 0.579* | 0.069 | −0.197** | −0.054 | −0.282*** |
| | | [0.069] | [0.066] | [0.069] | [0.313] | [0.150] | [0.087] | [0.151] | [0.090] |
| Federal $\text{Funds}_{\tau+t}$ | | | 0.667** | | | 0.498* | 0.586** | | |
| | | | [0.259] | | | [0.267] | [0.263] | | |
| Δ Federal $\text{Funds}_{\tau+t}$ | | | | 0.461 | −1.128*** | | | −0.977 | 0.004 |
| | | | | [0.601] | [0.228] | | | [0.922] | [1.030] |
| *Monetary conditions and bank characteristics* | | | | | | | | | |
| Federal $\text{Funds}_{\tau-1}$ | x (Liquid Assets/Assets)$_{\tau-1}$ | | | | | −0.014* | | −0.006 | |
| | | | | | | [0.008] | | [0.008] | |
| Federal $\text{Funds}_{\tau+t}$ | x (Liquid Assets/Assets)$_{\tau-1}$ | | | | | 0.012** | | | |
| | | | | | | [0.006] | | | |
| Δ Federal $\text{Funds}_{\tau-1}$ | x (Liquid Assets/Assets)$_{\tau-1}$ | | | | | | | 0.111** | |
| | | | | | | | | [0.053] | |

*(continued)*

*Table V*. (Continued)

| Variables | Model Dependent variable Estimated model | (1) Default Duration | (2) Default Duration | (3) Default Duration | (4) Time to Default OLS | (5) Default Duration | (6) Default Duration | (7) Default Duration | (8) Default Duration |
|---|---|---|---|---|---|---|---|---|---|
| Federal Funds$_{\tau-1}$ | x (Foreign Funds/Assets)$_{\tau-1}$ | | | | | | 0.014 | | 0.021** |
| | | | | | | | [0.010] | | [0.010] |
| Federal Funds$_{\tau+t}$ | x (Foreign Funds/Assets)$_{\tau-1}$ | | | | | | 0.006 | | |
| | | | | | | | [0.005] | | |
| Δ Federal Funds$_{\tau+t}$ | x (Foreign Funds/Assets)$_{\tau-1}$ | | | | | | | | 0.035 |
| | | | | | | | | | [0.049] |
| *Bank characteristics* | | | | | | | | | |
| ln(Assets)$_{\tau-1}$ | | 3.007*** | 2.997*** | 2.998*** | 0.618 | 3.009*** | 3.077*** | 3.096*** | 3.143*** |
| | | [0.598] | [0.602] | [0.600] | [1.106] | [0.658] | [0.620] | [0.659] | [0.607] |
| (Loans/Assets)$_{\tau-1}$ | | 0.076** | 0.077** | 0.076** | −0.120*** | 0.091*** | 0.078** | 0.081** | 0.084** |
| | | [0.034] | [0.034] | [0.034] | [0.042] | [0.033] | [0.034] | [0.032] | [0.036] |
| (Non-Performing Loans/Assets)$_{\tau-1}$ | | 0.038 | 0.038 | 0.038 | −0.211*** | 0.058* | 0.067** | 0.057* | 0.072** |
| | | [0.026] | [0.026] | [0.026] | [0.068] | [0.035] | [0.031] | [0.034] | [0.031] |
| (Capital/Assets)$_{\tau-1}$ | | 0.152*** | 0.153*** | 0.152*** | −0.147** | 0.137*** | 0.163*** | 0.131*** | 0.160*** |
| | | [0.037] | [0.037] | [0.037] | [0.069] | [0.039] | [0.035] | [0.039] | [0.035] |
| (Liquid Assets/Assets)$_{\tau-1}$ | | 0.054** | 0.052** | 0.054** | −0.051 | 0.082** | 0.053** | 0.089** | 0.059** |
| | | [0.026] | [0.026] | [0.026] | [0.041] | [0.036] | [0.026] | [0.037] | [0.027] |
| (Foreign Funds/Assets)$_{\tau-1}$ | | 0.006 | 0.005 | 0.006 | −0.127*** | −0.003 | −0.073* | −0.001 | −0.085* |
| | | [0.012] | [0.012] | [0.012] | [0.04935] | [0.014] | [0.042] | [0.014] | [0.044] |
| Individual Bank (12) Dummies | | Included | Included | Included | Included | Included | Included | Included | Included |
| *Firm characteristics* | | | | | | | | | |
| Bank Borrowing$_{\tau-1}$ | | −0.196*** | −0.194*** | −0.196*** | 0.068** | −0.200*** | −0.195*** | −0.197*** | −0.197*** |
| | | [0.059] | [0.059] | [0.059] | [0.034] | [0.059] | [0.060] | [0.059] | [0.060] |
| Legal Structure (3) and Industry (18) Dummies | | Included | Included | Included | Subsumed | Included | Included | Included | Included |
| Firm (2,582) Dummies | | Not Incl. | Not Incl. | Not Incl. | Included | Not Incl. | Not Incl. | Not Incl. | Not Incl. |
| *Bank–Firm Relationship Characteristics* | | | | | | | | | |
| Multiple Banks$_{\tau-1}$ | | 0.015 | 0.008 | 0.014 | 0.325 | 0.003 | 0.018 | 0.004 | 0.025 |

