

Monetary Policy and Subprime Lending:

“A Tall Tale of Low Federal Funds Rates, Hazardous Loans, and Reduced Loan Spreads”

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Abstract

We study the impact of monetary policy on bank risk-taking and pricing. Bolivia provides us with an excellent setting for econometric identification, with the US federal funds being an appropriate measure of monetary policy between 1999 and 2003. We study several loan specific measures of bank risk-taking that are available in the comprehensive local credit register: ex-post loan performance and time to default, internal credit ratings at origination, loan rates, and other ex-ante loan characteristics such as loan maturity and collateral.

We find that a decrease in the US federal funds rate prior to loan origination raises the monthly probability of default on individual bank loans. In pointed contrast, a decrease in the federal funds rate over the life of the loan lowers the probability of default. Initiating loans with a subprime credit rating or loans to riskier borrowers with current or past non-performance also become more likely when the federal funds rate is low.

However, the loan spreads do not increase in the changes in the monthly probability of default (spreads may actually decrease in this probability), hence banks do not seem to price the additional risk taken. Banks with more liquid assets and less funds from foreign financial institutions take more risk when the federal funds rate is lower and but these banks seem even less concerned than other banks about pricing this additional risk. All in all these results suggests monetary policy affects bank risk taking.

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

JEL: E44, G21, L14.

“The subprime and LBO booms required willing lenders. Low interest rates of 2001 to 2004 nurtured a class of investors and products to fill that role (...). Many borrowers got loans they wouldn't otherwise have had.”

“How credit got so easy and why is tightening”, Front Page, *The Wall Street Journal*, August 7th, 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 – an undesirable consequence at a moment when risk is being repriced many years of lax lending.”

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

I. Introduction

Increasing defaults on subprime mortgages in August 2007 led to an unprecedented virtual shutdown of interbank credit markets and a series of dramatic interventions by all major central banks. Many market observers immediately argued that during the long period of low interest rates that preceded this hot summer, banks softened their lending standards and took on extra risk. But while the effect of monetary policy on *credit volume* has been widely studied (Bernanke and Blinder (1992), Bernanke and Gertler (1995), Kashyap and Stein (2000)), we simply lack empirical evidence corroborating these claims.

The scarcity of disaggregate loan data combined with the difficulties in identifying the exogenous changes in monetary policy (i.e., changes in monetary policy are usually a response to changes in local economic activity) explain this gap in the literature. This paper contributes to our understanding by studying the impact of monetary policy on *bank risk-taking* using individual loan data in a setting where monetary policy is virtually exogenous. The unique availability of several, complementary measures of risk coupled with reliable information on loan pricing allows us to eliminate alternative, demand-driven, hypotheses.

The theoretical literature has already highlighted a number of reasons why lax monetary conditions might increase bank risk-taking. A recent contribution by Matsuyama (2007) for example models the impact of borrowers' net worth on the composition of credit. Low

interest rates increase borrowers' net worth thereby reducing agency costs and thus making financiers more willing to lend to riskier borrowers with less access to pledgeable assets. Low borrowers' net worth, on the other hand, may impel financiers to flee to quality (Bernanke, Gertler and Gilchrist (1996)). Low interest rates may also ameliorate adverse selection problems in the credit markets, causing banks to relax their lending standards and increase their risk-taking (Dell'Ariccia and Marquez (2006)). In general, low interest rates make riskless assets less attractive for financial institutions increasing their demand for riskier assets with higher expected returns. (Rajan (2006)).

To analyse the impact of monetary policy on risk-taking we access the credit register of Bolivia from 1999 to 2003. During this period the boliviano was pegged to the US dollar and the financial system was highly 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 study only US dollar denominated loans.

The credit register contains detailed contract information on all bank loans granted in Bolivia. We study several loan-specific measures of bank risk-taking: ex-post loan performance and time to default, internal credit ratings at origination, and other loan characteristics such as loan rate, maturity, and collateral.

We find that relaxing monetary conditions wets 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 probability of default (hazard rate) of the individual bank loans. Initiating loans with a subprime credit rating or loans to riskier borrowers with current or past non-performance also becomes more likely when the funds rate is low. Moreover, banks do not seem to price this additional risk

adequately suggesting changes in credit supply (and not demand) are identified. In pointed contrast, a decrease in the federal funds rate over the life of the loan lowers the hazard rate. Consequently, the “toxicity” of the “hazardous” cohort of loans, granted when rates were *low*, will be exacerbated by swiftly *increasing* policy rates.

Banks with more liquid assets and less funds from foreign financial institutions (who may monitor better) 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. Both findings provide further confidence our empirical testing strategy identifies supply not demand side effects.

