# Interest Rates, Market Power, and Financial Stability

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**Abstract**

This paper shows the relevance of financial intermediaries' market power to assess the effects of safe interest rates on their risk-taking decisions. We consider an economy where intermediaries have market power in lending and privately monitor loans, which reduces their probabilities of default. We show that lower safe rates lead to lower margins and higher risk-taking when intermediaries have low market power, but the result reverses for high market power. We show that this result is robust to introducing endogenous leverage and characterize how it is affected when introducing non-monitored bond finance, heterogeneous monitoring costs, and deposit insurance.

*JEL Classification*: G21, L13, E52

*Keywords*: Imperfect competition, intermediation margins, bank monitoring, bank risk-taking, monetary policy.

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# 1 Introduction

Lax monetary conditions leading to low levels of interest rates have been identified as an important driver of risk-taking in the financial sector, an effect termed the “risk-taking channel” of monetary policy.[1] This paper analyzes, from a theoretical perspective, how interest rates affect the risk-taking decisions of financial intermediaries. Its key contribution is to highlight the relevance of the financial sector’s market structure in shaping such relationship.

We model a one-period risk-neutral economy in which a fixed number of financial intermediaries raise uninsured funding from deep pocket investors and compete à la Cournot in providing loans to penniless entrepreneurs. Intermediaries privately choose the monitoring intensity of their loans, where higher monitoring results in lower probabilities of default. Crucially, we assume that the monitoring decision is costly and unobservable, which creates a moral hazard problem between each financial intermediary and its investors. The expected return that investors require for their funds is assumed to be equal to an exogenous safe rate, which is interpreted as a proxy for the stance of monetary policy.

We show that the effect of changes in the safe rate on the risk of the loan portfolios of financial intermediaries depends on their market power. In competitive loan markets the conventional prediction obtains: lower rates result in higher risk-taking by intermediaries. However, in monopolistic loan markets the opposite prediction obtains: lower rates result in lower risk-taking. These contrasting results obtain because in our setup monitoring incentives are driven by the intermediation margin, and market power determines the intensity of the pass-through of financing rates to loan rates. In particular, lower safe rates can lead to either lower (in competitive markets) or higher (in monopolistic markets) intermediation margins, which in turn determine lower or higher monitoring incentives. The conclusion is that *low interest rates are detrimental to financial stability when the market power of financial intermediaries is low, but beneficial when their market power is high.*[2]

[1] See the discussion in Adrian and Liang (2018), as well as the empirical papers by Jimenez et al. (2014) and Ioannidou et al. (2015), among many others.

[2] Moreover, in line with the traditional (charter value) literature on competition and financial stability, we also show that higher competition results in higher risk-taking for any level of the safe rate; see, for example, Keeley (1990), Allen and Gale (2000), Hellmann et al. (2000), and Repullo (2004).

After stating in Section 2 our initial results linking interest rates, market structure, and financial stability, Section 3 considers a situation in which entrepreneurs also have the possibility of being directly funded by competitive investors that do not monitor their projects.[3] In such situation the equilibrium loan rate is affected by the entrepreneurs' outside funding option. In particular, direct market finance imposes a constraint that limits the loan rates that intermediaries can charge and reduces their intermediation margins. We show that this constraint is more likely to bind in monopolistic loan markets and when the safe rate is low. This implies that *monopolistic markets exhibit a U-shaped relationship between the safe rate and intermediaries' risk-taking*. In contrast, in competitive loan markets direct market finance is not a threat for financial intermediaries (as they already compete intensely among themselves), and therefore it does not affect the negative relationship between the safe rate and intermediaries' risk-taking.

Section 4 extends the base model to a dynamic setup where intermediaries can also be funded with inside equity capital, i.e. funds provided by those responsible for the monitoring decisions.[4] Shareholders are risk-neutral long-lived agents that require a spread over the safe rate (a standard excess cost of capital) and take into account the possibility of losing the charter if their intermediary fails. We show that in this setup lower safe rates have two opposite effects. On the one hand, there is a *leverage effect* that follows from the fact that shareholders have lower incentives to use relatively more expensive equity, which leads to higher leverage and lower monitoring incentives. On the other hand, there is a *charter value effect* that follows from the fact that charter values goes up, which leads to higher monitoring incentives. The latter effect dominates in monopolistic environments, which exhibit a lower pass-through, while the former dominates in competitive environments, which exhibit a higher pass-through. Hence, we conclude that our initial results are robust to the introduction of endogenous leverage.

Section 5 analyzes three extensions of our base model: (i) heterogeneity in monitoring costs, (ii) replacing uninsured by insured deposits and, (iii) introducing competition à la

[3] We can think of these investors as unsophisticated bond financiers, as in Holmström and Tirole (1997).

[4] In our setup, outside equity capital plays essentially the same role as uninsured deposits.

Cournot in the deposit market.