*(continued)*

*Table V.* (Continued)

| Variables | Model / Dependent variable / Estimated model | (1) Default Duration | (2) Default Duration | (3) Default Duration | (4) Time to Default OLS | (5) Default Duration | (6) Default Duration | (7) Default Duration | (8) Default Duration |
|---|---|---|---|---|---|---|---|---|---|
| | | [0.192] | [0.191] | [0.192] | [0.318] | [0.186] | [0.190] | [0.189] | [0.193] |
| Main Bank$_{\tau-1}$ | | −0.388** | −0.366* | −0.389** | 0.481*** | −0.361* | −0.328* | −0.384** | −0.347* |
| | | [0.193] | [0.196] | [0.193] | [0.174] | [0.194] | [0.197] | [0.192] | [0.196] |
| Scope$_{\tau-1}$ | | 0.428*** | 0.431*** | 0.427*** | −0.641*** | 0.449*** | 0.433*** | 0.438*** | 0.422*** |
| | | [0.145] | [0.145] | [0.144] | [0.232] | [0.144] | [0.146] | [0.144] | [0.146] |
| *Loan characteristics* | | | | | | | | | |
| Amount$_{\tau}$ | | 0.324* | 0.319* | 0.322* | −0.056 | 0.342** | 0.332** | 0.324** | 0.337** |
| | | [0.171] | [0.169] | [0.172] | [0.151] | [0.157] | [0.166] | [0.165] | [0.165] |
| Interest Rate$_{\tau}$ | | 0.317*** | 0.314*** | 0.317*** | −0.532*** | 0.309*** | 0.319*** | 0.316*** | 0.319*** |
| | | [0.040] | [0.040] | [0.040] | [0.141] | [0.041] | [0.041] | [0.040] | [0.041] |
| Collateral Value$_{\tau}$ | | 0.003*** | 0.003*** | 0.003*** | −0.052*** | 0.003*** | 0.003*** | 0.003*** | 0.003*** |
| | | [0.000] | [0.000] | [0.000] | [0.017] | [0.000] | [0.000] | [0.000] | [0.000] |
| Maturity$_{\tau}$ | | −0.048*** | −0.048*** | −0.048*** | 0.018** | −0.048*** | −0.048*** | −0.048*** | −0.048*** |
| | | [0.008] | [0.008] | [0.008] | [0.008] | [0.008] | [0.008] | [0.008] | [0.008] |
| Installment$_{\tau}$ | | −0.158 | −0.201 | −0.16 | −0.506*** | −0.202 | −0.214 | −0.171 | −0.169 |
| | | [0.201] | [0.202] | [0.201] | [0.193] | [0.204] | [0.201] | [0.201] | [0.200] |
| *Banking market characteristics* | | | | | | | | | |
| Herfindahl Hirschman Index$_{\tau-1}$ | | −6.402** | −6.721** | −6.451** | 8.030* | −6.653** | −6.689** | −6.281** | −6.555** |
| | | [2.735] | [2.770] | [2.757] | [4.151] | [2.874] | [2.760] | [2.811] | [2.788] |
| Region (9) Dummies | | Included | Included | Included | Subsumed | Included | Included | Included | Included |
| *Macroeconomic conditions* | | | | | | | | | |
| Δ GDP Bolivia$_{\tau-1+t}$ | | 0.266 | −0.11 | 0.287 | −0.250 | −0.109 | −0.112 | 0.272 | 0.295 |
| | | [0.194] | [0.282] | [0.199] | [0.172] | [0.284] | [0.284] | [0.201] | [0.201] |
| Inflation Bolivia$_{\tau-1+t}$ | | −0.188*** | −0.378*** | −0.198*** | −0.104 | −0.384*** | −0.383*** | −0.195*** | −0.205*** |
| | | [0.056] | [0.099] | [0.060] | [0.198] | [0.100] | [0.099] | [0.060] | [0.059] |
| ICRG Country Risk Measure$_{\tau-1+t}$ | | 0.105 | 0.019 | 0.124 | 0.076 | 0.001 | 0.016 | 0.101 | 0.120 |
| | | [0.096] | [0.114] | [0.104] | [0.123] | [0.117] | [0.113] | [0.106] | [0.104] |