To the best of our knowledge Jiménez, Ongena, Peydró and Saurina (2007) and this paper are the first to investigate the impact of monetary policy on risk-taking. Using the Spanish credit register, Jiménez et al. (2007) analyse the dynamic implications of monetary policy and GDP growth for bank credit risk over a long time period in a larger and more developed financial market. This paper first shows that the baseline results in Jiménez et al. (2007) also hold in the Bolivian credit market — if anything an even more appropriate Mundell-Fleming type of economy. The paper then takes overall identification a number of important steps further by exploiting better measures of *ex ante* risk-taking and loan pricing information.

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 the impact of monetary policy on the banks’ appetite for risk – ideally –we would like to have: (i) changes in short-term interest rates that are not driven by local economic conditions; (ii) all (actual and potential) bank loan applications and actual

loans with very detailed information on each of them. 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 boliviano 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 implies that the federal funds rate is the proper measure of short-term interest rates in Bolivia.¹

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 (2007). We have access to information from 1998 to 2003. For each loan we have detailed *contract* information (e.g., date on 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 had a downgrade to default status). We complement this dataset with *bank* characteristics (e.g., capital ratios, non-performing loans, liquid assets, size, etc.) from bank balance sheet and income statements.

The richness of the Register allows us to construct several, complementary, measures of bank-risk taking. Since theory (e.g. Matsuyama (2007) and Dell'Ariccia and Marquez (2006)) shows that monetary policy affects risk taking and lending standards and, therefore also maturity, we construct a measure of loan default that is normalized per unit of period (hazard rate).² Within the framework of a fully specified duration model we use the time to default as a *dynamic* measure of risk. 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 lowest grade category (a 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. In addition to the hazard rate, for robustness, we also study internal credit ratings and past borrower non-performance as static but *ex-ante* measures of risk-taking. We analyze whether federal funds rate affect the lending volume to subprime borrowers.

Also grounded in theory the next step in our empirical strategy consists in exploiting the cross-sectional implications of the sensitivity in bank risk-taking to monetary policy according to the strength of banks’ balance sheet (Matsuyama (2007)) 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.

¹ Notice also that during the sample period, the correlation between the U.S. Federal funds rate and the 3-month Bolivian Treasury Bill rate is 0.88.

² See also Section 6 of the paper for an explanation of why duration analysis is needed in the case that loan maturity is affected by monetary policy changes.

The final step in of our empirical strategy is to show that banks are willing to take on more risk when the federal funds rate is lower. Even our cross-sectional findings that certain banks take on more risk when the federal funds rate is lower could still be driven by differential changes in demand for financing. For example, this would be the case if a lower funds rate increases more the demand from risky borrowers for financing from certain banks vis-à-vis low risk borrowers.³ To further identify that the results are supply driven, we also analyze loan prices. A sufficient condition for credit supply determining changes in risk is the following: lower federal funds rate increases the amount of risky loans but decreases the loan rates of risky vis-à-vis riskless loans.⁴ In this case, one can conclude that banks have more appetite for risk when monetary policy is expansionary.

III. Model and Variables

A. Duration Model

Following Shumway (2001), Chava and Jarrow (2004), and Duffie, Saita and Wang (2007) 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. (2007) making the results of the two studies comparable. The estimates from this analysis will then be used to investigate pricing.

³ In Stiglitz and Weiss (1981) the demand for funds from risky borrowers increases when interest rates are higher. The empirical evidence, however, seems mixed (Berger and Udell (1992)).

⁴ Suppose there are two types of borrowers: risky and riskless. Their demand for loans is affected by economic conditions and, in particular, by short-term interest rates. Assume that low interest rates increase more the demand for loans from risky borrowers. In this case, when interest rates are low more lending to risky borrowers is not necessarily the result of a more intense appetite for risk. However, if despite the higher demand for loans from risky borrowers when rates are low the observed loan rates charged to the risky vis-à-vis the riskless borrowers are reduced, then it implies that banks have more appetite for risk when monetary policy is expansionary.

⁵ See Heckman and Singer (1984b) and Kiefer (1988) for excellent reviews of duration analysis.

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 determines the probability that default will occur at time t , conditional on the spell surviving until time t , and is defined by:

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

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:

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

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 or logit models, may actually lead to fallacious inferences in case maturity changes. Indeed, the probability of an individual loan default does not uniformly correspond to the probability of default in each period (the hazard rate) on which we will rely to gauge bank risk taking. 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

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

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.

in Table 1. For expositional purposes we express the coefficients in terms of their impact on the hazard rate of the loans. 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 or logit 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 non time-varying and time-varying duration model.