Suppose first that there are two observable types of intermediaries, with high and low cost of monitoring entrepreneurs. In equilibrium, intermediaries with high monitoring costs have lower market shares and their loans have higher probabilities of default. We show that lower safe rates increase (decrease) the market share of high (low) monitoring cost intermediaries and can decrease (increase) the probability of default of their loans. This is so because lower safe rates have a higher impact on the margins of high cost intermediaries. We conclude that lower safe rates can have opposite effects on the risk of different intermediaries. We also highlight that, by increasing the market share of those intermediaries with higher cost of monitoring (which grant riskier loans), lower safe rates have an additional "composition effect" that increases the overall risk of the financial system.

Solving the model with insured deposits simplifies the analysis since intermediaries are then able to borrow at the safe rate. We show that in this case a decrease in the safe rate leads to a decrease in the probability of loan default irrespective of market power. The intuition for this result is that, in the perfect competition limit, insured deposits lead to zero intermediation margins and hence zero monitoring, so the relationship between the safe rate and the probability of loan default becomes flat. Away from this limit, i.e. when intermediaries have some market power, lower rates allow them to widen intermediation margins, which translates into higher monitoring and lower probabilities of default. This highlights the importance of taking into account the composition of intermediaries' funding structure in terms of insured and uninsured deposits when analyzing the effects of safe rates on risk-taking.

We end by considering the effects of changes in safe rates when intermediaries also compete à la Cournot in the deposit market. We show that the results are qualitatively similar to those of the base model: low interest rates have a negative impact on financial stability when the market power of financial intermediaries is low, and a positive impact when their market power is high.

**Suggestive evidence** Before going into our formal analysis, it is worth presenting some suggestive evidence on the relevance of bank competition for the transmission of safe rates to loan rates and intermediation margins, which is key for our results. Following Dreschler et al. (2017), we estimate the sensitivity of loan rates and intermediation margins to changes in the Federal funds rate for different deciles of the distribution of banks' market power.

We use quarterly data from the U.S. Call Reports for the period 1994 to 2019 to obtain loan rates and intermediation margins for each bank. For loan rates we compute the interest and fee income on loans divided by total loans. For intermediation margins we compute the difference between loan rates and deposit rates, which are obtained as a weighted average of the rates for transaction accounts, savings deposits, and time deposits. We use the Federal funds target rate as the monetary policy rate.[5] Finally, as a proxy for market power, we use data on new mortgage lending by banks from the Home Mortgage Disclosure Act (HMDA) to compute an average Herfindahl index (HHI) for each bank.[6]

We divide the bank-quarter observations into 10 equal-sized bins from lowest to highest HHI, and run the following regression with quarterly data for each bin:

$$\Delta y_{bt} = \alpha_b + \beta_i \Delta FF_t + \varepsilon_{bt}. \tag{1}$$

where $\Delta y_{bt}$ is the change in either the loan rate or the intermediation margin of bank $b$ that belongs to bin $i = 1, ..., 10$ at date $t$, $\Delta FF_t$ is the change in the Federal funds target rate at date $t$, and $\alpha_b$ are bank fixed effects. We refer to $\beta_i$ as the sensitivity of loan rates or intermediation margins of banks belonging to bin $i$ to changes in the Federal funds rate.

Figure 1 shows the results. Panel A plots the sensitivity of loan rates and Panel B the sensitivity of intermediation margins to changes in the Federal funds rate for each bin. Consistent with the mechanism in our theoretical model, we find a negative relationship in both cases. In other words, the higher the market power, the lower the effect of the policy

[5] After the introduction in 2008 of a target rate corridor we use the mid point of the target range.

[6] In particular, we first obtain for each year a county level HHI using new mortgages originated by banks. We then compute the weighted average of county HHIs across the counties in which a bank operates. Finally, we take the average HHI for each bank in all the years in the sample. Similar results obtain when we include mortgages originated by non-banks or we compute the HHI using data on deposits in bank branches from the Federal Deposit Insurance Corporation (FDIC).

rate on loan rates and intermediation margins. More importantly, and in line with the predictions of our base model, the sensitivity of intermediation margins changes sign from positive to negative. In particular, for banks operating in competitive markets lower policy rates translate into lower margins, while for banks operating in monopolistic markets lower policy rates translate into higher margins. Since in the context of our model monitoring incentives are driven by the intermediation margin, this evidence is consistent with our key result: lower rates lead to higher risk-taking when banks have low market power, and to lower risk-taking when banks have high market power.