*(continued)*

*Table V*. (Continued)

| Variables | Model<br>Dependent variable<br>Estimated model | (1)<br>Default<br>Duration | (2)<br>Default<br>Duration | (3)<br>Default<br>Duration | (4)<br>Time to Default<br>OLS | (5)<br>Default<br>Duration | (6)<br>Default<br>Duration | (7)<br>Default<br>Duration | (8)<br>Default<br>Duration |
|---|---|---|---|---|---|---|---|---|---|
| Exchange Rate Peso – Dollar$_{\tau-1+t}$ | | −0.442 | 1.580* | −0.334 | −0.931 | 1.409 | 1.453 | −0.335 | −0.526 |
| | | [0.519] | [0.951] | [0.557] | [0.930] | [0.966] | [0.960] | [0.565] | [0.544] |
| Price of Tin$_{\tau-1+t}$ | | 0.001*** | 0.002*** | 0.001*** | −0.000 | 0.002*** | 0.002*** | 0.001*** | 0.001*** |
| | | [0.001] | [0.001] | [0.000] | [0.001] | [0.001] | [0.001] | [0.000] | [0.000] |
| Net Exports Bolivia / GDP Bolivia$_{\tau-1+t}$ | | −0.111** | −0.143*** | −0.101** | −0.097 | −0.142*** | −0.141*** | −0.102** | −0.097** |
| | | [0.044] | [0.044] | [0.049] | [0.068] | [0.044] | [0.045] | [0.049] | [0.049] |
| Δ Real GDP US$_{\tau-1+t}$ | | −0.039 | −0.041 | −0.081 | 0.111 | −0.028 | −0.052 | −0.067 | −0.086 |
| | | [0.129] | [0.131] | [0.157] | [0.157] | [0.131] | [0.130] | [0.158] | [0.156] |
| Month (11) and Deposit Insurance Dummies | | Included | Included | Included | Included | Included | Included | Included | Included |
| Constant | | −45.505*** | −54.969*** | −47.281*** | 106.130*** | −54.310*** | −54.630*** | −47.325*** | −47.334*** |
| | | [8.302] | [9.853] | [9.136] | [11.570] | [9.945] | [9.795] | [9.096] | [8.893] |
| Estimated parameter of duration dependence ($\alpha$) | | 1.53*** | 1.50*** | 1.53*** | – | 1.59*** | 1.55*** | 1.56*** | 1.62*** |
| (Pseudo/Adjusted) $R^2$ | | 0.41 | 0.41 | 0.41 | 0.47 | 0.41 | 0.41 | 0.41 | 0.41 |

Models (5)–(8) in Table V aim to further identify the source of the changes in the hazard rate by interacting the federal funds rate with bank asset liquidity and borrowing from foreign financial institutions at loan origination, that is, the variables $(Liquid\,Assets/Assets)_{\tau-1}$ and $(Foreign\,Funds/Assets)_{\tau-1}$.[39] Banks with more liquid assets may be less constrained and banks with fewer funds from foreign financial institutions may be less monitored, and hence both groups of banks are expected to take more risk.

The estimates in Models (5)–(8) in Table V broadly confirm these priors, though not all the coefficients are statistically significant. The estimates in Model (5) for example suggest that a 100 basis points decrease in the $Federal\,Funds_{\tau-1}$ increases the hazard rate for liquid banks (with a ratio of 19, i.e., 1 standard deviation above the mean) with almost a fifth, while it hardly affects the hazard rate for illiquid banks (with a ratio of 6, i.e., 1 standard deviation below the mean). A 100 basis points increase in the $Federal\,Funds_{\tau+t}$ similarly doubles the hazard rate for liquid banks and increases it by three quarters for illiquid banks.

In unreported specifications, we also include interactions with $Log(Assets)_{\tau-1}$, $(Equity/Assets)_{\tau-1}$, and $(NPL/Assets)_{\tau-1}$. Importantly, larger banks and banks with a lower capital ratio or higher ratio of nonperforming loans take more risks when the funds rate is lower. We also introduce interactions with $HHI_{\tau-1}$,[40] but the estimated coefficients are not significant. We further drop both the interactions with the funds rate over the life of the loan in all exercises (as the theory is sharper about the implications for the interactions with the federal funds rate prior to origination) and the bank fixed effects (as in Kashyap and Stein (2000)). Results, however, are unaffected.

### 3.4 PRICING OF RISK

We now turn to the last step of our analysis, the investigation of the pricing of risk on the basis of the estimated duration models, to more deeply analyze whether there is excessive risk-taking by banks and whether it is the behavior of banks, and not firms, that is behind our findings. Banks may take more

[39] The ordinarily reported standard errors (and marginal effects) of interacted variables in nonlinear models may require corrections (Ai and Norton, 2003; Norton, Wang, and Ai, 2004). However, similar linear models broadly confirm most results.

[40] With more banking competition, proxied by a lower Herfindahl–Hirschman Index, banks have more incentives to take risk because their franchise value is lower (Keeley, 1990). Thus, with easy access to liquidity during monetary expansions, a very competitive environment for banks may enhance risk taking (Dell'Ariccia and Marquez, 2006).

risk, but they may adjust loan conditions, in particular its price. Our results so far suggest that banks do not adjust loan conditions fully, as the federal funds rate variables explain: (i) the borrower or loan risk measures despite the inclusion of the five key loan conditions (amount, rate, collateral, maturity, and type) in our specifications (Tables II and V); and, (ii) the (net) expected return of the loans (Table III).