[Insert Figure 1 here]

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 measures over the life of the loan as *Federal Funds* _{$\tau+t$} or *Federal Funds* _{$T-1$} , depending on whether we use a time-varying or a non time-varying model. 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]

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, $\text{Log}(\text{Assets})_{\tau-1}$, as a measure of bank size. Better possibilities for diversification or “too big to fail” perceptions (Boyd and Runkle (1993), Boyd and Runkle (1993)) for example may entice large banks to take more risks on individual bank loans. The median bank in Bolivia has around 600 mln. US dollar in assets.

Better access to liquid assets, $(\text{Liquid Assets}/\text{Assets})_{\tau-1}$, and less financing (and therefore control) from foreigners, $(\text{Foreign Funds}/\text{Assets})_{\tau-1}$, 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, $(\text{Equity}/\text{Assets})_{\tau-1}$, and the ratio of loans to total assets, $(\text{Loans}/\text{Assets})_{\tau-1}$, 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.

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 dollar and 50,000 US dollar, respectively, but have a high loan rate of around 14% (remember that the average federal funds rate is 4%). Only 27% of loans are collateralized.⁸ The average loan maturity is twenty months, much larger than the average time to default or repayment. 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 models as lenders may have foresight about early repayment. Finally, 71% of the loans are installment loans for which default can be triggered by a delay in repayment of the interest or part of the loan.

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.

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

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.

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 Table 1 in Degryse and Ongena (2007) for example). 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, $\Delta GDP\ Bolivia_{\tau-1}$, is included to control for variations in the demand for bank loans over the Bolivian business cycle. The mean 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, $Inflation\ US_{\tau-1}$ 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 (2.62%), though with a more than double variation. 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, $Country\ Risk_{\tau-1}$. 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.

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)).

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.

IV. Results

A. Time-Varying Duration Model

1. Estimated Coefficients

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 *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

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%.

diminishes the hazard rate on outstanding bank loans! This finding is in line with the results in Jiménez et al. (2007) 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 (not surprisingly) adjust loan conditions when they take on more risk. The coefficients on $Federal\ Funds_{\tau-1}$, however, suggest that these adjustments are not enough in times of monetary expansion.

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. Country risk and the growth rate of 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 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]

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

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. Exposing the “hazardous” cohort of loans, granted when rates were low, to swiftly increasing policy rates dramatically exacerbates their “toxicity”, these estimates suggest. 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 (loans granted during the period of the increase in the federal fund rate will have a lower hazard rate for example).

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 III to VI 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)). Instead, 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 III to VI in Table 2 broadly confirm these priors, though not all the coefficients are statistically significant.

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 $Current\ NPL_{t-1}$ 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 $Past\ Default_{t-1}$ 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 $Subprime_t$ 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.

[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. Some bank and loan characteristics change their sign as compared to Table 2, e.g., banks with more liquid assets 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 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.¹²

In Model V we report specifications featuring the federal funds rate in the month prior to origination, $Federal\ Funds_{\tau-1}$, while in Model VI we also include the change in the federal funds rate between maturity and origination, $\Delta Federal\ Funds_{\tau+T}$.¹³ In Models VII and VIII 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,¹⁴ the results are virtually unaffected across the board, except for the interaction between $Federal\ Funds_{\tau-1}$ and $(Liquid\ Assets/Assets)_{\tau-1}$.

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).

¹² 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).

¹³ In a linear setting the time series correlation between fund rate levels starts to mar the estimations.

¹⁴ 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.

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

“Back-of-the-envelope” OLS regressions of maturity on all predetermined variables suggest that maturity substantially shortens as the federal funds rate drops. This shortening of 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 a probit or logit 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 or logit models, may actually lead to fallacious inferences in case maturity changes.

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

$$\hat{p}(T) = 1 - \hat{S}(T) = 1 - \prod_{t=0}^T (1 - \hat{\lambda}(t)), \quad (3)$$

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.

To conclude, 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 (or any *ex ante* measure of default that is not normalized over time) may fail to capture the increase in actual risk-taking. We leave for future research why banks surprisingly 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 outstanding).

B. Pricing of Risk

We now turn to the second main step in our analysis, the investigation of the pricing of risk, to more deeply analyse 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 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.¹⁵ 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

¹⁵ 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.

