Monetary Policy, Risk-Taking, and Pricing

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MONETARY POLICY, RISK-TAKING AND PRICING: EVIDENCE FROM A QUASI-NATURAL EXPERIMENT

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Monetary Policy, Risk-Taking and Pricing:

Evidence from a Quasi-Natural Experiment

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Monetary Policy, Risk-Taking and Pricing:

Evidence from a Quasi-Natural Experiment

Abstract

We analyse the impact of monetary policy on bank risk-taking and pricing. Bolivia provides us with an excellent experimental setting to identify this impact. Its small economy is not synchronized with the US economy but its banking system is almost fully dollarized. Consequently the US federal funds rate is the appropriate measure of monetary policy. We study the impact of the federal funds rate on the riskiness and pricing of new bank loans granted in Bolivia between 1999 and 2003, a period of significant variation in the federal funds rate. We find robust evidence that a decrease in the US federal funds rate prior to loan origination raises the monthly probability of default on individual bank loans. We also find that initiating loans with a subprime credit rating or loans to riskier borrowers with current or past non-performance become more likely when the federal funds rate is low. However, loan spreads do not increase, seemingly even decrease, in changes in the probability of default. Hence banks do not seem to price the additional risk taken. Furthermore, banks with more liquid assets and less funds from foreign financial institutions take more risk when the federal funds rate is low, and reduce loan spreads more despite the additional risk they seemingly take.

Keywords: monetary policy, federal funds rate, lending standards, credit risk, subprime borrowers, duration analysis.

JEL: E44, G21, L14.

"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 – an undesirable consequence at a moment when risk is being repriced after many years of lax lending."

Monetary Policy — Hazardous times, Leaders, Opinion, *The Economist*, August 23rd, 2007

I. Introduction

Turmoil in the credit markets started in August 2007 and has continued almost unabated until today. Many observers have argued that during the long period of very low interest rates prior to the turmoil banks had softened their lending standards,[1] but may have failed to price the extra risks that were taken. But while variation over time in the price of risk may be common across financial assets (see, for example, Bernanke and Kuttner (2005) and Rigobon and Sack (2004) on equity, Manganelli and Wolswijk (2007) on bonds, and Axelson, Jenkinson, Strömberg and Weisbach (2007) on buyouts), to date no paper has identified this variation in bank loan rates. In particular, we analyze loan pricing in conjunction with loan risk-taking to assess whether monetary policy affects risk-taking. The scarcity of disaggregate bank loan data combined with the difficulties of identification may explain this gap in the literature.

This paper starts to fill this gap by studying the *pricing* of *risks taken by banks* using individual loan data in an almost perfect experiment in which monetary policy was close to exogenous and rapidly changing. The unique availability of several—and complementary—measures of risk coupled with reliable information on bank loan pricing allows us to eliminate alternative, demand-driven, hypotheses.

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[1] Between 2001 and 2005 nominal rates were the lowest in almost four decades and below Taylor rates in many countries, while real rates were negative (see Ahrend, Cournède and Price (2008), Taylor (2007). Borio and Zhu (2007), Dell'Ariccia, Igan and Laeven (2008), Rajan (2006) and numerous contributions in *The Wall Street Journal*, *The Financial Times* and *The Economist* conjecture that low interest rates may result in more risk-

To analyse the impact of monetary policy on bank risk-pricing we access the credit register of Bolivia from 1999 to 2003. During this period the local currency, Bolivian Peso, was pegged to the US dollar and the banking system was almost fully dollarized. The Bolivian monetary policy is consequently no longer independent from US monetary policy. The US federal funds rate is thus the best measure (Bernanke and Mihov (1998)) of the so predetermined stance of Bolivian monetary policy, in particular as we only study US dollar denominated loans. In addition, the Bolivian business cycle was not synchronized with the US business cycle.

The credit register contains detailed contract information on all bank loans granted in Bolivia. Employing a battery of time-varying duration and probit models, we study several loan-specific measures of bank risk-taking: time to individual loan default, current or past borrower default, and internal credit ratings at origination.

We find that relaxing monetary conditions wets the risk-appetite of banks: they take more risk and they do not seem to price it properly. Controlling for bank, firm, relationship, loan, market, macroeconomic and country-risk characteristics, a decrease in the US federal funds rate prior to loan origination raises the probability of default of the individual bank loans (in pointed contrast, a decrease in the federal funds rate over the life of the loan lowers the hazard rate). Initiating loans to riskier borrowers with current or past non-performance or loans with a subprime credit rating also becomes more likely when the federal funds rate is low.

Even more important banks do not seem to price this additional risk adequately: Spreads mostly decrease in the additional risk that is being taken! This finding suggests that it is

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taking. Loan securitization may have intensified risk-taking (Keys, Mukherjee, Seru and Vig (2008), Mian and Sufi (2008)).

likely that changes in credit supply (and not demand) are identified. In addition, banks with more liquid assets and less funds from foreign financial institutions (who may monitor better) take more risk when rates are low and price this additional risk even more negatively than other banks. Both findings provide further confidence that our empirical testing strategy identifies supply effects and suggest that lower interest rates create excessive risk-taking.

Our paper consequently makes two contributions. First, to the best of our knowledge this paper and Jiménez, Ongena, Peydró and Saurina (2008) are the only and first papers to investigate the impact of monetary policy on *risk-taking* by banks.[2] Using the Spanish credit register, Jiménez et al. (2008) analyse the dynamic implications of monetary policy for bank credit risk over a much longer time period in a larger and more developed financial market. This paper, by contrast, exploits better measures of *ex ante* risk-taking, in addition to actual loan performance, and shows that the baseline results in Jiménez et al. (2008) also hold in the Bolivian credit market – if anything an even more appropriate Mundell-Fleming type of economy. Second, and its main contribution, our paper analyses the *risk-pricing* by banks and this way take identification another step further. We find that following changes in the federal funds rate the extra risk taken by the banks is even negatively priced.

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[2] The impact of changes in the short-term interest rates on the aggregate volume of credit in the economy has been widely analyzed (Bernanke and Blinder (1992), Bernanke and Gertler (1995) and Kashyap and Stein (2000) among others). Recent theoretical work shows how changes in short-term interest rates may affect credit risk-taking by financial institutions. Lower interest rates by improving borrowers' net worth may imply financiers to venture away from quality (Bernanke, Gertler and Gilchrist (1996)) or to lend to borrowers with fewer pledgeable assets (Matsuyama (2007)). But lower interest rates may push financiers beyond this category of borrowers to finance firms and projects that are actually riskier in the present (Borio and Zhu (2007)), as lower interest rates may reduce the threat of deposit withdrawals (Diamond and Rajan (2006)), abate adverse selection problems in credit markets (Dell'Ariccia and Marquez (2006)) or improve banks' net worth (Stiglitz and Greenwald (2003)). Low levels of short-term interest rates may further lead to a search-for-yield (Rajan (2006)). On the other hand, higher interest rates increase the opportunity costs for banks to hold cash (Smith (2002)) or reduce the banks' net worth or charter value enough to make "gambling for resurrection" attractive (Kane (1989) and Hellman, Murdock and Stiglitz (2000)). Ultimately, the impact of short-term interest rates on credit risk-taking is a mostly unaddressed empirical question.

The rest of the paper proceeds as follows. Section II further reviews our empirical strategy. Section III models the time to default of bank loans and introduces the variables employed in the empirical specifications. Section IV presents the results. Section V summarizes the results and concludes.

II. Empirical Strategy

To econometrically identify changes in the banks' appetite for and pricing of risk ideally we would like to have: (i) changes in short-term interest rates that are not driven by local economic conditions; (ii) all bank loan applications (accepted or not) with detailed information on each of them, including loan rates. In this ideal setting a simple regression would identify the impact of short-term interest rates on the banks' appetite for risk. We think this ideal setting does not exist. However, Bolivia offers the closest setting – 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 percent of deposits and credits are in US dollars, which makes Bolivia one of the most dollarized economies among those that have stopped short of full dollarization. The exchange rate regime and the dollarization imply that the federal funds rate is the proper measure of monetary policy in Bolivia. In fact, during the sample period the correlation between the US Federal funds rate and the 3-month Bolivian Treasury Bill rate is 0.88 while the correlations between various measures of economic activity in the two countries were low.

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 employed by Ioannidou and Ongena (2008). We have access to information from 1999 to 2003. For each loan we have detailed *contract* information (e.g., date of initiation, maturity, amount, interest rate, rating, currency denomination, value and type of collateral, type of loan, etc.), information about the *borrower* (e.g., region, industry, legal status, number and scope of relationships, total bank debt, etc.), as well as information on *ex post performance* (e.g., for each month, we know whether a loan has overdue payments and whether it defaults). We complement this dataset with *bank* characteristics (e.g., size, capital ratios, non-performing loans, liquid assets, foreign financing, etc.) from bank balance sheet and income statements.

The richness of the Register allows us to construct several, complementary, measures of bank risk-taking. Within the framework of a fully specified duration model we use the time to default as a dynamic measure of risk that allows us to disentangle the differential effects of monetary policy on *new* and *outstanding* loans. In particular, we analyze the determinants of the hazard rate in each period, i.e., the probability that a loan defaults in period t, conditional on surviving until period t. We define default (the event we wish to model) to occur when the bank downgrades a loan to the default status (a rating of five) and estimate how the stance of monetary policy—at initiation *and* during the "life" of the loan— affects the probability of default in each period.[3] Ceteris paribus, the effect of monetary policy stance at initiation on ex post non-performance is attributed to risk-taking (i.e., the initiation of riskier loans).

[3] Small loans are downgraded to five 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 five when the borrower is considered insolvent (i.e., borrowers' net worth is close to zero).

One concern about using *ex post* performance to estimate *ex ante* risk-taking is that banks did not intend to take these risks but were just caught off guard during difficult times. To address this concern we also use ex ante measures of risk that were directly available to banks when making their loan decisions (e.g., their own internal ratings and the borrowers' credit history) and examine whether the stance of monetary policy affects the probability of initiating new loans to borrowers with a subprime rating and credit history problems.

The next step in our empirical strategy consists in exploiting the cross-sectional implications of recent theory regarding the sensitivity in bank risk-taking to monetary policy according to the strength of banks' balance sheets (Diamond and Rajan (2006)) and moral hazard problems (Rajan (2006)). Hence, we include interactions of the federal funds rates with these bank characteristics and study their impact on risk-taking.