As we cannot know how these five (but also other secondary) conditions will be adjusted to compensate for the changes in risk, we now focus on the loan rate as the most frequently and often the only- and lastly-adjusted salient loan condition.[41] The loan rate in any case offers an easily interpretable *numéraire* of risk. We therefore investigate how the loan rate reflects the different components of the hazard rate that were set before it. In particular, we examine how the loan rate accounts for: (i) the component of the hazard rate that is explained by the federal funds rate at loan origination, and (ii) the remaining part of the hazard rate that is explained by all the other factors (including the four remaining loan conditions).

For each individual loan we first calculate, using the estimates of Model (2) in Table V, a hazard rate in the month prior to the loan origination at the median value of the federal funds rate over the sample. We are interested in having an equal probability of a federal funds rate increase or decrease. We take the actual values for all other independent variables,[42] hence we call this variable the *Hazard Rate Component Explained by Other Variables*$_\tau$.

Next, we calculate the hazard rate at the actual value of the funds rate in the month prior to the loan origination, *Federal Funds*$_{\tau-1}$. We label the difference between this hazard rate and the *Hazard Rate Component Explained by the Other Variables*$_\tau$, the *Hazard Rate Component Explained by the Federal Funds*$_\tau$. This variable captures changes in the hazard rate caused by deviations of *Federal Funds*$_{\tau-1}$ from its median position. Positive deviations correspond to higher hazard rates that result from expansionary monetary conditions at origination in Model (2) in Table V.

The question we try to address: "Is the banks' appetite for risk increasing when funds rates are low such that banks grant loans with higher credit risk

[41] We cannot include loan conditions over the life of the loan, as loan conditions may not be "ancillary". An ancillary variable has a stochastic path that is not influenced by the duration of the spell. Loan conditions are mostly fixed at origination. But when adjusted (in the case of collateral), this will most likely occur in response to changes in the time to default of the loan.

[42] Except for the loan rate, which we also fix to its median. As the loan rate will be the dependent variable now, employing an actual loan rate would obviously result in a spurious correlation. Using its median value appropriately scales the hazard rate, facilitating the economic relevancy assessment of the estimated coefficients.

without adjusting the loan rate fully?" To answer this question we regress the actual loan rate, in %, on the *Hazard Rate Component Explained by the Other Variables*$_\tau$ and the *Hazard Rate Component Explained by the Federal Funds*$_\tau$. We include the monthly average London Interbank Offered Rate, $LIBOR_\tau$, and a constant to control for the general interest rate level. The $LIBOR_\tau$ is the rate on US dollar denominated loans matched in maturity with the time to repayment or default of the individual bank loans. We have access to LIBOR rates for loans with a maximum maturity of 12 months. Hence, we use a subsample of 26,640 loans with spells up to 1 year.[43] The OLS estimates are reported in Table VI.

The estimated coefficient on the constant in Model (1) in Table VI suggests that the spread between loan rate and the $LIBOR_\tau$ equals 10.8%. As expected from previous studies, the loan rate adjusts sluggishly to changes in the $LIBOR_\tau$.[44] More importantly for our purposes, the estimated coefficient on the *Hazard Rate Component Explained by the Other Variables*$_\tau$, which equals 802**, indicates that a 10 basis points increase in this hazard rate leads to an 80 basis points increase in the loan rate.[45]

If monetary conditions before origination shift to "expansionary", that is, if the *Federal Funds*$_{\tau-1}$ decreases from its median so that the *Hazard Rate Component Explained by the Federal Funds*$_\tau$ turns positive, the banks will actually charge less on average. The estimated negative coefficient is equal to −1,019**, which is clearly smaller than the estimated positive coefficient of the *Hazard Rate Component Explained by the Other Variables*$_\tau$. These differential coefficients suggest that the component of the hazard rate that is explained by the monetary policy rate has even a negative effect on the loan rate, while the remaining part of the hazard rate (explained by all the other factors) has a positive impact on the loan rate. This is not consistent with loan demand driving our results. Our findings also suggest that *ceteris*

[43] Hazard rates are calculated on the basis of the coefficients estimated using all loans.

[44] The change in the loan rate due to a basis point change in the $LIBOR_\tau$ equals 0.6*** in Model (1). This coefficient suggests sluggishness in loan rate adjustments, possibly due to the implicit interest rate insurance offered by banks (e.g., Berlin and Mester (1998)), credit rationing (e.g., Fried and Howitt (1980) and Berger and Udell (1992)), or the downward drift in Bolivian interest rates during our sample period. The size of the coefficient on a comparable variable, that is the interest rate on a government security with equal maturity in Petersen and Rajan (1994) and Degryse and Ongena (2005) for example is around 0.3*** and 0.5***, respectively.

[45] The mean hazard rate is around 20 basis points per loan − month. If the $LIBOR_\tau$ is equal to 2% for example and for median monetary conditions, a hazard rate of 0% results in a loan rate of 10.9%, while a hazard rate of 20 basis points corresponds to a loan rate of 12.5%.