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 coefficient 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 origination.¹⁶ For expositional purposes, we call this variable the *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, *Federal Funds* $_{\tau-1}$. We label the difference between this hazard rate and the *Neutral Hazard Rate* $_{\tau}$, the Δ *Neutral Hazard Rate* $_{\tau}$. This variable captures changes in the hazard rate caused by deviations in *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. 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 *Neutral Hazard Rate* $_{\tau}$ and the Δ *Neutral Hazard Rate* $_{\tau}$. We include the monthly average London Interbank Offered Rate, *LIBOR* $_{l,\tau}$, and a constant to control for interest rate levels. The *LIBOR* $_{l,\tau}$ 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 LIBORs with a

¹⁶ 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). As is standard all other independent variables are set equal to their mean.

maximum maturity of twelve months. Hence, we use a subsample of 23,412 loans with duration up to one year. 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 $LIBOR_{l,\tau}$ for the zero-hazard loan equals around 11%. As expected from previous studies, the loan rate adjusts sluggishly to changes in the $LIBOR_{l,\tau}$.¹⁷ 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% in the loan rate. If the $LIBOR_{l,\tau}$ 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., $19.4 - 12.0 = 7.4\%$).

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 Δ *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 strongly 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

¹⁷ The change in the loan rate due to a basis point change in the the $LIBOR_{l,\tau}$ 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.

by all the other factors) has a positive impact on the loan rate. Banks seemingly do not require extra compensation for the risk taken during expansionary monetary times.

Models II and III include interactions between $\Delta \text{Neutral Hazard Rate}_t$ and our two bank characteristics, $(\text{Liquid Assets} / \text{Assets})_{t-1}$ and $(\text{Foreign Funds} / \text{Assets})_{t-1}$. 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. As expected, the opposite is true for banks that borrow more from foreign financial institutions. Hence, banks, not firms, seem to determine our findings.

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 boliviano was pegged to the US dollar and the financial system was highly dollarized. The US federal funds rate is thus 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 adequately. 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 less 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. First, we want to further investigate the banks' pricing of loans and analyze the effects of both *ex ante* and *ex post* measures of risk. Second, given the cohorts of loans and initial and ending policy rates for a time period, one can calculate on the basis of the estimated coefficients the path of monetary policy rates that would minimize the total amount of credit risk. It would be interesting to compare this path to the actual path that was followed. Third, one can further investigate the effects of other macro conditions such as the volatility in GDP growth, inflationary expectations or the term structure for example on the risk and pricing of new and outstanding loans. Finally, bank ownership, in particular public listing, and ownership dispersion may matter for risk taking incentives and the pricing of the loans. Also the effect of monetary policy on risk-taking and pricing may depend on bank liquidity holdings, outstanding non-performing loans, and local banking competition.