The final step of our empirical investigation is to study loan pricing to further identify whether the observed increases in riskier loans are supply-driven (i.e., it is the banks that are willing to take more risk when the federal funds rate is low). If bad borrowers demand more loans when rates are low,[4] and more loans flow to these subprime borrowers, then loans should exhibit higher hazard rates and spreads should increase (i.e., ceteris paribus, if the demand for risk increases, the price per unit of risk should also increase). 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), the price per unit of risk should drop, and it should drop more for banks with more liquidity and less foreign financing.

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[4] 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)).

III. Model and Variables

A. Duration Model

We analyze the time to default of an individual loan as a measure of its risk.[5] The same methodology is also employed in Jiménez et al. (2008) making the results of the two studies directly comparable. The estimates from this analysis are then used to investigate pricing.

Let T represent the duration of time that passes before the loan defaults. This passage of time is often referred to as a spell. Repayment prevents us from ever observing a default on the loan, right-censoring the spell. We will return to this issue later.

The hazard function, $\lambda(t)$, determines the probability that default will occur at time t, conditional on the spell surviving until time t, and is defined by:

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{P(t \le T < t + \Delta t | T \ge t)}{\Delta t} = \frac{-d \log S(t)}{dt} = \frac{f(t)}{S(t)}, \quad (1)$$

where $f(t)$ is the density function associated with the distribution of spells. The hazard function summarizes the relationship between the length of a spell and the likelihood of switching. The hazard rate provides us effectively with a per-period measure of risk.

When estimating hazard function, it is econometrically convenient to assume a proportional hazard specification, such that:

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[5] As, for example, in McDonald and Van de Gucht (1999). Loans to small firms typically carry a relatively short maturity, often without early repayment possibilities; hence, we choose to ignore early repayment behavior captured in their competing risk model. Cameron and Trivedi (2005), Heckman and Singer (1984b), Kiefer (1988), Kalbfleisch and Prentice (2002) and Greene (2003) provide comprehensive treatments of duration analysis. Shumway (2001), Chava and Jarrow (2004) and Duffie, Saita and Wang (2007) discuss and employ empirical bankruptcy models.

$$\lambda(t, X(t), \beta) = \lim_{\Delta t \to 0} \frac{P(t \le T < t + \Delta t | T \ge t, X(t), \beta)}{\Delta t} = \lambda_0(t) \exp(\beta' X_t), \quad (2)$$

where X_t is a set of observable, possibly time-varying explanatory variables, β is a vector of unknown parameters associated with the explanatory variables, $\lambda_0(t)$ is the baseline hazard function and $\exp(\beta' X_t)$ is chosen because it is non-negative and yields an appealing interpretation for the coefficients. The logarithm of $\lambda(t, X(t), \beta)$ is linear in X_t. Therefore, β reflects the partial impact of each variable *X* on the log of the estimated hazard rate.

The baseline hazard $\lambda_0(t)$ determines the shape of the hazard function with respect to time. The Weibull specification assumes $\lambda_0(t) = \lambda \alpha t^{\alpha-1}$. This baseline hazard allows for duration dependence. When $\alpha > 1$ the distribution exhibits positive duration dependence. To estimate $\lambda_0(t)$ one uses maximum likelihood.

Censoring is a crucial issue to be addressed when estimating a duration model. With no adjustment to account for censoring, maximum likelihood estimation of the proportional hazard models produces biased and inconsistent estimates of model parameters. Accounting for right-censored observations can be accomplished by expressing the log-likelihood function as a weighted average of the sample density of completed duration spells and the survivor function of uncompleted spells (see Kiefer (1988)).[6]

In this context, we also note that relying on the probability of individual loan default, which is assessed in standard probit models, may actually lead to fallacious inferences in case maturity changes. Indeed, the probability of an individual loan default does not uniformly

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[6] Controlling for left-censoring is less straightforward (Heckman and Singer (1984a)); hence, in economic duration analysis is often ignored. However, we start our sample in 1999:03 and study only the new loans granted since then, effectively removing the left censoring problem. As the actual time to repayment is typically very short, around half a year, the reduction in sample size is very small.

correspond to the probability of default in each period (the hazard rate) on which we will rely to gauge bank risk-taking and pricing. We will briefly return to this issue later in the paper.

Apart from analyzing the impact of interest rates prior to loan origination on the time to default, we also analyze the impact of monetary policy on *ex ante* proxies of risk-taking that are based on internal credit scores and lending standards. In particular, we examine whether the probability of initiating loans with subprime ratings or to borrowers with bad credit histories (i.e., prior defaults or non-performing loans) is higher when interest rates are low.

B. Variables

1. Dependent Variable and Timing of the Independent Variables

We study the impact of monetary policy on the time to default or repayment. The mean time to default or repayment is six months, but varies between one and 52 months as reported in Table 1. For expositional purposes we express the coefficients in terms of their impact on the hazard rate. The hazard rate has an intuitive interpretation as the probability of default in period t, conditional on surviving until period t. It is our main proxy for bank risk.

[Insert Table 1 here]

Say a loan l is granted in month τ, where τ indicates calendar time. We denote as T the time to default in case of a downgrade to the default rating or the time to maturity in case of repayment. Hence, either default or repayment occurs in month $\tau+T$. We differentiate between monetary policy conditions present in the month prior to the loan origination, $\tau-1$, and policy conditions prevailing during the life of the loan (i.e., from τ to $\tau+T$). In time-varying duration models all months between τ and $\tau+T-1$ will contribute to the estimation (i.e., the fact that a loan survives until a given period is used when estimating the parameters of the duration model). This information is lost when estimating a probit model. We index these periods with $\tau + t$, $t : 0 \rightarrow T - 1$. Figure 1 clarifies the timing of the variables within the context of a time-varying duration model.

[Insert Figure 1 here]

2. *Monetary Policy Conditions*

We measure monetary policy conditions using the monthly average of the nominal US federal funds rate. Hence, we label the monetary policy measure prior to loan origination as $Federal\ Funds_{\tau-1}$ and the measure over the life of the loan as $Federal\ Funds_{\tau+t}$. The US federal funds rate averaged around 4.25% during the sample period, but varied substantially throughout (see Figure 2). 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 plateau of 6.5% until October 2000, followed by a steep decline during a period of monetary expansion to 1.75% in December 2001. The rate was then cut further to end up at 1% in December 2003. The path of the US federal funds rate is largely disconnected from the growth rate of the gross domestic product in Bolivia (see Figure 2). In fact, the correlation coefficient between these two variables is only -0.27.

[Insert Figure 2 here]

3. *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. Table 1 defines all the variables employed in the empirical specifications and provides their mean, standard deviation, minimum, median and maximum.

Bank characteristics, all taken in the month prior to the loan origination, include the log of total bank assets in millions of US dollar, $Log(Assets)_{\tau-1}$, as a measure of bank size. Better possibilities for diversification or "too big to fail" perceptions (Boyd and Runkle (1993)) for example may entice large banks to initiate riskier loans. The median bank in Bolivia has around 600 million US dollar in assets.

Better access to liquid assets, $(Liquid\ Assets / Assets)_{\tau-1}$, and less financing (and therefore control) from foreigners, $(Foreign\ Funds / Assets)_{\tau-1}$, 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 ten percent.

We also include the leverage ratio, $(Equity / Assets)_{\tau-1}$, and 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 have on risk management. Finally, a backlog of non-performing loans may also temper a bank's appetite for more risk; hence, we also include the ratio of non-performing loans to total loans, $(NPL / Assets)_{\tau-1}$. On average almost eight percent of the loan volume is non-performing, with substantial variation across banks and time.

As *firm characteristics* we include three dummy variables to control for the legal structure of the firm and eighteen industry dummies. Using the information in the Register we also compute a firm's total outstanding bank debt, $Bank\ Debt_{\tau-1}$, 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 (for confidentiality reasons the borrower's identities have been altered). Hence, to control for possible unobserved firm heterogeneity we introduce firm fixed effects in a set of corresponding linear regressions in a sensitivity analysis. We use linear regressions since the estimation of the duration model does not permit the inclusion of firm fixed effects.

As the database contains the universe of Bolivian bank loans we can construct three comprehensive measures of the *bank-firm relationships*. $Multiple\ Banks_{\tau-1}$ equals one if the firm has outstanding loans with more than one bank, and equals zero otherwise; $Main\ Bank_{\tau-1}$ equals one if the value of loans from a bank is at least 50% of the firm's loans, and equals zero otherwise; and, $Scope_{\tau-1}$ equals one 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 zero otherwise. While more than half of the loans are taken by firms that have multiple bank relationships, almost three quarters of these firms borrow at least 50% from one bank.[7] Only 25% of the loans are obtained jointly with additional bank products.

4. *Loan Characteristics*

For *loan characteristics* we include $Amount_{\tau}$, $Interest\ Rate_{\tau}$, $Collateral_{\tau}$, $Maturity_{\tau}$, and $Loan\ Type_{\tau}$. 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%; the average federal funds rate is 4%. Only 27% of loans are collateralized.[8] The median loan maturity is twelve months, while the median time to default or repayment is four months. Defaults and early repayments explain the difference between the loan maturity and the length of a loan spell (i.e., the time between τ and $\tau + T$). To keep our estimated results more easily interpretable, we ignore early repayment behavior captured in competing risk

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[7] 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 (2005) and Ongena, Tümer-Alkan and von Westernhagen (2007) on borrower concentration.

[8] Comparable to the degree of collateralization of small business loans in Belgium (26 %, Degryse and Van Cayseele (2000), but much lower than the degree of collateralization reported in the US Small Business Survey (53%, Berger and Udell (1995)).

models as lenders may have foresight about early repayment. Finally, 71% of the loans in our sample are installment loans, while the remaining 29% of the loans are single-payment loans.

It is crucial to understand the role loan conditions play in our regressions. If banks *ex ante* correctly assess the risk on the individual and adjust loan conditions fully to "price it in", then including these loan conditions should not leave any room for monetary conditions to explain the hazard rate unless changes in monetary conditions directly modify bank risk-appetite.

5. *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 United States and other countries (see, for example, Table 1 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.

We include four variables capturing *macroeconomic conditions*. The growth rate in the real gross domestic product in Bolivia, $\Delta\, GDP\ Bolivia_{\tau-1+t}$, 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%,[9] varying between 0.42 and 3.60%. We further include the US and the Bolivian inflation rates, $Inflation\ US_{\tau-1+t}$ and $Inflation\ Bolivia_{\tau-1+t}$, 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 (2.62%), though with a more than double variation.

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[9] All statistics in Table 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.

Finally, 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, $Country\ Risk_{\tau-1+t}$. This indicator is available on a monthly frequency and encompasses three types of risk: political, financial, and economic. According to the Guide, a value of zero 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.