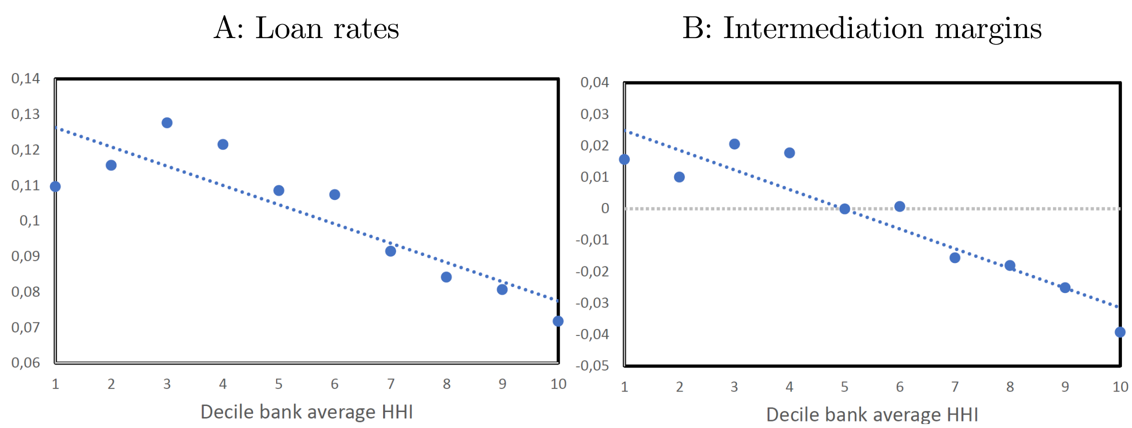


**Figure 1. Sensitivities of loan rates and intermediation margins to the Federal funds rate for different levels of banks' market power**

This figure shows the relationship between market power (from the lowest to the highest decile in banks' average Herfindahl index) and the sensitivity of loan rates (Panel A) and intermediation margins (Panel B) to changes in the Federal funds rate.

**Related literature** This paper is at the intersection of two strands of literature, one that analyzes the effect of competition on financial stability, and another one that analyzes the effect of lax monetary policy on banks' risk-taking incentives. Our main contribution is to provide a unifying framework that shows that the competitive structure of the financial sector together with the level of interest rates determine banks' intermediation margins and risk-taking incentives. Our interest in how the transmission of policy rates is affected by market power relates our paper to a large literature analyzing the effects of financial frictions (in our case, moral hazard) on economic outcomes.

The relationship between competition and stability has been extensively examined, both theoretically and empirically. Seminal papers like Keeley (1990) or Allen and Gale (2000) provide theoretical setups showing how, due to excessive risk-taking incentives, a more competitive banking sector results in higher probabilities of bank failure.[7] This relationship between competition and stability has also been investigated in many empirical papers; see for example the survey in Beck et al. (2006). More recently, Jiang et al. (2017) find a positive relationship between bank competition and risk-taking, using a gravity-based measure of contestability during the branch deregulation period in the US. We contribute to this literature by showing that different market structures, combining for example monitored bank and non-monitored bond finance, are also relevant in shaping the relationship between safe rates and risk-taking.

Our paper is also related to studies that highlight the importance of competition for assessing the effects of different policies on banks' risk-taking. Hellmann et al. (2000) show that, given the effect of competition on deposit rates, both capital and deposit rate regulations are needed in order to minimize risk-taking incentives. Repullo (2004) shows how the effect of bank capital regulation on risk-taking incentives depends on the competitive structure of the banking sector.

The papers more closely related to ours are Dell'Ariccia et al. (2014), which focusses on the relevance of leverage for the relationship between safe rates and banks' risk-taking, and Martinez-Miera and Repullo (2017), which studies the relationship between aggregate savings, safe rates, and the structure and risk of the financial sector.[8] While both papers provide models in which banks' risk-taking decisions are affected by safe rates, and show

[7] A more recent strand of this literature builds on Stiglitz and Weiss (1981) to show how this relationship can be reversed when the risk-taking decisions are taken by the borrower instead of by the bank, and how a U-shaped relationship can arise when imperfect correlation of loan defaults is taken into account; see Boyd and De Nicolo (2005) and Martinez-Miera and Repullo (2010).

[8] See also Boissay et al. (2016) for a theoretical model on how safe rates affect risk-taking in the presence of informational asymmetries in the interbank market, and Dell'Ariccia et al. (2017) for empirical evidence on the relevance of leverage for the connection between safe rates and banks' risk-taking.

circumstances under which lower safe rates can lead to higher risk-taking, our paper emphasizes the effect of the market structure of the financial sector in shaping such relationship. In particular, Martinez-Miera and Repullo (2017) only consider the limit case of perfect competition, while Dell'Ariccia et al. (2014) mainly focus on the limit case of monopoly and do not consider different types of market structures.

Our results with endogenous leverage differ from those of Dell'Ariccia et al. (2014). In particular, they consider a static setup in which lower rates always lead to higher risk-taking due to a *leverage effect*. This effect follows from the fact that with a fixed excess cost of capital, low rates makes equity capital relatively more expensive than deposits, so banks have an incentive to increase their leverage, which leads them to decrease their monitoring. In contrast, we show that in a dynamic setup there is also a *charter value effect* that works in the opposite direction, since a lower cost of funding leads to higher intermediation margins and higher charter values, so banks have an incentive to increase their monitoring in order to preserve their charter.

Our focus on how interest rates affect banks' risk-taking in markets with financial frictions relates our work to the literature building on the seminal papers of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) that highlights the importance of (information-driven) financial frictions for economic outcomes. More specifically, our paper is closely connected to papers analyzing the effects of monetary policy on banks' risk-taking incentives, the so-called "risk-taking channel" of monetary policy; see Adrian and Shin (2010), Borio and Zhu (2012), and Coimbra and Rey (2023), among many others. This literature, predominantly empirical, provides evidence on how lax monetary policy conditions lead to higher risk-taking by banks; see Maddaloni and Peydro (2011), and Jimenez et al. (2014), among many others.[9]

The literature analyzing the transmission of monetary policy has emphasized the role of banks, the so-called "bank lending channel" of monetary policy, because of frictions arising in the deposit or more generally the funding markets; see the seminal studies by Bernanke and

[9] A recent study by Corbae and Levine (2020) provides empirical evidence on the relevance of competition in the banking sector for the effects of monetary policy on banks' probability of failure using branch deregulation shocks in the US.