We leave all these extensions for future developments of this and other 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: $\tau-1$ 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
<i>Monetary Conditions</i>							
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
<i>Bank Characteristics</i>							
In(Assets) _{$\tau-1$}	The log of total bank assets	mIn. 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
<i>Firm Characteristics</i>							
Bank Borrowing _{$\tau-1$}	Total bank borrowing by the firm	mIn. US\$	1.85	3.58	0.00	0.47	45.11
<i>Bank - Firm Relationship Characteristics</i>							
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
<i>Loan Characteristics</i>							
Amount _{τ}	Loan amount	mIn. US\$	0.17	0.49	0.00	0.05	12.21
Rate _{τ}	Loan rate	%	13.96	2.64	0.16	14.5	35
Collateral _{τ}	= 1 if loan is collateralized; = 0 otherwise	-	0.27	0.45	0	0	1
Maturity _{τ}	Loan maturity	months	20.00	22.58	0	11.83	180.43
Type _{τ}	= 1 if loan is an installment loan; = 0 otherwise	-	0.71	0.45	0	1	1
<i>Banking Market Characteristics</i>							
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
<i>Macro Conditions</i>							
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 $\tau+t$. 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
<i>Monetary Conditions</i>							
Federal Funds _{t-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 _{t+t}		0.195 [0.092] **		0.066 [0.106]	0.151 [0.120]		
Δ Federal Funds _{t+t}			1.056 [0.417] **			-0.273 [0.699]	0.415 [0.693]
<i>Monetary Conditions and Bank Characteristics</i>							
Federal Funds _{t-1} * (Liquid Assets/Assets) _{t-1}				-0.018 [0.007] **		-0.009 [0.007]	
Federal Funds _{t-1} * (Foreign Funds/Assets) _{t-1}					0.017 [0.008] **		0.021 [0.008] ***
Federal Funds _{t+t} * (Liquid Assets/Assets) _{t-1}				0.013 [0.005] ***			
Federal Funds _{t+t} * (Foreign Funds/Assets) _{t-1}					0.005 [0.004]		
Δ Federal Funds _{t+t} * (Liquid Assets/Assets) _{t-1}						0.105 [0.053] **	
Δ Federal Funds _{t+t} * (Foreign Funds/Assets) _{t-1}							0.053 [0.042]
<i>Bank Characteristics</i>							
ln(Assets) _{t-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) _{t-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 _{t-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) _{t-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) _{t-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) _{t-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
<i>Firm Characteristics</i>							
Bank Borrowing _{t-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
<i>Bank - Firm Relationship Characteristics</i>							
Multiple Banks _{t-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 _{t-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 _{t-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] ***
<i>Loan Characteristics</i>							
Amount _t	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 _t	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 _t	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 _t	-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 _t	-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]
<i>Banking Market Characteristics</i>							
Herfindahl Hirschman Index _{t-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
<i>Macro Conditions</i>							
Δ GDP Bolivia _{t-1}	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 _{t-1}	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 _{t-1}	-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 _{t-1}	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 Dependent Variable	Probit Current NPL	Probit Past Default	Probit Subprime	OLS Time to Default	OLS Time to Default	OLS Time to Default	OLS Time to Default
<i>Monetary Conditions</i>							
Federal Funds _{τ-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 _{τ+T}					-1.101 [0.126] ***	-1.471 [0.244] ***	-0.283 [0.187]
<i>Monetary Conditions and Bank Characteristics</i>							
Federal Funds _{τ-1} * (Liquid Assets/Assets) _{τ-1}						-0.037 [0.006] ***	
Federal Funds _{τ-1} * (Foreign Funds/Assets) _{τ-1}							-0.038 [0.007] ***
Δ Federal Funds _{τ+T} * (Liquid Assets/Assets) _{τ-1}						0.031 [0.017] *	
Δ Federal Funds _{τ+T} * (Foreign Funds/Assets) _{τ-1}							-0.075 [0.017] ***
<i>Bank Characteristics</i>							
ln(Assets) _{τ-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) _{τ-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 _{τ-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) _{τ-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) _{τ-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) _{τ-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
<i>Firm Characteristics</i>							
Bank Borrowing _{τ-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
<i>Bank - Firm Relationship Characteristics</i>							
Multiple Banks _{τ-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 _{τ-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 _{τ-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] ***
<i>Loan Characteristics</i>							
Amount _τ	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 _τ	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 _τ	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 _τ	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 _τ	-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] ***
<i>Banking Market Characteristics</i>							
Herfindahl Hirschman Index _{τ-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
<i>Macro Conditions</i>							
Δ GDP Bolivia _{τ-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 _{τ-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 _{τ-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 _{τ-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* _{τ} 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; all other independent variables are set equal to their mean. The Δ *Neutral Hazard Rate* _{τ} 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* _{τ} . The *LIBOR* _{l,τ} is the average monthly London Interbank Offered Rate in US dollars and matched in maturity to the bank loan (up to one year). The definition of the other variables can be found in Table 1. The number of observations equals 23,412 as loans with maturity longer than one year are dropped. 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 _{τ}	3.708 [1.635] **	3.138 [1.551] **	3.691 [1.638] **
Δ Neutral Hazard Rate _{τ}	-4.138 [2.193] *	17.785 [4.014] ***	-5.962 [2.300] ***
Δ Neutral Hazard Rate _{τ} * (Liquid Assets/Assets) _{$\tau-1$}		-0.691 [0.103] ***	
Δ Neutral Hazard Rate _{τ} * (Foreign Funds/Assets) _{$\tau-1$}			0.322 [0.126] **
LIBOR _{τ}	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] ***

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.