*Table VI*. Hazard rates and the loan interest rate

The estimates this table lists are based on ordinary least squares. The *Hazard Rate Explained by the Other Variables* is the estimated hazard rate when in Table IV Model (2) all variables are set at their actual values except for the Federal $\text{Funds}_{t-1}$ which is set to the sample median for all loans. The *Hazard Rate Explained by the Federal Funds* is the estimated hazard when in Table IV Model (2) all variables are at their actual values minus the Hazard Rate of Other Variables (i.e., it captures changes in the hazard rate caused by deviations in the Federal Funds from its median). The *LIBOR is* the rate on US dollar denominated loans matched in maturity with the time to repayment or default of the individual bank loans. The definition of the other variables can be found in Table I. The number of loan observations equals 26,640. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. Coefficients are listed in the first row and the standard errors that are clustered at the bank-month level are reported between parentheses in the second row. Significance levels are indicated adjacent to the coefficients. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

| Variables | | Model | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|---|
| Hazard Rate Component Explained by the Other $\text{Variables}_{\tau}$ | | | 802.265** | 712.519** | 803.763** | 1,230.200*** |
| | | | [317.888] | [294.254] | [322.036] | [307.964] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | | | −1,019.999** | 519.555 | −1,200.878*** | −37,609.689*** |
| | | | [417.066] | [729.899] | [422.732] | [10,716.077] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | $(\text{Liquid Assets/Assets})_{\tau-1}$ | | −46.904** | | −134.537* |
| | | | | [20.958] | | [69.386] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | $(\text{Foreign Funds/Assets})_{\tau-1}$ | | | 33.580* | 272.184*** |
| | | | | | [19.406] | [68.156] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | $\ln(\text{Assets})_{\tau-1}$ | | | | 2,492.716** |
| | | | | | | [1,185.279] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | $(\text{Loans/Assets})_{\tau-1}$ | | | | 235.671** |
| | | | | | | [93.536] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | $(\text{Non-Performing Loans/Assets})_{\tau-1}$ | | | | −317.107*** |
| | | | | | | [56.488] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | $(\text{Capital/Assets})_{\tau-1}$ | | | | 463.961*** |
| | | | | | | [112.927] |
| Hazard Rate Component Explained by the Federal $\text{Funds}_{\tau}$ | x | Herfindahl Hirschman $\text{Index}_{\tau-1}$ | | | | 27,187.622*** |
| | | | | | | [5,918.492] |
| $\text{LIBOR}_{\tau}$ | | | 0.615*** | 0.632*** | 0.615*** | 0.632*** |
| | | | [0.033] | [0.034] | [0.033] | [0.034] |
| Constant | | | 10.881*** | 10.804*** | 10.884*** | 10.814*** |
| | | | [0.156] | [0.161] | [0.156] | [0.157] |
| $R^2$ | | | 0.22 | 0.22 | 0.22 | 0.23 |

*paribus* banks do not seem to require extra compensation for the risk taken during expansionary monetary times.

Models (2) and (3) include the interactions of *Hazard Rate Component Explained by the Federal Funds*$_\tau$ with $(Liquid\,Assets/Assets)_{\tau-1}$ and $(Foreign\,Funds/Assets)_{\tau-1}$, respectively. We find that banks with more liquidity, hence banks that are less constrained, price the increment in the hazard rate even less so than banks that are more constrained. The opposite is true for banks with more foreign financing, possibly because foreign institutions monitor more.

In Model (5), we add the interactions of the *Hazard Rate Component Explained by the Federal Funds*$_\tau$ with bank size, loans/assets, nonperforming loans/assets, capital/assets, and the Herfindahl–Hirschman Index, all taken in the month prior to loan origination. We find again that more liquid and domestically funded banks price the increment in the hazard rate less sharply. Also smaller banks with a lower loan to asset ratio, more nonperforming loans, a lower capital ratio, and operating in less concentrated banking markets price the increment in the hazard rate less sharply—recall that all these banks also take more risk!

### 3.5 SUBSAMPLE STABILITY AND MARGINS OF BANK RISK-TAKING

Finally, in Table VII we check subsample stability for all estimates reported in Models (1)–(4) from Table II and Models (1) and (2) from Table V, and in addition explore the various salient margins of bank risk-taking by adding interactions of the *Federal Funds*$_{\tau-1}$ with selected firm, relationship, loan, and macro variables to these models. To conserve space, we stack the relevant estimated coefficients in ten panels and suppress all other estimates because these are mostly similar to those we have already presented in Tables II and V, respectively.