IV. Results

A. Time-Varying Duration Model

1. Estimated Coefficients

We start with the maximum likelihood estimation of the proportional hazard model using the Weibull distribution as the baseline hazard rate (results for Cox proportional hazard models are very similar and not reported). We report the estimated coefficients, standard errors and significance levels in Table 2. Model I features only the US federal funds rate in the month prior to the loan origination, i.e., the variable $Federal\ Funds_{\tau-1}$. Model II also includes the time-varying changes of the US federal funds rate after loan origination until default or repayment, $Federal\ Funds_{\tau+t}$. This model is our benchmark specification on the basis of which we will make most of our further assessments and calculations.

[Insert Table 2 here]

The coefficients of $Federal\ Funds_{\tau-1}$ in Models I and II are negative, statistically significant, and equal to –0.137** and –0.150*** respectively.[10] The coefficient of the

[10] 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%.

Federal Funds$_{\tau+t}$ in Model II, instead, is positive and significant at the 5% level and equals 0.195**. In Model III we use the monthly changes in the federal funds rate over the lifetime of the loan, Δ *Federal Funds*$_{\tau+t}$, instead of the level. The results, however, are very similar.

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 hazard rate on new loans, *but* a lower hazard rate on outstanding loans. Hence expansionary monetary policy seems to encourage the initiation of riskier loans, but diminishes the hazard rate on outstanding bank loans! This finding is in line with the results in Jiménez et al. (2008) for Spain. In this paper we go a step further and also study the pricing of this risk under different monetary conditions.

Before turning to an economic assessment and a deeper interpretation of the estimated coefficients on the federal funds rate, we briefly review the estimated coefficients on the other (control) variables. Most of these coefficients are fairly stable in magnitude and statistical significance throughout most specifications.

Large banks grant more risky loans, as do banks that have more loans on their books. Banks with stronger balance sheets in terms of liquidity and capital take loans with higher credit risk. Banks with a higher rate of non-performance in their loan portfolio continue to issue more risky loans, though the estimated coefficient is not always statistically significant. Banks with higher foreign financing, $(Foreign\ Funds\,/\,Assets)_{\tau-1}$, not surprisingly take loans with lower credit risk, though the coefficient is not always statistically significant. Larger firms, also not surprisingly, are more likely to repay.

The loan rate, collateral, and maturity are also relevant for the ensuing hazard rate. *Ceteris paribus*, loans with higher loan rates, that require collateral, or have shorter maturities, have a higher hazard rate, suggesting that banks adjust loan conditions when they take on more risk.

The coefficients on $Federal\ Funds_{\tau-1}$, 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 grant loans with a higher hazard rate, possibly because more intense competition lowers lending standards (Keeley (1990)). The inflation in Bolivia lowers the loan hazard rate, while inflation in the US increases it (i.e., given a nominal exchange an increase in the real exchange rate increases the hazard rate). Country risk and the growth rate of real GDP are overall not statistically significant in determining the hazard rate.

2. *Paths of Monetary Policy and Bank Risk-taking*

Before turning to alternative *ex ante* measures of risk, we investigate the economic relevancy of the estimated coefficients on the federal funds variables. We analyze how different "paths of monetary policy" (i.e., different combinations of $Federal\ Funds_{\tau-1}$ and $Federal\ Funds_{\tau+t}$) affect the hazard rate. Employing the coefficients of Model II in Table 2, we calculate an annualized hazard rate for a loan with a twelve months spell,[11] but otherwise mean characteristics, for various different combinations of $Federal\ Funds_{\tau-1}$ and $Federal\ Funds_{\tau+t}$. Figure 3 displays some of these combinations.

[Insert Figure 3 here]

For example, if the federal funds rate is equal to its sample mean throughout the loan's life, the annualized loan hazard rate estimated is 1.84%. In sharp contrast, if the federal funds rate is equal to its sample minimum (1.01%) at origination, but increases to its sample maximum (6.54%) at maturity, the loan hazard rate more than doubles to 4.98%. On the other hand, if

[11] The choice of twelve months matters because the estimated parameter of duration dependence is larger than one. As we annualize the hazard rate, this choice facilitates interpretation and does not qualitatively alter the results.

the "path is reversed" and the funds rate drops from its maximum to its minimum, the hazard rate more than halves to 0.72%. Keeping the funds rate steady at half a percent results in hazard rates similar to the "path connecting the means", 1.63% and 2.50% respectively. Figure 4 plots the convex contour of the estimated hazard rate for all combinations of funds rates between zero and ten percent.

[Insert Figure 4 here]

The estimated effects of the federal funds rate on loan hazard rates are economically relevant and in accordance with recent conjectures (Rajan (2006)). During long periods of low interest rates banks may take on more risk and relax lending standards. These estimates suggest that exposing the "hazardous" cohort of loans, granted when rates were low, to swiftly increasing policy rates dramatically exacerbates their "toxicity". But while suggestive of the impact of changes in monetary policy on the loan hazard rates, the estimates so far are really only calculated for one loan cohort at a time. To obtain a comprehensive assessment of a monetary policy path on the aggregate hazard rate, cohort size and timing needs to be properly accounted for (for example, loans granted during the period of the increase in the federal fund rate will have a lower hazard rate).

3. *Bank Characteristics*

While controlling for an array of factors, the estimates could still result from changes in the demand for credit (though a lower interest rate actually decreases the demand from risky borrowers in Stiglitz and Weiss (1981) for example). Models IV to VII in Table 2 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, i.e., the variables $(Liquid\ Assets / Assets)_{\tau-1}$ and $(Foreign\ Funds / Assets)_{\tau-1}$.

Banks with more access to liquidity, hence banks that are less constrained, may take on more risk and relax standards more when interest rates are low to see the default on their loans increase more when the federal funds rate rises (Myers and Rajan (1998)). Banks with more liquidity can also refinance loans more easily when the federal funds rate is low during the life of the loan thereby decreasing its hazard rate. Banks that borrow heavily from foreign financial institutions are expected to take less risk, either because they are subject to more market discipline or because the reason they have access to foreign markets in the first place is because they are more prudent.

The estimates in Models IV to VII in Table 2 broadly confirm these priors, though not all the coefficients are statistically significant. In unreported specifications we also include interactions with the log of bank assets, the capital ratio and the ratio of non-performing loans over assets. Larger banks and banks with a lower capital ratio or higher ratio of non-performing loans take more risks when the funds rate is lower. We further drop the interactions with the funds rate over the life of the loan in all exercises (as theory is sharper about the implications for the interactions with the federal funds rate prior to origination). Results, however, are unaffected.

4. Ex Ante *Measures of Risk*

One concern about using *ex post* non-performance information to estimate the *ex ante* risk-taking is that the banks never intended to take these risks and were just caught off guard during difficult times. To address this concern we use three *ex ante* measures of riskiness that were all directly available to banks when making their loan decisions. A dummy $Current\ NPL_{\tau-1}$ that equals one if any of the borrower's outstanding loans in the month prior to the loan initiation is non-performing, and equals zero otherwise; A dummy $Past\ Default_{\tau-1}$ that equals one if in the month prior to the loan initiation the borrower has a prior loan default (i.e., if it has ever defaulted on a loan in the past) and equals zero otherwise; And a dummy $Subprime_{\tau}$ that equals one 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). Results are tabulated in Table 3.[12]

[Insert Table 3 here]

We find that lower funds rate prior to loan origination implies that banks give more loans to borrowers with present (Model I) or past defaults (Model II) and to borrowers with subprime credit scores (Model III). We also add the change in the federal funds rate over the life of the loan in these three models, assuming foresight on the part of the banks. The estimated coefficients on this change variable are not statistically nor economically significant, while the coefficients on the federal funds rate prior to loan origination retain their significance (we choose not to report these specifications). Hence, banks do not seem to take into account the expected future developments in the federal funds rate when taking more risk at initiation. Finally, some bank and loan characteristics change their sign as compared to Table 2. For example, banks with more liquid assets now take lower risk.

5. *Firm Fixed (Demand) Effects*

Firm characteristics may capture important changes in loan demand but our models feature too few of them. Introducing firm identity dummies in a time-varying duration model is technically infeasible; hence, we transform the duration model into a simple linear specification. We define the dependent variable to equal the actual time to default, in

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[12] The number of loans employed for the estimation of models I-III varies because the binary dependent variable in the dropped cases is perfectly predicted by bank identity, firm type, industry and/or region or some combination of these variables.

months, or in case of repayment to equal twice the length of the maximum time to repayment during the sample period, which is equal to 96 months.[13]

In Model IV we report specifications featuring the federal funds rate in the month prior to origination, $Federal\ Funds_{\tau-1}$, while in Model V we also include the change in the federal funds rate between maturity and origination, $\Delta\ Federal\ Funds_{\tau+T}$.[14] In Models VI and VII we include interactions of the $Federal\ Funds_{\tau-1}$ and $\Delta\ Federal\ Funds_{\tau+T}$ with bank characteristics variables $(Liquid\ Assets / Assets)_{\tau-1}$ and $(Foreign\ Funds / Assets)_{\tau-1}$. Despite the presence of 1,880 firm fixed effects,[15] the results are virtually unaffected across the board. Except for the interaction between $Federal\ Funds_{\tau-1}$ and $(Liquid\ Assets / Assets)_{\tau-1}$, the estimated coefficients on the two interactions with the liquidity ratio are small compared to the estimated coefficients on the federal funds rate.

Firm fixed effects control for firm specific risk that is constant over the sample period. Consequently, when the federal funds rate is low, banks not just simply start financing risky firms that were excluded otherwise, but also engage in funding riskier projects (i.e., firms that would only have obtained loans for their safer projects when rates were high, are able to obtain financing for their riskier projects when rates are low).

6. Monetary Policy, Loan Maturity and Probability of Loan Default

"Back-of-the-envelop" OLS regressions of maturity on all predetermined variables suggest that maturity substantially shortens as the federal funds rate drops. This shortening of

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[13] This transformation broadly aligns the linear model with a duration model that controls for right censoring and allows for more efficient use of the available information (i.e., the time to default).

[14] In a linear setting the time series correlation between fund rate levels starts to mar the estimations.

[15] Industry and firm type dummies are still included as these dummies are actually loan specific and numerous firms are in multiple industries (in which case loan industry is indicative of its purpose) or switch industry and/or type over the sample period.

maturity over the monetary cycle makes not only controlling for maturity at origination but also the use of duration analysis (with a careful handling of the right censoring problem) imperative. Indeed, the probability of an individual loan default (which one would rely on in probit models) does not uniformly correspond to the period default probability (the hazard rate) on which we relied on so far to gauge bank risk-taking. The probability of individual loan default, which is assessed in standard probit models, may actually lead to fallacious inferences in case maturity changes.