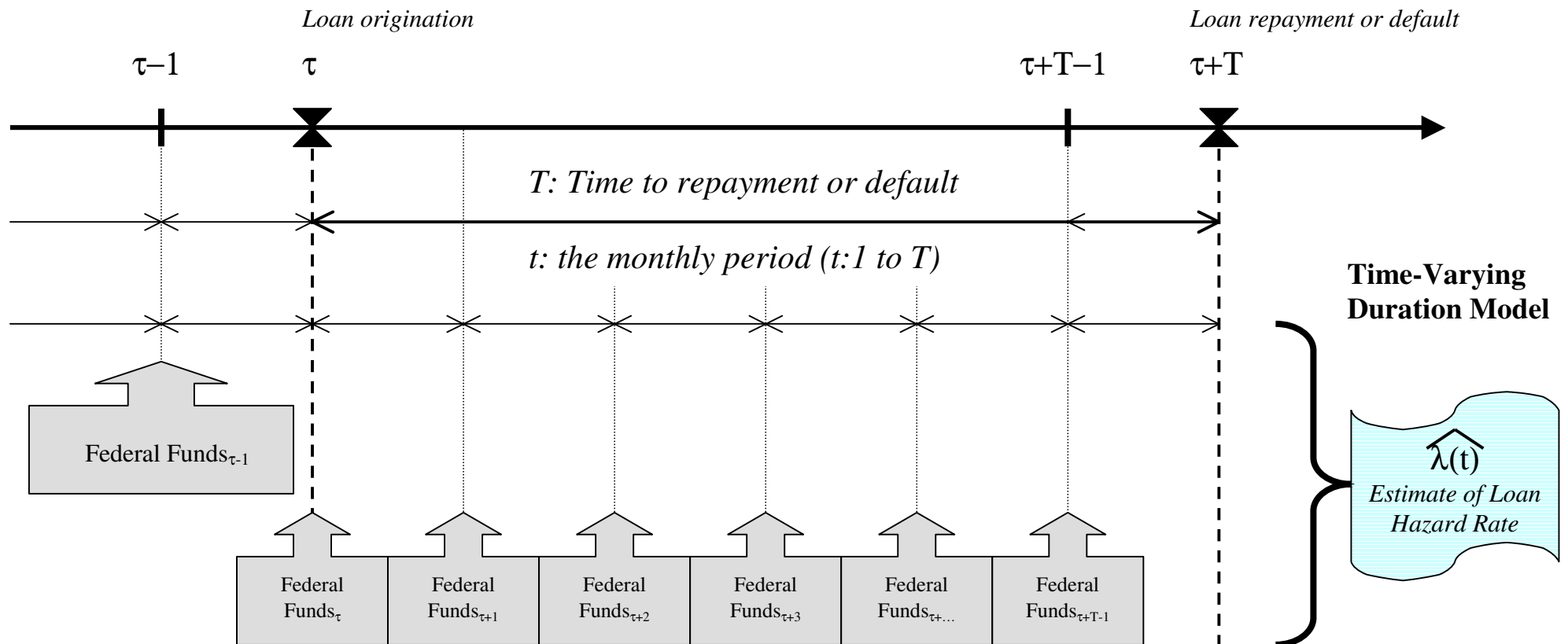


FIGURE 2. THE US FEDERAL FUNDS RATE, THE GROWTH IN BOLIVIAN GROSS DOMESTIC PRODUCT AND THE US INFLATION RATE

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.