The top panel, that is, Panel A, contains the estimates from a subsample exercise whereby the period between 2002:4 and 2003:1 is removed. This is a period characterized by intense political uncertainty in Bolivia (which is also reflected in the spikes in the Bolivian T-Bill rate and the interbank rate in Figure 1),[46] yet removing this period all together does not alter the results

[46] It is the period around the elections of July 2002. In July 2001, the president was diagnosed with cancer and stepped down. He was replaced by the vice president and elections were called for July 2002. During this period, Evo Morales decided to run for president and started to gain momentum. His potential victory—which in the end did not occur but only by a small margin—was widely expected to lead to major changes in the political and economic system in the direction of socialism. In addition, after the election period violent confrontations took place between the police and demonstrators because of the coca

*Table VII*. The impact of monetary conditions on measures of bank risk-taking in probit models and on an ex post measure of bank risk-taking in time-varying duration models across time, industry, firms, and loans

The estimates this table lists in the first four columns are based on probit estimations as in Table II while the last two columns are based on ML estimation of the proportional hazard model using the Weibull distribution as the baseline hazard rate as in Table IV. Bank Borrowing > 75%$_{\tau-1}$ is a dummy variable which equals one if the firm's total outstanding bank loans is larger than the 75th percentile of all firms, and equal zero otherwise. The definition of the other variables can be found in Table I. Subscripts indicate the time of measurement of each variable. $\tau$ is the month the loan was granted. $T$ is the time to default or maturity. Variables that vary over time have a subscript that includes $t$. The estimated coefficients are listed on the first row and the standard errors that are clustered at the bank-month level are reported between parentheses on the second row. N.C. indicates that there is no convergence because the variance matrix is nonsymmetric or highly singular. Significance levels are indicated adjacent to the coefficients. ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

| Model | Probit Models | | | | Duration Models | |
|---|---|---|---|---|---|---|
| Variables | (1) Past NPL | (2) Past Default | (3) Subprime | (4) Default | (1) Default | (2) Default |
| *Panel A: period 2002:4–2003:1 Removed* | | | | | | |
| Federal Funds$_{\tau-1}$ | –0.116** | –0.114 | –0.033 | –0.083 | –0.179** | –0.174** |
| | [0.050] | [0.118] | [0.044] | [0.088] | [0.075] | [0.073] |
| Federal Funds$_{\tau+T \text{ or } t}$ | | | | 0.294*** | | 0.718*** |
| | | | | [0.078] | | [0.274] |
| Number of observations | 27,613 | 16,321 | 27,149 | 25,206 | 137,946 | 137,946 |
| *Panel B: only the manufacturing industry* | | | | | | |
| Federal Funds$_{\tau-1}$ | –0.170*** | 0.766* | –0.005 | –0.195 | –0.255* | N.C. |
| | [0.062] | [0.403] | [0.066] | [0.146] | [0.144] | |
| Federal Funds$_{\tau+T \text{ or } t}$ | | | | 0.219* | | N.C. |
| | | | | [0.123] | | |
| Number of observations | 9,566 | 3,705 | 9,116 | 7,250 | 46,649 | |
| *Panel C: only the wholesale and retail trade industries* | | | | | | |
| Federal Funds$_{\tau-1}$ | –0.283*** | 0.138 | –0.132* | –0.076 | –0.265*** | –0.267*** |
| | [0.062] | [0.254] | [0.080] | [0.120] | [0.101] | [0.101] |

*(continued)*

*Table VII.* (Continued)

| Variables | Model | Probit Models (1) Past NPL | (2) Past Default | (3) Subprime | (4) Default | Duration Models (1) Default | (2) Default |
|---|---|---|---|---|---|---|---|
| Federal Funds$_{\tau+T\ or\ t}$ | | | | | 0.174* | | 0.329 |
| | | | | | [0.104] | | [0.371] |
| Number of observations | | 9,306 | 2,877 | 8,710 | 8,277 | 48,242 | 48,242 |
| *Panel D: all industries, except manufacturing and wholesale and retail trade industries* | | | | | | | |
| Federal Funds$_{\tau-1}$ | | −0.207*** | −2.772** | −0.055 | −0.256** | −0.093 | N.C. |
| | | [0.078] | [1.124] | [0.070] | [0.122] | [0.127] | |
| Federal Funds$_{\tau+T\ or\ t}$ | | | | | 0.368*** | | N.C. |
| | | | | | [0.115] | | |
| Number of observations | | 12,621 | 3,777 | 12,618 | 11,602 | 63,064 | |
| *Panel E: interaction with bank borrowing > 75%* | | | | | | | |
| Federal Funds$_{\tau-1}$ | | −0.261*** | −0.546*** | −0.072 | −0.167* | −0.238*** | −0.227*** |
| | | [0.049] | [0.156] | [0.053] | [0.086] | [0.070] | [0.067] |
| Federal Funds$_{\tau-1}$ * | Bank Borrowing > 75%$_{\tau-1}$ | 0.056** | 0.331*** | 0.019 | 0.013 | 0.280*** | 0.268*** |
| | | [0.025] | [0.084] | [0.025] | [0.032] | [0.102] | [0.100] |
| Federal Funds$_{\tau+T\ or\ t}$ | | | | | 0.248*** | | 0.659** |
| | | | | | [0.071] | | [0.260] |
| Bank Borrowing$_{\tau-1}$ > 75% | | 0.144 | −0.671** | 0.029 | −0.439*** | −2.241*** | −2.185*** |
| | | [0.114] | [0.266] | [0.117] | [0.162] | [0.524] | [0.519] |
| *Panel F: interaction with 1-multiple banks* | | | | | | | |
| Federal Funds$_{\tau-1}$ | | −0.278*** | −0.209* | −0.089** | −0.186** | −0.295*** | −0.283*** |
| | | [0.053] | [0.111] | [0.044] | [0.089] | [0.074] | [0.071] |
| Federal Funds$_{\tau-1}$ * | 1-Multiple Banks$_{\tau-1}$ | 0.083*** | 0.038 | 0.016 | 0.037 | 0.325*** | 0.313*** |
| | | [0.029] | [0.060] | [0.024] | [0.035] | [0.096] | [0.093] |
| Federal Funds$_{\tau+T\ or\ t}$ | | | | | 0.260*** | | 0.648** |
| | | | | | [0.070] | | [0.258] |
| Multiple Banks$_{\tau-1}$ | | 0.473*** | −0.498* | −0.076 | −0.274 | −1.527*** | −1.478*** |