Blinder (1988) and Kashyap and Stein (1995). Recent research by Dreschler et al. (2017) has shown the relevance of deposit market competition for the pass-through of monetary policy to deposit rates, with more competitive markets exhibiting a higher pass-through. We contribute to this literature by highlighting the importance of taking into account imperfect competition in both the loan and the deposit markets, and showing the implications for the connection between safe rates and financial stability.[10]

# 2 Model of Bank Competition and Risk-taking

Consider an economy with two dates ($t = 0, 1$) populated by three types of risk-neutral agents: a continuum of deep pocket *investors*, a continuum of penniless *entrepreneurs*, and $n$ identical financial intermediaries, which for brevity we refer to as *banks*.[11] Investors are characterized by an infinitely elastic supply of funds at an expected gross return equal to $R_0$ (the safe rate). Each entrepreneur has an investment project that can only be funded by a single bank.[12] Banks in turn have no capital and are funded by investors.[13]

Entrepreneurs' projects require a unit investment at $t = 0$ and yield a stochastic return at $t = 1$ given by

$$\widetilde{R} = \begin{cases} R, & \text{with probability } 1 - p + m, \\ 0, & \text{with probability } p - m, \end{cases} \tag{2}$$

where $p \in (0, 1)$ is the probability of failure in the absence of monitoring, and $m \in [0, p]$ is the monitoring intensity of the lending bank.[14] While $p$ is known, $m$ is not observed by investors.

The outcome of entrepreneurs' projects is driven by a single aggregate risk factor $z$ that is uniformly distributed in $[0, 1]$. A project monitored with intensity $m$ will fail if and only

[10] Other work has focussed on the effects of (unconventional) monetary policy on banks' risk-taking. For example, Chodorow-Reich (2014) shows that there is very little risk-taking response to expansionary monetary policy after 2009, while Heider et al. (2019) provide evidence on these effects in a negative interest rate environment.

[11] We analyze the relevance of some features that characterize commercial banks such as deposit insurance and imperfect competition in the deposit market in Section 5.

[12] Section 3 extends our setup to incorporate the posibility of entrepreneurs being directly funded by investors.

[13] Section 4 extends our framework to allow for banks raising (inside) equity capital.

[14] We are implicitly assuming that each firm is only funded by one bank.

if $z < p - m$. This assumption implies that the return of projects monitored with the same intensity will be perfectly correlated.

The success return $R$ is assumed to be a decreasing function of the aggregate investment of entrepreneurs.[15] Given that entrepreneurs only receive funding from banks, their aggregate investment equals the aggregate supply of loans $L$. Thus, we can write write the success return of a project as $R(L)$. We assume that this relationship is linear, so

$$R(L) = a - bL, \tag{3}$$

where $a > 0$ and $b > 0$. Free entry of entrepreneurs ensures that the success return $R(L)$ equals the rate at which they borrow from banks, which means that $R(L)$ is also the inverse loan demand function.

Monitoring is costly, and the cost function is assumed to take the simple functional form

$$c(m) = \frac{\gamma}{2} m^2, \tag{4}$$

where $\gamma > 0$. Since monitoring is not observed by investors, there is a moral hazard problem between banks and investors.

Banks compete à la Cournot for loans. Specifically, each bank $j = 1, ..., n$ chooses its supply of loans $l_j$, which determines the total supply of loans $L = \sum_{j=1}^{n} l_j$ and the loan rate $R(L)$. Then, bank $j$ offers an interest rate $B_j$ to the (uninsured) investors, and once the lending and the funding rates are set it chooses the monitoring intensity of its loans $m_j$.

The objective of bank $j$ is to maximize its expected profits, which are computed as follows: With probability $1 - p + m_j$ all loans are performing, so the bank gets $R(L)$ and pays $B_j$ per unit of loans, while with probability $p - m_j$ all loans default, so by limited liability the bank gets a zero return. Finally, we have to subtract the monitoring costs per unit of loans $c(m_j)$. Hence, the problem of bank $j$ may be written as

$$\max_{(l_j, B_j, m_j)} \{ l_j \left[ (1 - p + m_j)(R(L) - B_j) - c(m_j) \right] \} \tag{5}$$

[15] This may be rationalized by assuming that the higher the investment and the output of entrepreneurs' projects (if successful), the lower the price that this output will command.

subject to the incentive compatibility constraint that determines its optimal choice of monitoring

$$m_j = \arg\max[(1-p+m_j)(R(L)-B_j)-c(m_j)] \tag{6}$$

and the participation constraint of the investors that is required to secure their funding[16]

$$(1-p+m_j)B_j = R_0. \tag{7}$$

To characterize the equilibrium of the model we proceed backwards. In Section 2.1 we determine the bank's borrowing rate $B_j$ and monitoring intensity $m_j$ as a function of the loan rate $R(L)$. Notice that since the monitoring intensity $m_j$ is not observed by investors, $B_j$ cannot depend on $m_j$. Notice also that at this point all banks face the same problem so we can drop the subindex $j$ and simply write $B(L)$ and $m(L)$. Then, in Section 2.2 we solve for the equilibrium supply of loans $L$.