To elucidate this problem further, we combine monthly estimated hazard rates as:

$$\hat{p}(T) = 1 - \hat{S}(T) = 1 - \prod\nolimits_{t=0}^{T} (1 - \hat{\lambda}(t)) \,, \tag{3}$$

where $\hat{p}(T)$ is the estimated probability that the loan of maturity *T* defaults and $\hat{S}(T)$ is the estimated probability that a loan of maturity *T* is repaid. In Figure 5 we specify four representative tracks of monetary policy rates that all finish at the maximum rate and plot the resulting $\hat{p}(T)$.

[Insert Figure 5 here]

Figure 5 illustrates that any decrease in the federal funds rate in the month before loan origination, $Federal\ Funds_{\tau-1}$, will monotonically increase the estimated loan hazard rate, $\hat{\lambda}(t)$ (of which the slopes of the convex curves are a monotonic transformation). However if loan maturity *T* also shortens as a result of the decrease in the federal funds rate before origination, the probability that the loan defaults may actually drop, causing severe difficulties in interpreting results from binary models of loan default.

We conclude that in order to analyze the impact of monetary policy on bank risk-taking a measure of default that is normalized per period (and that accounts for right censoring) is essential as loan maturity may also change. Any *ex post* measure of actual loan default may fail to capture the increase in actual risk-taking. We leave for future research why banks try to offset their risk-taking by shortening loan spells (most likely only partly; in the limit loan spells may drop to zero and no loans may be outstanding).

B. Pricing of Risk

1. Main Result

We now turn to the second main step in our analysis, the investigation of the pricing of risk, to more deeply analyze whether banks, not firms, are the drivers of our findings. Banks may take more risk, but they may also price it and/or adjust other loan conditions. Our results so far suggest that banks do not adjust loan conditions fully, as we include the four key loan conditions (amount, rate, collateral, and maturity) of the individual bank loans at origination in all regressions, but the federal funds rate variables explain loan hazard rates nevertheless.[16] Consequently, banks take more risks, but do not seem to fully adjust loan conditions.

As we cannot know in what combinations these four (but also other secondary) conditions will be adjusted to compensate for the changes in risk, we focus on the loan rate as the most salient loan condition. We want to investigate how loan rates reflect the different components of the hazard rate, in particular we want to check if the component of the hazard rate that is explained by monetary policy and the remaining part of the hazard rate (explained by all the other factors) have similar pricing implications.

For each individual loan we first calculate, using the estimates of Model II in Table 2, a hazard rate at the *median* value of the federal funds rate in the month prior to the loan

[16] 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 for example) this will most likely occur in response to changes in the time to default of the loan.

origination.[17] For expositional purposes, we call this variable the $\textit{Neutral Hazard Rate}_{\tau}$, considering monetary conditions "neutral" if the federal funds rate is equal to its sample median. Next, we calculate the hazard rate at the *actual* value of the funds rate in the month prior to the loan origination, $\textit{Federal Funds}_{\tau-1}$. We label the difference between this hazard rate and the $\textit{Neutral Hazard Rate}_{\tau}$, the $\Delta\,\textit{Neutral Hazard Rate}_{\tau}$. This variable captures changes in the hazard rate caused by deviations in $\textit{Federal Funds}_{\tau-1}$ from its median or "neutral" position. Positive deviations correspond to higher hazard rates that result from expansionary monetary conditions at origination in Model II (Table 2).

The question we try to address is: Is the banks' appetite for risk increasing when funds rates are low such that banks grant loans with higher credit risk without adjusting the loan rates fully? To answer this question we regress the actual loan rate, in percent, on the $\textit{Neutral Hazard Rate}_{\tau}$ and the $\Delta\,\textit{Neutral Hazard Rate}_{\tau}$. We include the monthly average London Interbank Offered Rate, $\textit{LIBOR}_{\tau}$, and a constant to control for interest rate levels. The $\textit{LIBOR}_{\tau}$ 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 twelve months. Hence, we use a sub-sample of 23,412 loans with spells up to one year.[18] The OLS estimates are reported in Table 4.

[Insert Table 4 here]

The coefficient on the constant in Model I in Table 4 suggests that the spread between loan rate and a zero $\textit{LIBOR}_{\tau}$ for the zero-hazard loan equals around 11%. As expected from

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[17] We are interested in having an equal probability of a federal funds rate increase or decrease. Similarly, we set the loan rate equal to its median (to scale the hazard rate as the loan rate will be the dependent variable now). We take the actual values for all other independent variables.

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

previous studies, the loan rate adjusts sluggishly to changes in the $LIBOR_\tau$.[19] More importantly for our purposes, the coefficient on the $Neutral\ Hazard\ Rate_\tau$ indicates that a one percent increase in the hazard rate leads to a 3.7% increase in the loan rate.[20]

If monetary conditions before origination shift from neutral to "expansionary", i.e., if the $Federal\ Funds_{\tau-1}$ decreases from its median so that the $\Delta\ Neutral\ Hazard\ Rate_\tau$ turns positive, the banks will actually charge less on average. The estimated negative coefficient is equal to –4.138*, which is smaller than the estimated positive coefficient of $Neutral\ Hazard\ Rate_\tau$, that equals +3.708***. These differential coefficients suggest that the component of the hazard rate that is explained by monetary policy has no or 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. Hence, banks do not seem to require extra compensation for the risk taken during expansionary monetary times.

2. *Interactions and* Ex Ante *Measures of Risk*

Models II and III include interactions between $\Delta\ Neutral\ Hazard\ Rate_\tau$ and our two bank characteristics, $(Liquid\ Assets\,/\,Assets)_{\tau-1}$ and $(Foreign\ Funds\,/\,Assets)_{\tau-1}$. Banks with more access to liquidity, hence banks that are less constrained, price the increment in the hazard rate less sharply than banks that are constrained. The opposite is true for banks that

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[19] The change in the loan rate due to a basis point change in the $LIBOR_\tau$ equals 0.6*** in Model I. 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, i.e., the interest rate on a government security with equal maturity in Petersen and Rajan (1994) and Degryse and Ongena (2005) is around 0.3*** and 0.5***, respectively.

[20] If the $LIBOR_\tau$ is equal to two percent for example and for neutral monetary conditions, a hazard rate of zero percent results in a loan rate of 12.0%, while a hazard rate of two percent corresponds to a loan rate of 19.4% (i.e., 19.4 – 12.0 = 7.4%).

borrow more from foreign financial institutions, either because these foreign institutions monitor more or because only the more prudent banks are able to borrow abroad.

In unreported specifications, we also include interactions with the log of bank assets, the capital ratio and the ratio of non-performing loans over assets. Larger banks and banks with a lower capital ratio price the increment in the hazard rate less sharply (these banks also take more risk). Banks with a lower ratio of non-performing loans price less sharply, which is somewhat surprising as these banks are also found to be less willing to take on extra risk.

Finally, we study the pricing to borrowers with present (Model IV) or past defaults (Model V) and to borrowers with subprime credit scores (Model VI). In each case we use the models from Table 3, i.e., Models I, II and III, to calculate the part of the probability of engaging the high-risk borrower that is attributable to changes in the federal funds rate. As before, we label this part the $\Delta\, Neutral\ Rate_{\tau}$, and regress the actual loan rate on this variable, the $Neutral\ Rate_{\tau}$ (also similarly defined as before), the $LIBOR_{\tau}$, and a constant. As an additional robustness and to maximize the number of observations (for past defaults) we assign the twelve-month LIBOR to loans with maturity longer than one year.

The pricing of loans to borrowers with present or past defaults again seems to ignore the extra risks taken that are attributable to the changes in the federal funds rate. The estimated coefficient on $\Delta\, Neutral\ Rate_{\tau}$ (i.e., –0.847 and –11.637***) is in both cases smaller than the estimated coefficient on $Neutral\ Rate_{\tau}$ (i.e., 6.592*** and 32.611***). The engagement of subprime borrowers due to funds rate changes, on the other hand, seems almost properly priced: The estimated coefficients on $\Delta\, Neutral\ Rate_{\tau}$ and $Neutral\ Rate_{\tau}$ are almost equal (i.e., 12.470*** and 14.034***). Of course, any ex-ante measure may fail to predict the actual performance of the loans and hence the pricing of the risky loan may still be inadequate (as suggested by Model I).

V. Conclusion

We analyse the impact of monetary policy on bank risk-taking by accessing the credit register of Bolivia from 1999 to 2003. During this period, the Bolivian Peso was pegged to the US dollar and the banking system was almost completely dollarized. In addition, the business cycles of Bolivia and US were not correlated. The US federal funds rate is therefore a proper measure of the so predetermined stance of Bolivian monetary policy.

We find that relaxing monetary conditions increases the risk-appetite of banks. Controlling for bank, firm, relationship, loan, market, macroeconomic and country-risk characteristics, a decrease in the US federal funds rate prior to loan origination raises the hazard rate on the individual bank loans. Observing loans with a subprime credit rating or loans to riskier borrowers with current or past non-performance also becomes more likely when the federal funds rate is low, but banks do not seem to price this additional risk. In pointed contrast, a decrease in the federal funds rate over the life of the loan lowers the hazard rate.

Banks with more liquid assets and fewer funds from foreign financial institutions take more risk when rates are low and seem even less concerned *ex ante* than other banks about the pricing of this additional risk that is being taken.

We are currently working to extend our study in a number of directions. Bank portfolio composition may be important for risk-taking and pricing. Also, bank ownership, in particular public listing, and ownership dispersion may matter for risk-taking incentives and the pricing of the loans. And the effect of monetary policy on risk-taking and pricing may depend on bank liquidity holdings and local banking competition. We leave all these extensions for future work.

TABLE 1. 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. τ is the month the loan was granted. Variables that vary over time have a subscript $\tau+t$. The number of loan – month observations equals 156,808. The number of loan observations equals 27,007. The timing of the variables is similar to the empirical models: τ-*1* is the month prior to the month the loan was granted and *t* is during the life of the loan.