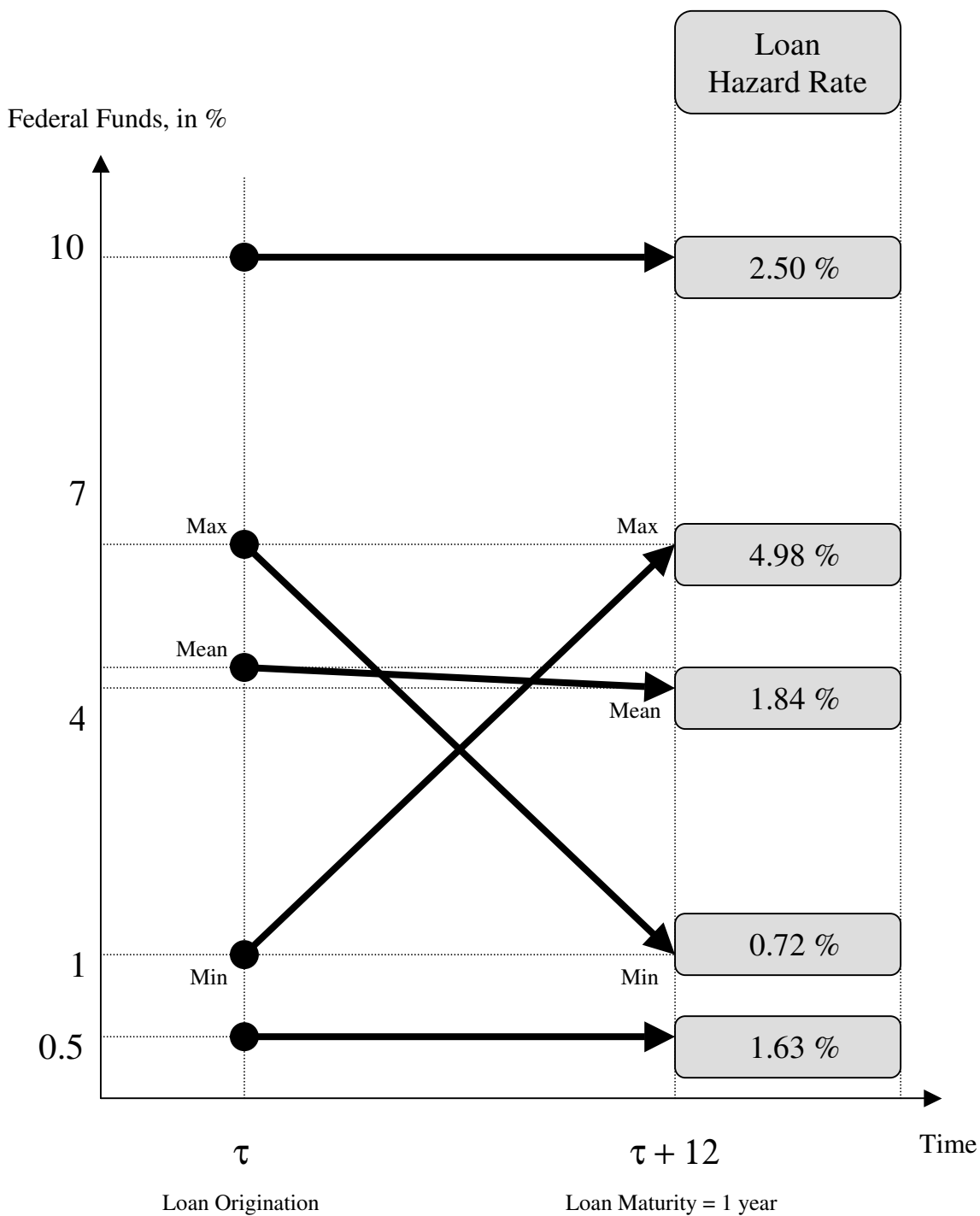


FIGURE 4. FEDERAL FUNDS RATES BEFORE LOAN ORIGINATION AND UNTIL MATURITY (ONE YEAR) AND THE LOAN HAZARD RATE

The figure displays the *Federal Funds* _{$\tau-1$} , in the month before the loan origination date $\tau-1$, on the left horizontal axis, the *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.