## 2.1 Equilibrium monitoring decisions

Banks' choice of monitoring $m(L)$ for a given borrowing rate $B(L)$ is given by

$$m(L) = \arg\max_m \left\{(1-p+m)[R(L)-B(L)]-c(m)\right\}. \tag{8}$$

By (4), the first-order condition that characterizes an interior solution to this problem is

$$R(L)-B(L) = \gamma m(L). \tag{9}$$

Thus, the banks' monitoring intensity $m(L)$ is proportional to the intermediation margin $R(L)-B(L)$.[17]

The investors' participation constraint is

$$[1-p+m(L)]B(L) = R_0. \tag{10}$$

[16] With an infinetely elastic supply of funds at the rate $R_0$, the participation constraint holds with equality.

[17] We implicitly assume that the marginal cost of monitoring $\gamma$ is sufficiently high, so we do not reach the corner solution $m(L) = p$ in which bank loans are safe. By Proposition 1 below, the condition that guarantees that $m(L) < p$ is $\gamma > (R(L)-R_0)/p$.

Solving for $B(L)$ in this constraint, substituting it into the first-order condition (9), and rearranging gives the key equation that characterizes banks' monitoring intensity

$$\gamma m(L) + \frac{R_0}{1 - p + m(L)} = R(L). \tag{11}$$

The function in the left-hand side of (11) is convex in $m$. Let us then define

$$\underline{R} = \min_{m \in [0,p]} \left( \gamma m + \frac{R_0}{1 - p + m} \right) = \gamma \underline{m} + \frac{R_0}{1 - p + \underline{m}}. \tag{12}$$

We can now prove the following result.

**Proposition 1** *Banks are able to fund their lending $L$ if $R(L) \geq \underline{R}$, in which case the optimal contract between banks and investors is given by*

$$m(L) = \max \left\{ m \in [0,p] \mid \gamma m + \frac{R_0}{1 - p + m} = R(L) \right\} \text{ and } B(L) = \frac{R_0}{1 - p + m(L)}. \tag{13}$$

Proposition 1 implies that of the two possible solutions to equation (11), the one with higher monitoring characterizes the optimal contract. Solving for $m(L)$ in (11) then gives

$$m(L) = \frac{1}{2\gamma} \left[ R(L) - \gamma(1-p) + \sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0} \right]. \tag{14}$$

From here it follows that an increase in total lending $L$, which according to (3) leads to a decrease in the loan rate $R(L)$, reduces the monitoring intensity of banks, so $m'(L) < 0$. At the same time, (14) implies that an increase in the safe rate $R_0$, for a given value of $L$, also reduces monitoring.

## 2.2 Equilibrium lending decisions

To compute the symmetric Cournot equilibrium of the loan market, note that the objective function of an individual bank is given by the product of its lending $l$ by the profits per unit of loans, which are given by

$$\pi(L) = [1 - p + m(L)][R(L) - B(L)] - c(m(L)). \tag{15}$$

A symmetric Cournot equilibrium $l^*$ is then defined by

$$l^* = \arg\max_{l} \left[ l \pi(l + (n-1)l^*) \right], \tag{16}$$

and is characterized by the first-order condition

$$L^*\pi'(L^*) + n\pi(L^*) = 0, \tag{17}$$

where $L^* = nl^*$ is the equilibrium total lending.

Using (4) and (9), the function $\pi(L)$ in (15) may be written as

$$\pi(L) = (1-p)\gamma m(L) + \frac{\gamma}{2} m(L)^2. \tag{18}$$

This implies that bank profits per unit of loans $\pi(L)$ will be positive whenever the intermediation margin $R(L) - B(L) = \gamma m(L)$ is positive. Given that $m'(L) < 0$ this also implies

$$\pi'(L) = \gamma[1 - p + m(L)]m'(L) < 0. \tag{19}$$

However, the sign of $\pi''(L)$ is in principle ambiguous,[18] so in what follows we assume that parameter values are such that

$$L\pi''(L) + (n+1)\pi'(L) < 0. \tag{20}$$

This implies that the second-order condition for the symmetric Cournot equilibrium $L^*\pi''(L^*) + 2n\pi'(L^*) < 0$ is satisfied.

The equilibrium loan rate is $R^* = R(L^*)$, and the rate at which banks borrow from investors is $B^* = B(L^*)$. The probability of loan default is $PD = p - m^*$, where $m^* = m(L^*)$ is the banks' equilibrium monitoring intensity. Note that the assumption of a single aggregate risk factor implies that probability of loan default equals the probability of bank failure. Hence, $PD$ is a sufficient statistic for the stability of the financial system.

We are interested in analyzing the effect on the probability of default $PD$ of changes in two parameters, namely the safe rate $R_0$ and the number of banks $n$, which measures (the inverse of) their market power.