*(continued)*

*Table VII.* (Continued)

| Variables | Model | Probit Models | | | | Duration Models | |
|---|---|---|---|---|---|---|---|
| | | (1) Past NPL | (2) Past Default | (3) Subprime | (4) Default | (1) Default | (2) Default |
| | | [0.131] | [0.279] | [0.119] | [0.173] | [0.488] | [0.478] |
| *Panel G: interaction with main bank* | | | | | | | |
| Federal Funds$_{\tau-1}$ | | −0.209*** | −0.231 | −0.039 | −0.160* | 0.058 | 0.058 |
| | | [0.076] | [0.163] | [0.068] | [0.090] | [0.114] | [0.113] |
| Federal Funds$_{\tau-1}$ * | Main Bank$_{\tau-1}$ | −0.024 | −0.017 | −0.024 | −0.011 | −0.291** | −0.280** |
| | | [0.039] | [0.084] | [0.043] | [0.038] | [0.117] | [0.115] |
| Federal Funds$_{\tau+T \text{ or } t}$ | | | | | 0.263*** | | 0.654** |
| | | | | | [0.071] | | [0.257] |
| Main Bank$_{\tau-1}$ | | 0.098 | −0.257 | 0.05 | −0.252 | 0.982 | 0.951 |
| | | [0.177] | [0.410] | [0.178] | [0.175] | [0.617] | [0.611] |
| *Panel H: interaction with maturity* | | | | | | | |
| Federal Funds$_{\tau-1}$ | | −0.214*** | −0.255** | −0.078* | −0.163* | −0.169 | −0.166 |
| | | [0.046] | [0.112] | [0.041] | [0.089] | [0.127] | [0.127] |
| Federal Funds$_{\tau-1}$ * | Maturity$_{\tau}$ | 0.001 | 0.003*** | 0.000 | 0.000 | 0.001 | 0.001 |
| | | [0.001] | [0.001] | [0.001] | [0.002] | [0.008] | [0.008] |
| Federal Funds$_{\tau+T \text{ or } t}$ | | | | | 0.262*** | | 0.669*** |
| | | | | | [0.070] | | [0.259] |
| Maturity$_{\tau}$ | | −0.001 | −0.009 | 0.010*** | −0.001 | −0.052 | −0.053 |
| | | [0.005] | [0.006] | [0.003] | [0.009] | [0.043] | [0.043] |
| *Panel I: interaction with installment* | | | | | | | |
| Federal Funds$_{\tau-1}$ | | −0.223*** | −0.205 | −0.049 | −0.146* | −0.122 | −0.116 |
| | | [0.070] | [0.125] | [0.052] | [0.083] | [0.121] | [0.117] |
| Federal Funds$_{\tau-1}$ * | Installment$_{\tau}$ | −0.017 | −0.078 | −0.026 | −0.046 | −0.051 | −0.049 |
| | | [0.027] | [0.051] | [0.025] | [0.029] | [0.121] | [0.118] |
| Federal Funds$_{\tau+T \text{ or } t}$ | | | | | 0.261*** | | 0.667** |
| | | | | | [0.070] | | [0.259] |

*(continued)*

*Table VII.* (Continued)

| Variables / Model | Probit Models | | | | Duration Models | |
|---|---|---|---|---|---|---|
| | (1) Past NPL | (2) Past Default | (3) Subprime | (4) Default | (1) Default | (2) Default |
| Installment$_{\tau}$ | −0.024 | 0.319* | −0.049 | 0.305** | 0.064 | 0.015 |
| | [0.107] | [0.184] | [0.111] | [0.129] | [0.624] | [0.614] |
| *Panel J: interaction with deposit insurance* | | | | | | |
| Federal Funds$_{\tau-1}$ | −0.128*** | −0.129 | −0.068 | −0.076 | −0.134 | −0.179 |
| | [0.049] | [0.123] | [0.044] | [0.091] | [0.143] | [0.142] |
| Federal Funds$_{\tau-1}$ * Deposit Insurance$_{\tau-1}$ | −1.117*** | −1.107 | −0.162 | −1.479*** | −0.033 | 0.037 |
| | [0.359] | [0.799] | [0.282] | [0.546] | [0.178] | [0.171] |
| Federal Funds$_{\tau+T \text{ or } t}$ | | | | 0.290*** | | 0.673*** |
| | | | | [0.072] | | [0.255] |
| Deposit Insurance$_{\tau-1}$ | 2.423*** | 2.623 | 0.551 | 2.757** | 1.494 | 1.584 |
| | [0.757] | [1.703] | [0.579] | [1.137] | [1.020] | [1.059] |
| *In Panels E to J:* number of observations see equivalent model in | Table II | Table II | Table II | Table II | Table V | Table V |
| *In Panels A to J:* controls from equivalent model in | Table II | Table II | Table II | Table II | Table V | Table V |

much. In Panels B–D, we focus on the most-prevalent industries, that is, Manufacturing and Wholesale and Retail Trade, and on the other industries to see if bank risk-taking would differ by industry. Again the estimates are mostly in line with those reported so far.