Variables	Definition	Unit	Mean	St.Dev.	Min.	Med.	Max.
Time to Loan Default or Repayment	Time to loan default or repayment	months	6.29	6.10	1	4	52
Monetary Conditions							
Federal Funds$_{\tau-1}$	US federal funds rate in the month prior to loan origination	%	4.28	1.81	1.01	4.81	6.54
Federal Funds$_{\tau+t}$	US federal funds rate during the life of the loan until default of repayment	%	4.03	2.12	1.01	4.99	6.54
Bank Characteristics							
ln(Assets)$_{\tau-1}$	The log of total bank assets	mln. US$	6.27	0.73	2.79	6.43	7.27
(Liquid Assets/Assets)$_{\tau-1}$	Ratio of bank liquid assets over total assets	%	12.61	6.51	1.43	11.06	49.08
(Foreign Funds/Assets)$_{\tau-1}$	Ratio of financing by foreign institutions over total assets	%	10.50	8.11	0	9.05	46.43
(Debt/Assets)$_{\tau-1}$	Ratio of bank debt over total assets	%	10.37	4.33	5.34	9.28	54.22
(Loans/Assets)$_{\tau-1}$	Ratio of bank loans over total assets	%	71.01	6.73	9.91	71.16	86.16
(Non-Performing Loans/Assets)$_{\tau-1}$	Ratio of non-performing bank loans over total assets	%	7.70	4.58	0.60	6.17	41.60

Firm Characteristics							
Bank Borrowing$_{\tau-1}$	Total bank borrowing by the firm	mln. US$	1.85	3.58	0.00	0.47	45.11
Bank - Firm Relationship Characteristics							
Multiple Banks$_{\tau-1}$	= 1 if the firm has outstanding loans with more than one bank; = 0 otherwise	-	0.54	0.50	0	1	1
Main Bank$_{\tau-1}$	= 1 if the value of loans from a bank is at least 50% of the firm's loans; = 0 otherwise	-	0.72	0.45	0	1	1
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	-	0.25	0.43	0	0	1
Loan Characteristics							
Amount$_{\tau}$	Loan amount	mln. US$	0.17	0.49	0.00	0.05	12.21
Rate$_{\tau}$	Loan rate	%	13.96	2.64	0.16	14.5	35
Collateral$_{\tau}$	= 1 if loan is collateralized; = 0 otherwise	-	0.27	0.45	0	0	1
Maturity$_{\tau}$	Loan maturity	months	20.00	22.58	0	11.83	180.43
Type$_{\tau}$	= 1 if loan is an installement loan; = 0 otherwise	-	0.71	0.45	0	1	1
Banking Market Characteristics							
Herfindahl Hirschman 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
Macro Conditions							
Δ GDP Bolivia$_{\tau-1}$	Growth in the gross domestic product in Bolivia	%	1.87	0.80	0.42	2.04	3.60
Inflation US$_{\tau-1}$	Monthly change in the US consumer price index	%	2.62	0.74	1.07	2.65	3.70
Inflation Bolivia$_{\tau-1}$	Monthly change in the Bolivian consumer price index	%	2.72	1.66	-1.23	2.71	6.42
ICRG Country Risk 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

TABLE 2. TIME-VARYING DURATION 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. The definition of the variables can be found in Table 1. The number of loan – month observations equals 156,808. The number of loan observations equals 27,007. Subscripts indicate the time of measurement of each variable. τ 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 column and the standard errors are reported between brackets in the second column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Independent Variables	I	II	III	IV	V	VI	VII
Monetary Conditions							
Federal Funds$_{\tau-1}$	-0.137 [0.056] **	-0.150 [0.057] ***	-0.133 [0.057] **	0.127 [0.124]	-0.212 [0.073] ***	0.017 [0.124]	-0.256 [0.069] ***
Federal Funds$_{\tau+t}$		0.195 [0.092] **		0.066 [0.106]	0.151 [0.120]		
Δ Federal Funds$_{\tau+t}$			1.056 [0.417] **			-0.273 [0.699]	0.415 [0.693]
Monetary Conditions and Bank Characteristics							
Federal Funds$_{\tau-1}$ * (Liquid Assets/Assets)$_{\tau-1}$				-0.018 [0.007] **		-0.009 [0.007]	
Federal Funds$_{\tau-1}$ * (Foreign Funds/Assets)$_{\tau-1}$					0.017 [0.008] **		0.021 [0.008] ***
Federal Funds$_{\tau+t}$ * (Liquid Assets/Assets)$_{\tau-1}$				0.013 [0.005] ***			
Federal Funds$_{\tau+t}$ * (Foreign Funds/Assets)$_{\tau-1}$					0.005 [0.004]		
Δ Federal Funds$_{\tau+t}$ * (Liquid Assets/Assets)$_{\tau-1}$						0.105 [0.053] **	
Δ Federal Funds$_{\tau+t}$ * (Foreign Funds/Assets)$_{\tau-1}$							0.053 [0.042]
Bank Characteristics							
ln(Assets)$_{\tau-1}$	2.861 [0.604] ***	2.897 [0.606] ***	2.872 [0.605] ***	2.985 [0.623] ***	3.033 [0.591] ***	3.058 [0.611] ***	3.058 [0.587] ***
(Liquid Assets/Assets)$_{\tau-1}$	0.050 [0.025] **	0.047 [0.025] *	0.049 [0.025] *	0.090 [0.035] **	0.048 [0.025] *	0.094 [0.035] ***	0.054 [0.025] **
Foreign Funds/Assets)$_{\tau-1}$	0.013 [0.010]	0.007 [0.011]	0.009 [0.010]	-0.002 [0.012]	-0.084 [0.034] **	0.001 [0.012]	-0.079 [0.035] **
(Debt/Assets)$_{\tau-1}$	0.158 [0.035] ***	0.163 [0.036] ***	0.159 [0.035] ***	0.142 [0.036] ***	0.176 [0.031] ***	0.135 [0.035] ***	0.170 [0.031] ***
(Loans/Assets)$_{\tau-1}$	0.082 [0.027] ***	0.073 [0.027] ***	0.076 [0.027] ***	0.089 [0.028] ***	0.076 [0.028] ***	0.082 [0.027] ***	0.086 [0.028] ***
(Non-Performing Loans/Assets)$_{\tau-1}$	0.025 [0.022]	0.040 [0.023] *	0.035 [0.022]	0.066 [0.028] **	0.076 [0.028] ***	0.060 [0.026] **	0.067 [0.027] **
Individual Bank (17) Dummies	Included	Included	Included	Included	Included	Included	Included

Firm Characteristics							
Bank Borrowing$_{\tau-1}$	-0.186 [0.054] ***	-0.183 [0.054] ***	-0.186 [0.054] ***	-0.189 [0.054] ***	-0.185 [0.054] ***	-0.187 [0.054] ***	-0.190 [0.054] ***
Type (3) and Industry (18) Dummies	Included	Included	Included	Included	Included	Included	Included
Bank - Firm Relationship Characteristics							
Multiple Banks$_{\tau-1}$	0.039 [0.158]	0.030 [0.157]	0.037 [0.158]	0.024 [0.155]	0.041 [0.156]	0.026 [0.156]	0.050 [0.157]
Main Bank$_{\tau-1}$	-0.291 [0.179]	-0.279 [0.179]	-0.293 [0.179]	-0.266 [0.179]	-0.242 [0.180]	-0.282 [0.178]	-0.258 [0.180]
Scope$_{\tau-1}$	0.451 [0.129] ***	0.453 [0.129] ***	0.451 [0.129] ***	0.475 [0.128] ***	0.457 [0.129] ***	0.466 [0.129] ***	0.447 [0.129] ***
Loan Characteristics							
Amount$_{\tau}$	0.279 [0.179]	0.257 [0.184]	0.269 [0.182]	0.284 [0.169] *	0.281 [0.177]	0.272 [0.174]	0.296 [0.172] *
Rate$_{\tau}$	0.332 [0.035] ***	0.332 [0.035] ***	0.333 [0.035] ***	0.327 [0.036] ***	0.338 [0.036] ***	0.333 [0.035] ***	0.336 [0.036] ***
Collateral$_{\tau}$	0.763 [0.165] ***	0.774 [0.163] ***	0.763 [0.164] ***	0.792 [0.165] ***	0.759 [0.166] ***	0.780 [0.165] ***	0.754 [0.166] ***
Maturity$_{\tau}$	-0.058 [0.008] ***	-0.057 [0.009] ***	-0.058 [0.008] ***	-0.058 [0.009] ***	-0.057 [0.009] ***	-0.058 [0.008] ***	-0.057 [0.008] ***
Type$_{\tau}$	-0.038 [0.177]	-0.085 [0.180]	-0.054 [0.179]	-0.090 [0.181]	-0.097 [0.181]	-0.069 [0.177]	-0.050 [0.179]
Banking Market Characteristics							
Herfindahl Hirschman Index$_{\tau-1}$	-6.999 [2.376] ***	-7.183 [2.350] ***	-6.883 [2.346] ***	-7.082 [2.382] ***	-7.207 [2.332] ***	-6.694 [2.348] ***	-6.895 [2.331] ***
Region (12) Dummies	Included	Included	Included	Included	Included	Included	Included
Macro Conditions							
Δ GDP Bolivia$_{\tau-1+t}$	0.247 [0.140] *	0.194 [0.147]	0.332 [0.147] **	0.157 [0.151]	0.165 [0.149]	0.314 [0.149] **	0.321 [0.149] **
Inflation US$_{\tau-1+t}$	0.358 [0.186] *	0.393 [0.188] **	0.441 [0.187] **	0.357 [0.191] *	0.374 [0.189] **	0.434 [0.189] **	0.427 [0.188] **
Inflation Bolivia$_{\tau-1+t}$	-0.224 [0.055] ***	-0.304 [0.064] ***	-0.300 [0.066] ***	-0.307 [0.065] ***	-0.315 [0.065] ***	-0.291 [0.067] ***	-0.302 [0.066] ***
ICRG Country Risk Measure$_{\tau-1+t}$	0.148 [0.089] *	0.121 [0.093]	0.228 [0.101] **	0.089 [0.096]	0.111 [0.095]	0.204 [0.102] **	0.234 [0.102] **
Month (11) and Deposit Insurance Dummies	Included	Included	Included	Included	Included	Included	Included
Constant	-47.03 [7.327] ***	-45.62 [7.477] ***	-52.35 [8.250] ***	-46.06 [7.685] ***	-46.21 [7.354] ***	-53.07 [8.302] ***	-54.74 [8.203] ***