The effect of changes in the number of banks $n$ is straightforward. Differentiating the first-order condition (17) and using the assumption (20) gives

$$\frac{\partial L^*}{\partial n} = -\frac{\pi(L^*)}{L^*\pi''(L^*) + (n+1)\pi'(L^*)} > 0. \tag{21}$$

[18] One can show that $R'(L) < 0$ and $R''(L) = 0$ imply that the function $m(L)$ in (14) is strictly concave. But by (18) bank profits per unit of loans are strictly convex in $m(L)$. Thus, the sign of $\pi''(L)$ is ambiguous, although it is negative in all our numerical results.

Thus, increasing the number of banks $n$ increases equilibrium total lending $L^*$. But since $m'(L) < 0$, this lowers the equilibrium monitoring intensity $m^*$ and consequently increases the probability of default $PD$. This result is in line with the traditional (charter value) view of the relationship between competition and financial stability, according to which higher competition results in higher risk-taking.

In order to analyze the effect of changes in the safe rate $R_0$ on the probability of default $PD$, we first have to sign its effect on equilibrium lending $L^*$.

**Proposition 2** *An increase in the safe rate $R_0$ leads to a reduction in equilibrium lending $L^*$.*

The effect of changes in the safe rate $R_0$ on the equilibrium monitoring intensity $m^*$ is however ambiguous. To see this, note that

$$\frac{dm^*}{dR_0} = \frac{\partial m^*}{\partial L^*}\frac{\partial L^*}{\partial R_0} + \frac{\partial m^*}{\partial R_0}. \tag{22}$$

Using the expression for $m(L)$ in (14), we have already noted that $\partial m/\partial L < 0$ and $\partial m/\partial R_0 < 0$. Given that by Proposition 2 we have $\partial L^*/\partial R_0 < 0$, the first term in the right-hand side of (22) is positive, while the second term is negative.

The negative term may be called the *funding rate effect*, and it follows from the fact that, by the investors' participation constraint (10), an increase in the safe rate $R_0$ increases the borrowing rate $B(L^*)$, and hence decreases the intermediation margin $R(L^*) - B(L^*)$. The positive term may be called the *lending rate effect*, which comes from the fact that an increase in the safe rate $R_0$ reduces equilibrium lending $L^*$, which pushes up the loan rate $R(L^*)$ and the intermediation margin $R(L^*) - B(L^*)$. Thus, one effect pushes down the margin, while the other pushes it up. Since according to (9) the banks' monitoring intensity is proportional to the intermediation margin, we have an ambiguous effect on risk-taking.

In what follows we show that the sign of derivative in (22) depends on the number of banks $n$. In particular, when $n$ is large the derivative is positive, so higher safe rates lead to lower risk-taking, while when $n$ is small the derivative is negative, so higher safe rates lead to higher risk-taking.

The proof of the $n$ large case is essentially identical to the one in Martinez-Miera and Repullo (2017). As shown in (21), increasing the number of banks $n$ increases equilibrium lending $L^*$ and reduces the equilibrium loan rate $R^*$. There will be a point in which the constraint $R(L) \geq \underline{R}$ becomes binding,[19] in which case by Proposition 1 the equilibrium monitoring intensity $m^*$ equals the value $\underline{m}$ that minimizes the convex function in brackets in (12). The derivative with respect to $m$ of the first term of this function captures the effect on the marginal cost of monitoring, which is constant, while the derivative of the second term captures the effect on the marginal benefit of monitoring, in terms of a reduction in the borrowing rate, which is increasing (in absolute value) in the safe rate $R_0$. Hence, when $\underline{m}$ is not at the corner with zero monitoring, increases in $R_0$ push $\underline{m}$ to the right, as the marginal benefit of monitoring is higher for higher safe rates, so the equilibrium monitoring intensity of the competitive banks will increase. Formally, solving the minimum condition

$$\frac{d}{dm}\left(\gamma m + \frac{R_0}{1-p+m}\right) = 0, \tag{23}$$

gives

$$\underline{m} = \sqrt{\frac{R_0}{\gamma}} - (1-p). \tag{24}$$

Hence, increases in the safe rate $R_0$ increase the monitoring intensity $\underline{m}$ of the competitive banks and consequently reduce the probability of default of their loans.

In the case of monopoly ($n = 1$), we first note that the monopolist's objective function $\Pi(L) = L\pi(L)$ is decreasing in safe rate $R_0$, since $\pi(L)$ is monotonic in $m(L)$ by (18), and $m(L)$ is decreasing in $R_0$ by (14). By the envelope theorem, the monopolist's equilibrium total profits $\Pi^*$ will then be decreasing in $R_0$. Assuming that the monopolist's equilibrium profits per unit of loans $\pi^*$ is also decreasing in its funding costs,[20] it follows by (18) that

[19] In fact, the constraint will be binding for a finite number of banks $\underline{n}$. Ignoring integer constraints, $\underline{n}$ satisfies the first-order condition $L^*\pi'(L^*) + \underline{n}\pi(L^*) = 0$ for $L^* = \underline{L}$ such that $R(\underline{L}) = \underline{R}$. Thus, the equilibrium loan rates and risk-taking decisions for all $n > \underline{n}$ will be the same as those for $n = \underline{n}$.