Next, Panels E–J report the interaction estimates. Important to note at once is that also the sign, size and in many cases the statistical significance of the estimated coefficients on $Federal\ Funds_{\tau-1}$ and its interactions imply that bank risk-taking occurs across the board and is not simply an "average" firm, relationship, or loan phenomenon.

In Panel E, the federal funds rate is interacted with $Bank\ Borrowing > 75\%_{\tau-1}$, a dummy variable which equals 1 if the firm's total outstanding bank loans are in total volume larger than the 75th percentile of all firms, and equal 0 otherwise. The estimated coefficients on the interaction terms in all models imply that bank risk-taking is less pronounced when credit is granted to the largest firms. This is likely because small firms are more opaque and hence a relevant margin of bank risk-taking.

In Panel F we isolate firms with single versus multiple bank relationships. The estimates show that risk-taking is relatively muted when firms are engaged bilaterally. This is potentially the case because the lending bank then has to internalize all risk and can also not free ride on the monitoring done by other banks (Carletti, 2004; Carletti, Cerasi, and Daltung, 2007).

Next, in Panel G we interact the federal funds rate with $Main\ Bank_{\tau-1}$, which (recall) equals 1 if the value of loans from a bank is at least 50% of the firm's loans, and equals 0 otherwise. Though estimated imprecisely also in this case the estimated coefficients are not necessarily inconsistent with free riding in the sense that a main bank is willing to take more risk because potentially having an informational advantage (being the main bank) it can "share" the resultant risks with other banks.

Loan characteristics do not seem to play a sizeable role in Panels H and I, but the introduction of deposit insurance in December 2001 does (see the lowest Panel J). Though again estimates are at times imprecise, more risk-taking seemingly occurs after its introduction, likely because bank agency issues then became even more pronounced. But it is important to notice that also prior to the introduction additional risk-taking occurred with almost the same intensity when the federal funds rate was lower.

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eradication policy which was introduced after intense pressure from the USA and various international organizations.

## 4. Conclusion

We analyze the impact of monetary policy on bank loan risk-taking, pricing, and expected returns by accessing the unique, detailed credit register of Bolivia from 1999 to 2003. During this period, the Bolivian peso was pegged to the US dollar, there were hardly any restrictions in the Bolivian capital account, and the banking system was almost completely dollarized. In addition, the Bolivian business cycle and the US federal funds rate were not correlated. The US federal funds rate is therefore a proper measure of the so-predetermined stance of monetary policy in Bolivia and is exogenous to the local economic conditions. Hence, employing the US federal funds rate and the very detailed Bolivian credit register we can examine whether and how monetary policy rates affect banks' loan risk-taking, pricing and expected returns.

We find that lower monetary policy rates increase the risk appetite of banks. Controlling for bank and firm observables and unobservable heterogeneity, bank–firm relationship, loan, and banking market characteristics and macroeconomic conditions, a decrease in the US federal funds rate makes it more likely that banks grant loans to ex-ante observable riskier borrowers with past nonperformance or with a subprime rating, or grant loans that are more likely to default over their life or per month outstanding.

In pointed contrast, a decrease in the federal funds rate prior to repayment or over the loan's life lowers the default rate! Therefore, the moment of highest credit risk is when the monetary policy rate is low and they substantially increase over the life of the loans, as was the case for example in the USA and Europe in 2002–07 before the start of the worst financial crisis since the 1930s, in Japan in the 1980s, or in the US in the 1920s. Our findings, therefore, have crucial implications for bank credit risk once the USA and Europe leave their ultralow monetary policy rates that have been in place since 2008 and return to normal historical levels.

Results also suggest that banks do not price this additional risk they take, both analyzing loan spreads and expected returns (including collateral values). We further find that especially banks with more liquid assets, fewer funds from foreign financial institutions, lower capital ratios and more NPLs take more risk when rates are low and price this additional risk even less so than other banks. This pricing combined with our findings that risk-taking is more pronounced for banks with more acute moral hazard problems, when dealing with small firms, in multiple relationships or after the introduction of explicit deposit insurance, suggests a causal link from low policy rates to excessive risk-taking.

All in all, given that credit risk is the most important risk for banks, the results suggest that central banks should take into account the financial stability implications of their monetary policy decisions. Therefore, our results are consistent with the new macroprudential policy responsibilities by central banks in Europe and USA.

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