TABLE 3. LINEAR REGRESSION MODELS

The estimates this table lists are based on probit (Models I to IV) and OLS (Models V to VIII) estimations. The dependent variables are: A dummy *Current* $NPL_{\tau-1}$ that equals one if any of the borrower's outstanding loans in the month prior to the loan initiation is non-performing, and equals zero otherwise; A dummy *Past* $Default_{\tau-1}$ that equals one if in the month prior to the loan initiation the borrower has a prior loan default (i.e., if it has ever defaulted on a loan in the past) and equals zero otherwise; And a dummy $Subprime_{\tau}$ that equals one 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). *Time to* $Default_{\tau}$ equals the actual time to default or in case of repayment set equal to 96, in months. The definition of the other variables can be found in Table 1. The number of loan observations is indicated in the Table. Subscripts indicate the time of measurement of each variable. τ is the month the loan is granted. $\tau+T$ is the month the loan is repaid or defaults. Coefficients are listed in the first column and the standard errors are reported between brackets in the second column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Independent Variables	I	II	III	IV	V	VI	VII
Model	Probit	Probit	Probit	OLS	OLS	OLS	OLS
Dependent Variable	Current NPL	Past Default	Subprime	Time to Default	Time to Default	Time to Default	Time to Default
Monetary Conditions							
Federal Funds$_{\tau-1}$	-0.092 [0.025] ***	-0.145 [0.064] **	-0.059 [0.030] **	0.204 [0.107] *	0.341 [0.107] ***	0.850 [0.154] ***	0.501 [0.110] ***
Δ Federal Funds$_{\tau+T}$					-1.101 [0.126] ***	-1.471 [0.244] ***	-0.283 [0.187]
Monetary Conditions and Bank Characteristics							
Federal Funds$_{\tau-1}$ * (Liquid Assets/Assets)$_{\tau-1}$						-0.037 [0.006] ***	
Federal Funds$_{\tau-1}$ * (Foreign Funds/Assets)$_{\tau-1}$							-0.038 [0.007] ***
Δ Federal Funds$_{\tau+T}$ * (Liquid Assets/Assets)$_{\tau-1}$						0.031 [0.017] *	
Δ Federal Funds$_{\tau+T}$ * (Foreign Funds/Assets)$_{\tau-1}$							-0.075 [0.017] ***
Bank Characteristics							
ln(Assets)$_{\tau-1}$	0.508 [0.195] ***	-0.522 [0.915]	0.031 [0.175]	1.350 [0.722] *	1.563 [0.716] **	2.822 [0.779] ***	0.499 [0.732]
(Liquid Assets/Assets)$_{\tau-1}$	-0.013 [0.006] **	-0.046 [0.021] **	-0.002 [0.008]	0.008 [0.019]	-0.012 [0.019]	0.101 [0.030] ***	0.012 [0.019]
Foreign Funds/Assets)$_{\tau-1}$	0.019 [0.004] ***	0.003 [0.021]	-0.004 [0.005]	-0.108 [0.025] ***	-0.160 [0.025] ***	-0.181 [0.027] ***	0.089 [0.046] *
(Debt/Assets)$_{\tau-1}$	0.037 [0.010] ***	0.026 [0.056]	-0.011 [0.011]	-0.072 [0.045]	-0.118 [0.044] ***	-0.141 [0.044] ***	-0.132 [0.044] ***
(Loans/Assets)$_{\tau-1}$	0.015 [0.006] ***	0.006 [0.021]	0.002 [0.010]	-0.056 [0.022] ***	-0.101 [0.021] ***	-0.097 [0.021] ***	-0.097 [0.020] ***
(Non-Performing Loans/Assets)$_{\tau-1}$	-0.001 [0.008]	0.004 [0.036]	0.037 [0.008] ***	-0.346 [0.036] ***	-0.273 [0.036] ***	-0.221 [0.036] ***	-0.346 [0.038] ***
Individual Bank (17) Dummies	Included	Included	Included	Included	Included	Included	Included

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firm Characteristics							
Bank Borrowing$_{\tau-1}$	0.008 [0.004] **	-0.165 [0.038] ***	-0.005 [0.005]	0.103 [0.029] ***	0.096 [0.029] ***	0.095 [0.029] ***	0.095 [0.029] ***
Type (3) and Industry (18) Dummies	Included	Included	Included	Included	Included	Included	Included
Firm Fixed Effects				Included	Included	Included	Included
Bank - Firm Relationship Characteristics							
Multiple Banks$_{\tau-1}$	0.785 [0.042] ***	-0.353 [0.165] **	-0.002 [0.047]	0.409 [0.240] *	0.339 [0.241]	0.347 [0.241]	0.324 [0.241]
Main Bank$_{\tau-1}$	-0.250 [0.034] ***	-0.578 [0.176] ***	-0.255 [0.048] ***	0.524 [0.181] ***	0.450 [0.181] **	0.473 [0.181] ***	0.390 [0.180] **
Scope$_{\tau-1}$	0.474 [0.030] ***	0.216 [0.098] **	0.198 [0.037] ***	-0.533 [0.185] ***	-0.556 [0.184] ***	-0.547 [0.184] ***	-0.508 [0.184] ***
Loan Characteristics							
Amount$_{\tau}$	0.003 [0.039]	0.313 [0.063] ***	0.185 [0.028] ***	0.028 [0.142]	0.004 [0.142]	0.028 [0.144]	0.040 [0.144]
Rate$_{\tau}$	0.178 [0.010] ***	0.115 [0.021] ***	0.206 [0.012] ***	-0.573 [0.056] ***	-0.561 [0.056] ***	-0.548 [0.056] ***	-0.569 [0.056] ***
Collateral$_{\tau}$	0.216 [0.037] ***	0.331 [0.126] ***	0.136 [0.044] ***	-1.178 [0.222] ***	-1.116 [0.221] ***	-1.094 [0.220] ***	-1.101 [0.219] ***
Maturity$_{\tau}$	0.004 [0.001] ***	0.006 [0.002] ***	0.010 [0.001] ***	0.003 [0.007]	0.016 [0.007] **	0.015 [0.007] **	0.015 [0.007] **
Type$_{\tau}$	-0.138 [0.032] ***	-0.041 [0.094]	-0.187 [0.040] ***	-0.854 [0.177] ***	-0.770 [0.175] ***	-0.779 [0.175] ***	-0.858 [0.176] ***
Banking Market Characteristics							
Herfindahl Hirschman Index$_{\tau-1}$	-3.950 [0.538] ***	-3.777 [1.988] *	-7.052 [0.858] ***	9.370 [2.533] ***	8.781 [2.515] ***	8.825 [2.502] ***	9.275 [2.508] ***
Region (12) Dummies	Included	Included	Included	Included	Included	Included	Included
Macro Conditions							
Δ GDP Bolivia$_{\tau-1}$	0.033 [0.020] *	-0.162 [0.072] **	-0.059 [0.027] **	0.217 [0.079] ***	0.403 [0.083] ***	0.423 [0.083] ***	0.371 [0.083] ***
Inflation US$_{\tau-1}$	-0.042 [0.039]	-0.021 [0.111]	0.119 [0.046] ***	-1.356 [0.166] ***	-0.970 [0.168] ***	-0.964 [0.168] ***	-0.667 [0.167] ***
Inflation Bolivia$_{\tau-1}$	0.034 [0.021]	0.070 [0.059]	0.008 [0.022]	0.172 [0.070] **	0.164 [0.070] **	0.115 [0.071]	0.204 [0.071] ***
ICRG Country Risk Measure$_{\tau-1}$	-0.067 [0.019] ***	-0.032 [0.059]	0.019 [0.023]	-0.122 [0.073] *	0.047 [0.074]	0.086 [0.074]	0.075 [0.073]
Month (11) and Deposit Insurance Dummies	Included	Included	Included	Included	Included	Included	Included
Constant	-4.02 [1.971] **	3.68 [8.036]	-5.68 [2.178] ***	107.42 [8.105] ***	96.18 [8.143] ***	83.06 [8.489] ***	99.44 [8.191] ***
Number of Loan Observations	29,831	17,871	29,368	29,900	29,900	29,900	29,900

TABLE 4. PRICING OF RISK-TAKING

The estimates this table lists are based on OLS estimation. The dependent variable is the actual loan rate, in percent. The *Neutral Hazard Rate*$_\tau$ used in models I to III is calculated on the basis of the coefficient estimates of Model II in Table 2 at the *median* value of the federal funds rate in the month prior to origination (as the loan rate is the dependent variable we set it equal to its median value as well); all other independent variables are set equal to their actual values. The Δ *Neutral Hazard Rate*$_\tau$ used in Models I to III is the difference between the hazard rate at the *actual* value of the federal funds rate in the month prior to origination and the *Neutral Hazard Rate*$_\tau$. The *Neutral Rate*$_\tau$ and Δ *Neutral Rate*$_\tau$ used in Models IV to VI, are similarly calculated on the basis of the coefficient estimates of Models I to III in Table 3. The $LIBOR_{l,\tau}$ is the average monthly London Interbank Offered Rate in US dollars and matched in maturity to the bank loan (loans with a maturity longer than one year are matched to the one year LIBOR). The definition of the other variables can be found in Table 1. The number of observations equals 23,412 (as loans with a maturity longer than one year are dropped), 28,699, 17,434 and 28,234, respectively. Subscripts indicate the time of measurement of each variable. τ is the month the loan was granted. Coefficients are listed in the first column and the standard errors are reported between brackets in the second column. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Independent Variables	**I**	**II**	**III**
Neutral Hazard Rate$_\tau$	3.708 [1.635] **	3.138 [1.551] **	3.691 [1.638] **
Δ Neutral Hazard Rate$_\tau$	-4.138 [2.193] *	17.785 [4.014] ***	-5.962 [2.300] ***
Δ Neutral Hazard Rate$_\tau$ * (Liquid Assets/Assets)$_{\tau-1}$		-0.691 [0.103] ***	
Δ Neutral Hazard Rate$_\tau$ * (Foreign Funds/Assets)$_{\tau-1}$			0.322 [0.126] **
LIBOR$_\tau$	0.624 [0.009] ***	0.646 [0.009] ***	0.624 [0.009] ***
Constant	10.785 [0.043] ***	10.675 [0.046] ***	10.789 [0.043] ***
Number of Loan Observations	23,412	23,412	23,412

Independent Variables	**IV**	**V**	**VI**
Rate	*Current NPL*	*Past Default*	*Subprime*
Neutral *Rate*$_\tau$	6.592 [0.114] ***	32.611 [1.163] ***	14.034 [0.213] ***
Δ Neutral *Rate*$_\tau$	-0.847 [1.543]	-11.637 [1.793] ***	12.470 [2.690] ***
LIBOR$_\tau$	0.483 [0.059] ***	0.170 [0.073] **	0.904 [0.056] ***
Constant	10.965 [0.768] ***	16.357 [0.890] ***	3.874 [1.349] ***
Number of Loan Observations	28,699	17,434	28,248

FIGURE 1. THE TIMING OF THE MONETARY POLICY VARIABLES IN THE TIME-VARYING DURATION ANALYSIS

The figure clarifies the timing of the monetary policy variables within the context of the time-varying duration analysis.