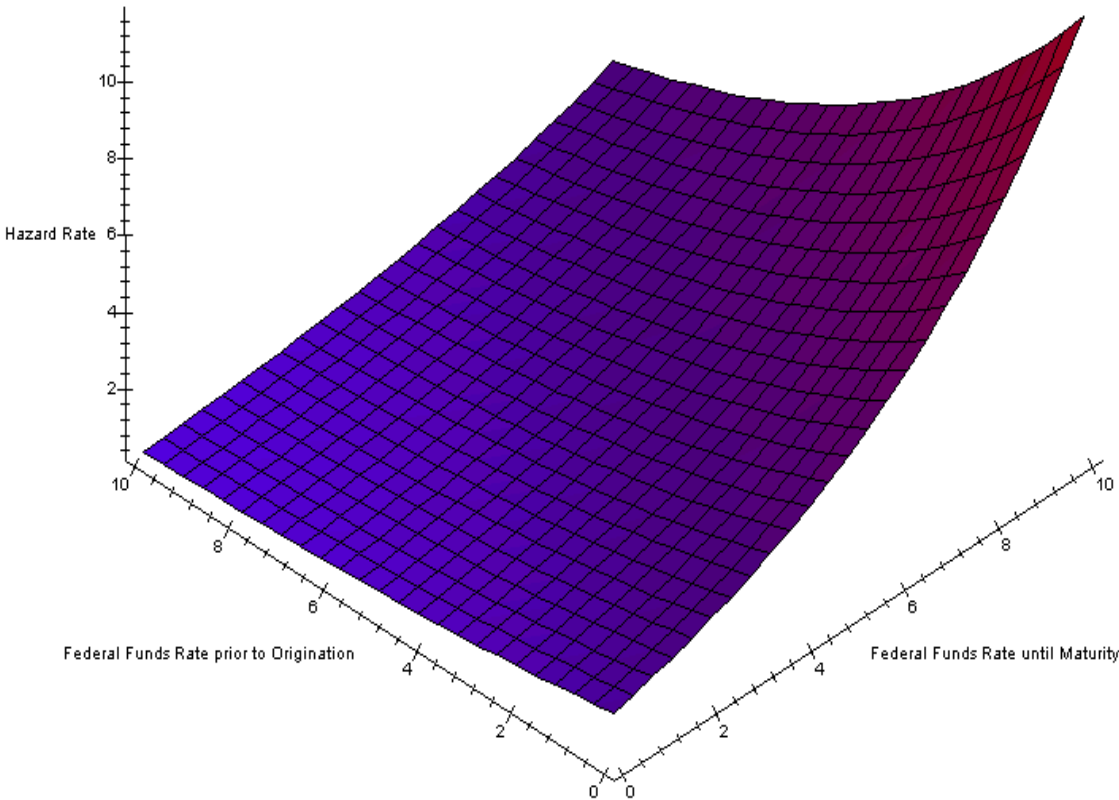
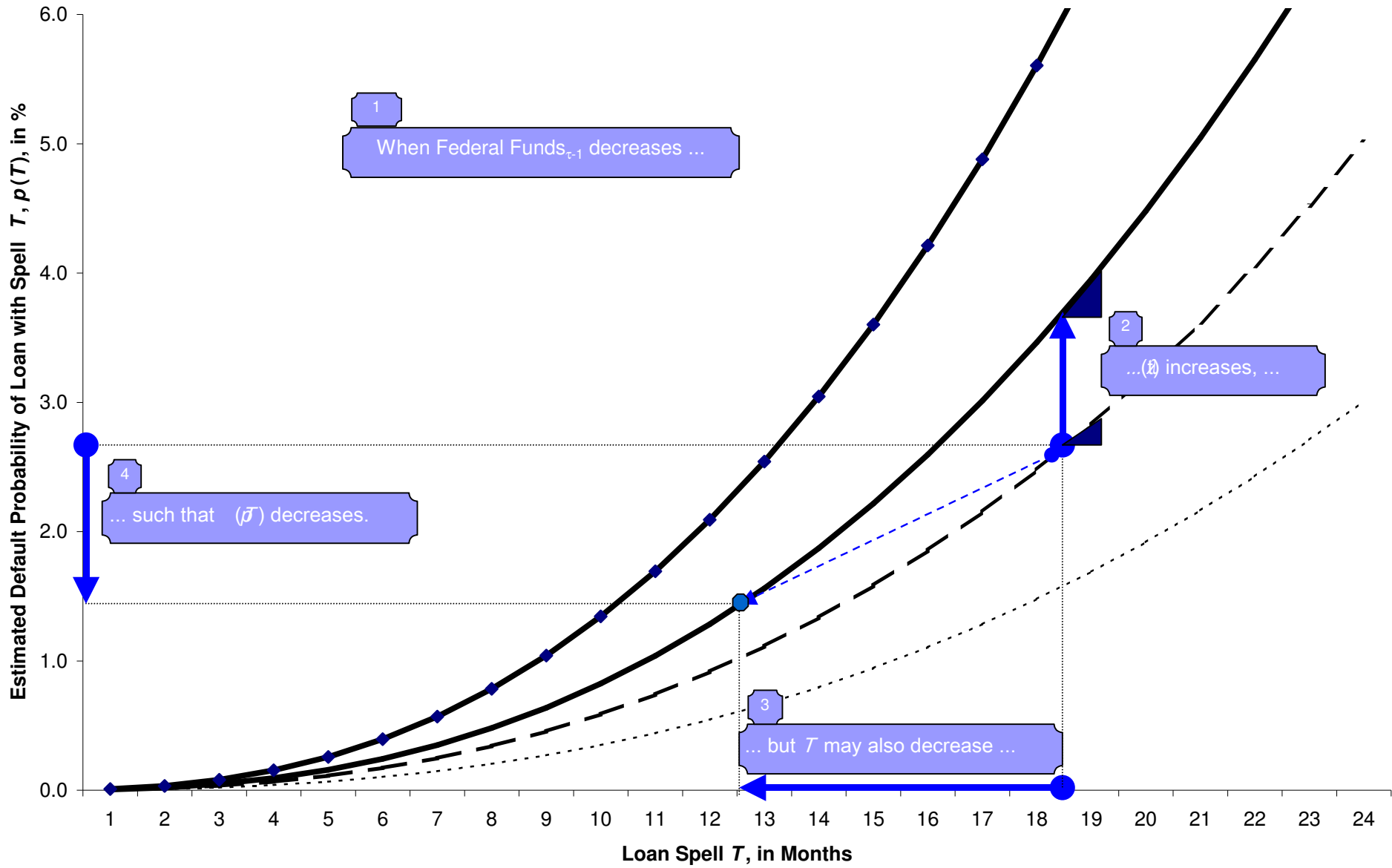


FIGURE 5. THE FEDERAL FUNDS RATE AT LOAN ORIGINATION, MATURITY AND INTEGRATED HAZARD RATE

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 Tabel 2 and the mean values of all independent variables, with the exception of the *Federal Funds* _{$\tau-1$} , which equals 1.01% (minimum), 4.28% (mean), 6.54% (maximum) and 10%, respectively, and the *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.



—◆— = 1.01% — = 4.28% - - = 6.54% = 10%

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