[20] This is an assumption, since $dL^*/dR_0 < 0$ (by Proposition 2) implies that the sign of

$$\frac{d\pi^*}{dR_0} = \frac{d}{dR_0}\left(\frac{\Pi^*}{L^*}\right) = \frac{1}{L^*}\left[\frac{d\Pi^*}{dR_0} - \pi^*\frac{dL^*}{dR_0}\right]$$

is in principle ambiguous, although it is negative in all our numerical results.

equilibrium monitoring $m^*$ will be decreasing in $R_0$. Hence, increases in the safe rate $R_0$ reduce the monitoring intensity $m^*$ of the monopoly bank and consequently increase the probability of default of its loans.

Summing up, under monopoly increases in the safe rate $R_0$ increase the probability of default of bank loans, while under perfect competition increases in the safe rate $R_0$ reduce it. These results suggest that the slope of the relationship between $R_0$ and $PD$ changes from positive to negative as we increase the number of banks $n$, so that $\partial^2 PD/\partial R_0 \partial n < 0$. Indeed, as Figure 2 illustrates, an increase in the number of banks $n$ leads to a reduction in the slope of the relationship between the safe rate $R_0$ (in the horizontal axis) and the probability of loan default $PD$ (in the vertical axis). For sufficiently high $n$ the slope changes sign from positive to negative. Figure 2 also illustrates that, as shown above, an increase in the number of banks $n$ increases the probability of loan default $PD$.

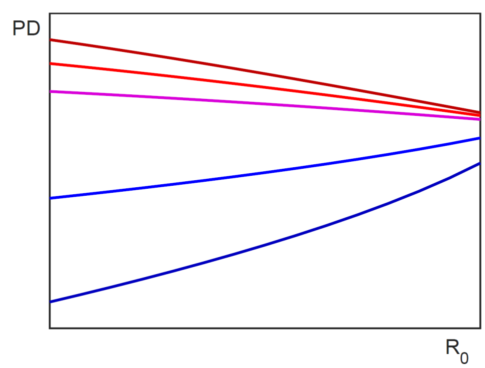


**Figure 2. Effect of the safe rate on the probability of loan default**

This figure shows the relationship between the safe rate and the probability of default for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks.

The intuitive explanation of this result is as follows. A reduction in the safe rate reduces banks' funding costs which translates into lower loan rates. In monopolistic markets, the pass-through from funding costs to loan rates is small, as banks take into account the market-wide effect of their individual lending decisions, which results in higher intermediation margins and higher monitoring incentives. In contrast, in competitive markets, the pass-through is large, as banks do not internalize the market-wide effect of their individual lending decisions, which results in lower intermediation margins and lower monitoring incentives.

This is illustrated in Figure 3, where we show the effect of changes in the safe rate $R_0$ on equilibrium loan rates $R^*$ (Panel A) and intermediation margins $R^* - B^*$ (Panel B) for different values of the number of banks $n$. The slopes of the lines in Panel A become steeper (a higher pass-through) with increases in $n$, which leads to the change in the slope of the lines in Panel B from positive (for high $n$) to negative (for low $n$).

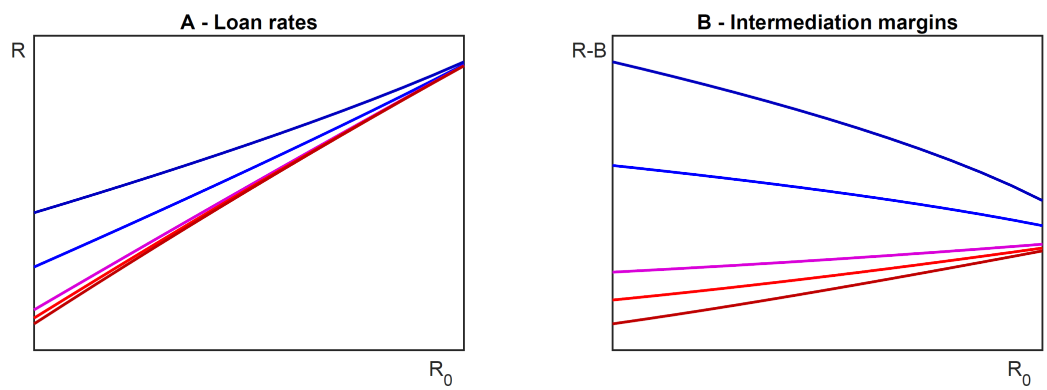


**Figure 3. Effect of the safe rate on loan rates and intermediation margins**

This figure shows the relationship between the safe rate and the equilibrium loan rates (Panel A) and intermediation margins (Panel B) for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks.

The conclusion is that market power is key for assessing the effect of interest rates on risk-taking. In particular, low interest rates are detrimental to financial stability when banks' market power is low, but beneficial when their market power is high.

# 3 Model with a Competitive Bond Market

This section considers a variation of our base model in which entrepreneurs can obtain funding for their projects from banks and also directly from investors.