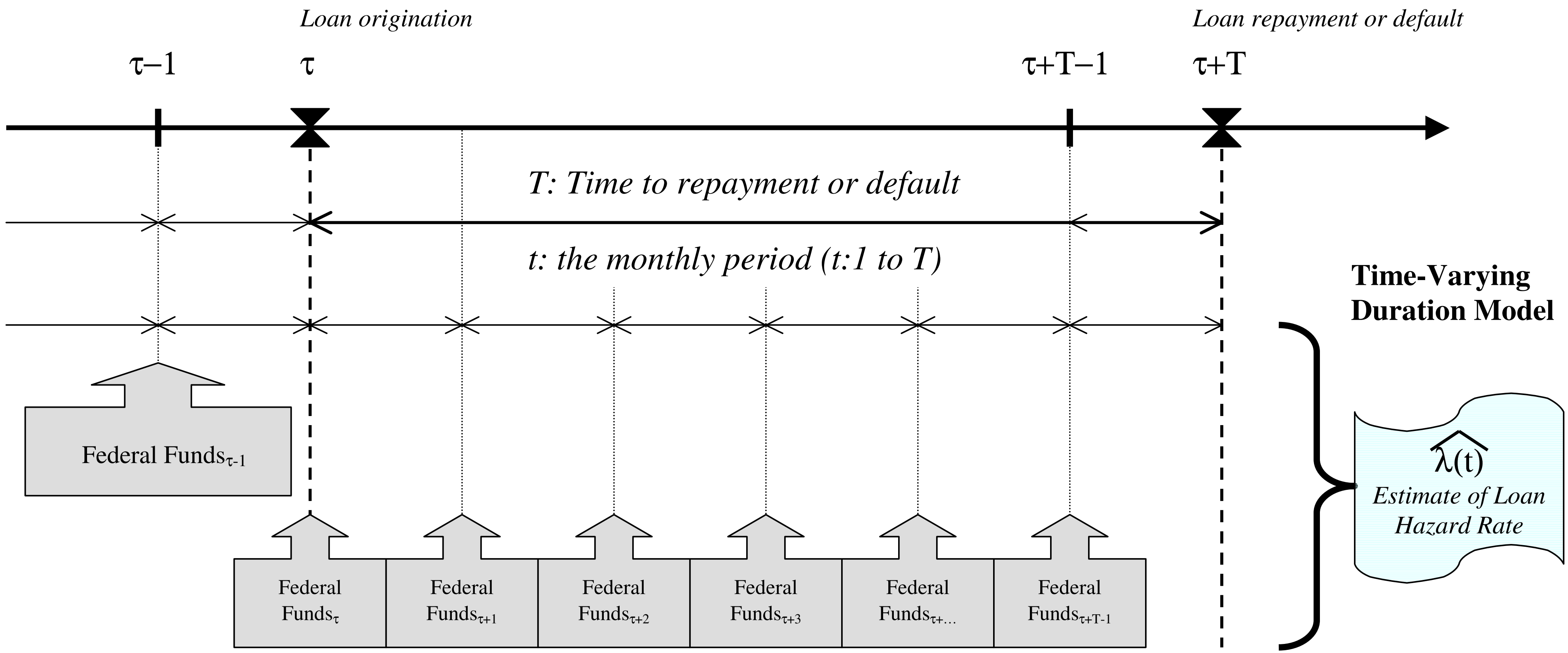


FIGURE 2. THE US FEDERAL FUNDS RATE, THE GROWTH IN BOLIVIAN GROSS DOMESTIC PRODUCT AND THE US INFLATION RATE

The figure displays monthly values of the US federal funds rate, the growth in Bolivian gross domestic product and the US inflation rate.

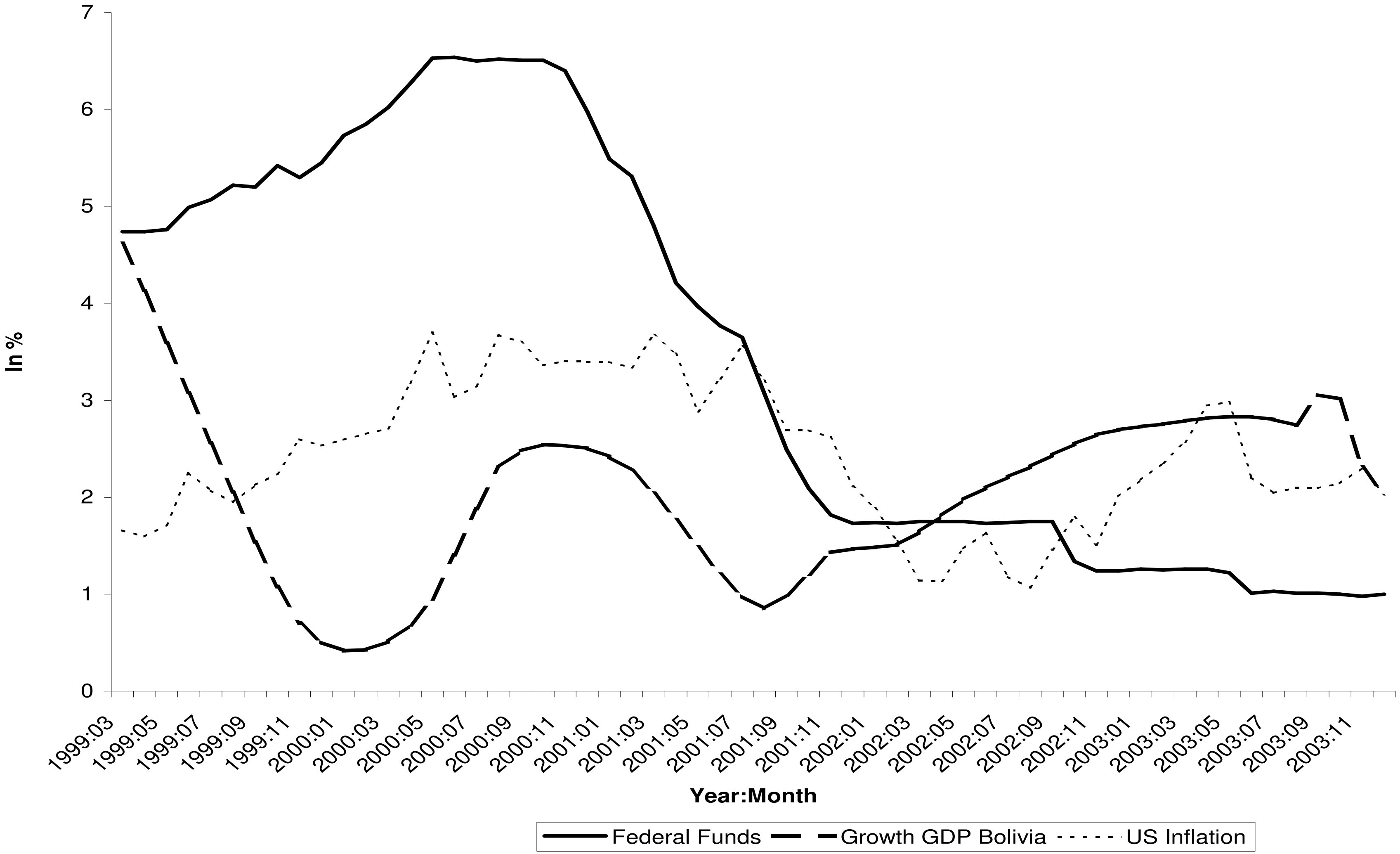


FIGURE 3. MONETARY POLICY PATHS AND LOAN HAZARD RATE

The figure displays various paths for the Federal Funds rate (in%) and the resulting annualized Loan Hazard Rate (in%) calculated for a loan with a maturity of twelve months but otherwise mean characteristics, based on the coefficients of Model II in Table 2.

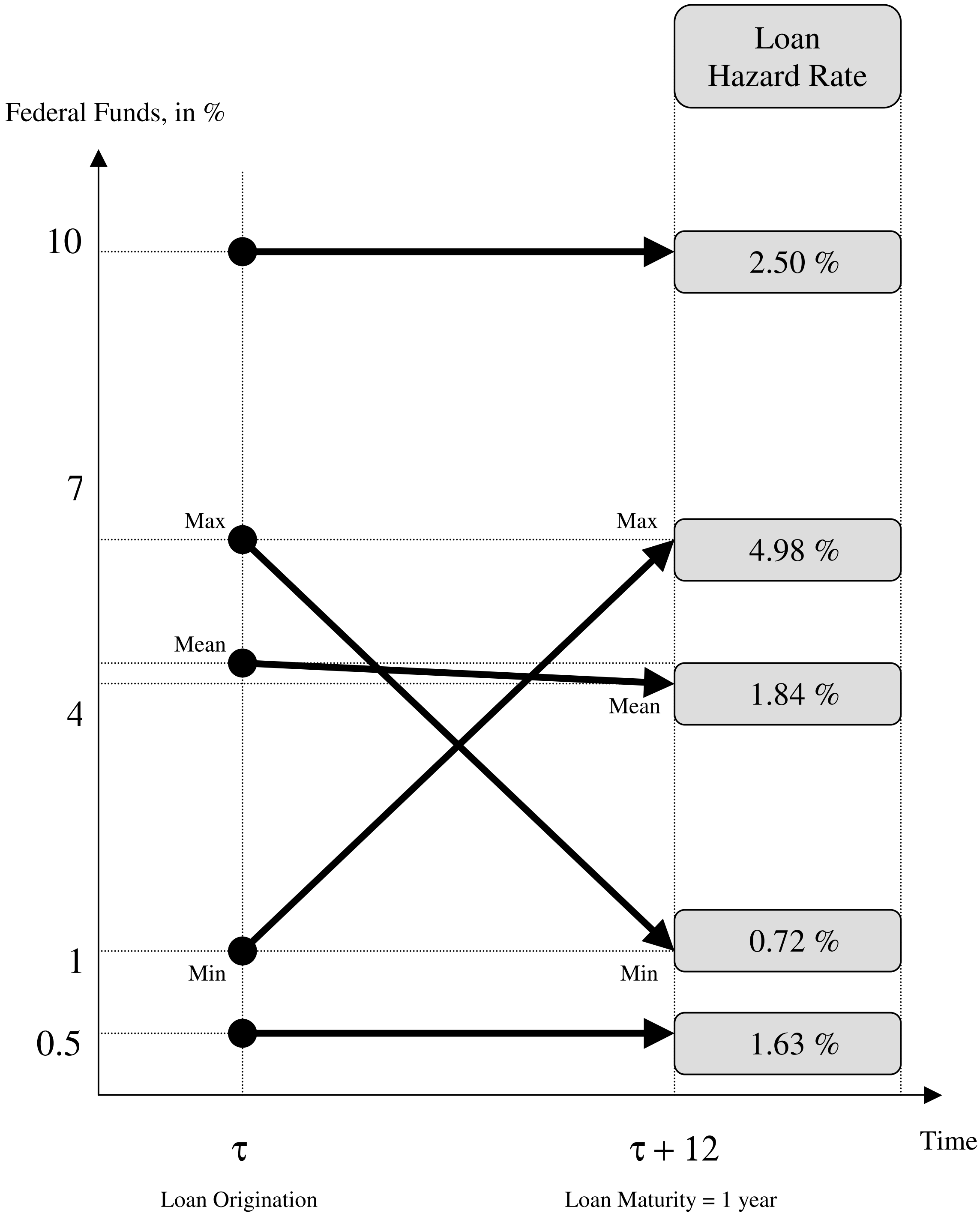


FIGURE 4. FEDERAL FUNDS RATES BEFORE LOAN ORIGINATION AND UNTIL MATURITY (ONE YEAR) AND THE LOAN HAZARD RATE

The figure displays the $\textit{Federal Funds}_{\tau-1}$, in the month before the loan origination date τ-1, on the left horizontal axis, the $\textit{Federal Funds}_{\tau+t}$, until maturity $\tau + t$, on the right horizontal axis, and the resulting annualized loan Hazard rate calculated for a loan with a maturity of twelve months but otherwise mean characteristics on the vertical axis. All variables are displayed in percent.

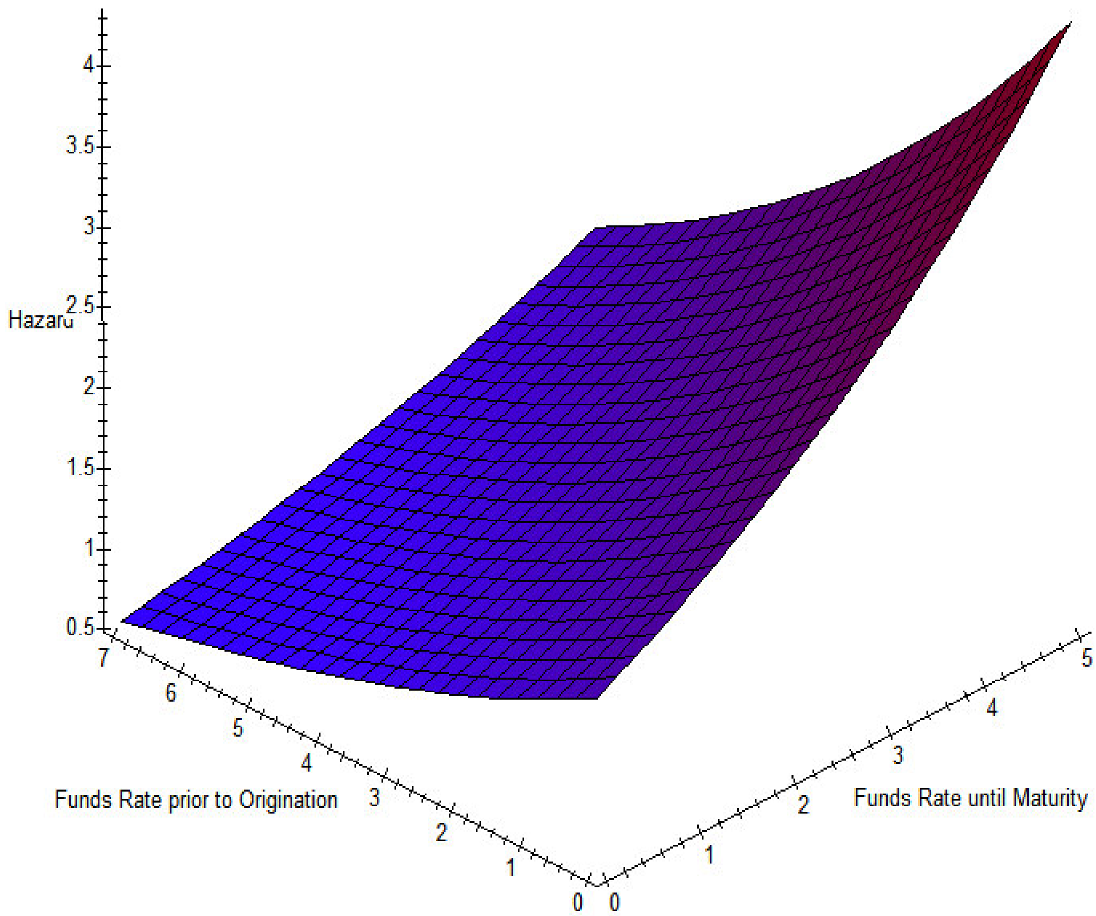
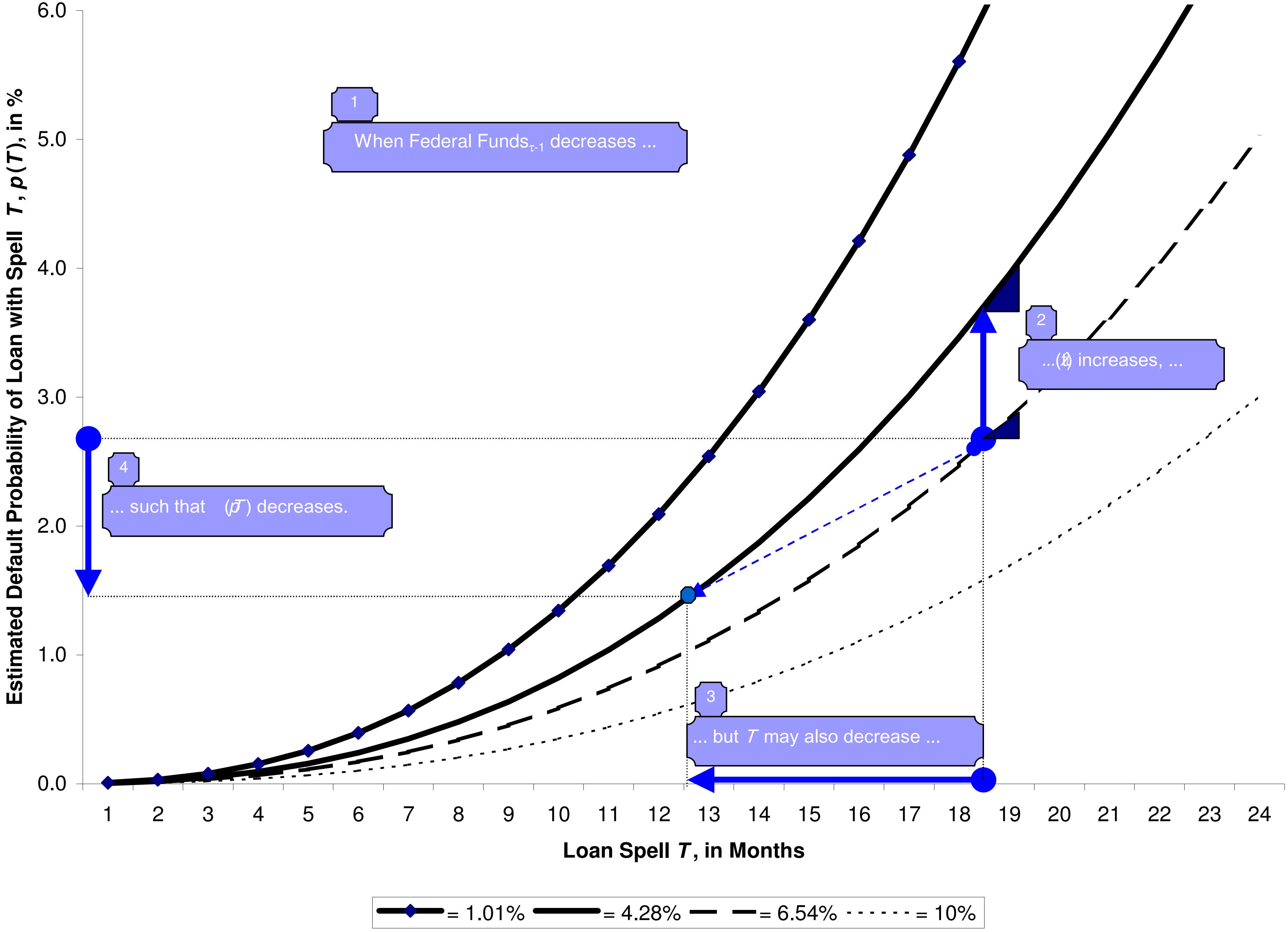


FIGURE 5. THE FEDERAL FUNDS RATE AT LOAN ORIGINATION, MATURITY AND INTEGRATED HAZARD RATE

The figure displays the estimated probability $\hat{p}(T)$ that a loan of maturity T defaults, with $\hat{p}(T) = 1 - \hat{S}(T) = 1 - \prod_{t=0}^{T}(1 - \hat{\lambda}(t))$. The estimated loan hazard rate $\hat{\lambda}(t)$, with t: 0 to T, is calculated for each individual loan on the basis of the coefficient estimates in Model II of Table 2 and the mean values of all independent variables, with the exception of the $\textit{Federal Funds}_{\tau-1}$, which equals 1.01% (minimum), 4.28% (mean), 6.54% (maximum) and 10%, respectively, and the $\textit{Federal Funds}_{\tau+T-1}$ which in all four cases equals 6.54% (maximum). **(1)** A decrease in the Federal Funds rate in the month before the origination of the loan will **(2)** monotonically increase the loan hazard rate $\hat{\lambda}(t)$. **(3)** If loan maturity T shortens however, as a result of the decrease in the federal funds rate, **(4)** the probability that a loan defaults can also decrease, causing difficulties interpreting the results from binary models of loan default.



Estimated Default Probability of Loan with Spell T, p(T), in %
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
When Federal Funds$_{\tau-1}$ decreases ...
2
...(t) increases, ...
3
... but T may also decrease ...
4
... such that (pT) decreases.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Loan Spell T, in Months
= 1.01%
= 4.28%
= 6.54%
= 10%

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