We assume that investors are not able to monitor entrepreneurs's projects (because they may be dispersed and subject to a free rider problem). Since they are competitive, they are willing to lend to entrepreneurs at a rate $\overline{R}$ that satisfies their participation constraint

$$(1-p)\overline{R} = R_0. \tag{25}$$

The presence of market lenders imposes a constraint on banks' lending, since the loan rate $R(L)$ cannot exceed the market rate $\overline{R}$.[21] This means that the inverse loan demand function (3) now becomes

$$R(L) = \min\{a - bL, \overline{R}\}. \tag{26}$$

The upper bound $\overline{R}$ will be binding whenever the original equilibrium (in the absence of the bound) is such that $R^* > \overline{R}$. In this case the candidate equilibrium lending will be $\overline{L} > L^*$ such that $R(\overline{L}) = a - b\overline{L} = \overline{R}$. By our previous results, the banks' borrowing rate and monitoring intensity will be given by $B(\overline{L})$ and $m(\overline{L})$, respectively. Given that we focus on symmetric Nash equilibria, the question is: will any bank $j$ want to deviate from setting $l_j = \bar{l} = \overline{L}/n$ when the other $n-1$ banks choose to lend $\bar{l}$?

There are two cases to consider. First, note that setting $l_j < \bar{l}$ is not profitable, since given the upper bound in loan rates the profits per unit of loans would not change from $\pi(\overline{L})$. Second, setting $l_j > \bar{l}$ is not profitable either since assumption (20) together with $\overline{L} > L^*$ implies

$$\frac{d}{dl}[l\pi(l + (n-1)\bar{l})]\bigg|_{l=\bar{l}} = \bar{l}\pi'(\overline{L}) + \pi(\overline{L}) < l^*\pi'(L^*) + \pi(L^*) = 0, \tag{27}$$

where the last equality is just the equilibrium condition in the absence of direct market finance.

[21] Note that if $R(L) > \overline{R}$, more entrepreneurs would enter the market, borrowing at the market rate $\overline{R}$, driving down the success return $R(L)$ until it coincides with $\overline{R}$.

Hence, whenever the upper bound $\overline{R}$ is binding, equilibrium bank lending will be $\overline{L}$. Although there is no lending through direct market finance, it makes the loan market contestable, and therefore has a significant effect on equilibrium loan rates, which by (25) are equal to $\overline{R} = R_0/(1-p)$. Substituting this expression into (14) yields

$$m^* = \frac{R_0}{\gamma(1-p)} - (1-p), \tag{28}$$

We conclude that when the presence of market lenders binds the loan rate, increases in the safe rate $R_0$ increase the monitoring intensity $m^*$ of the banks, and consequently reduce the probability of default of their loans.

Figure 4 illustrates the effect of changes in the safe rate $R_0$ on equilibrium loan rates $R^*$ (Panel A) and intermediation margins $R^* - B^*$ (Panel B) in the presence of direct market finance. The solid lines in Panel A show the relationship between $R^*$ and $R_0$ for different values of $n$. The dashed line shows the upper bound $\overline{R} = R_0/(1-p)$, which is binding in monopolistic markets (low $n$) and for low values of the safe rate $R_0$. The lines in Panel B show the implied relationship between $R^* - B^*$ and $R_0$ for different values of $n$.

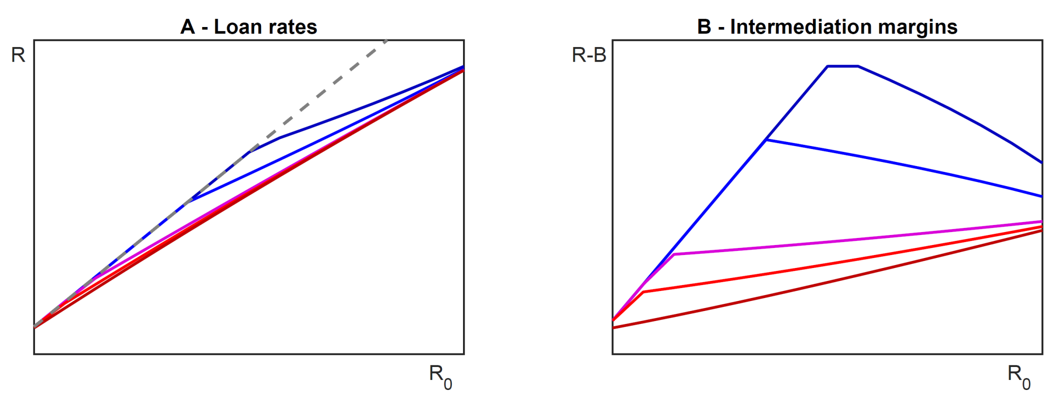


**Figure 4. Effect of the safe rate on loan rates and intermediation margins in the presence of direct market finance**

This figure shows the relationship between the safe rate and the equilibrium loan rates (Panel A) and intermediation margins (Panel B) in the presence of market finance for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks. The dashed line in Panel A represents the loan rate under direct market finance.

Figure 5 shows the effect of introducing direct market finance on the relationship between the safe rate $R_0$ (in the horizontal axis) and the probability of loan default $PD$ (in the vertical axis), for different values of the number of banks $n$. In competitive markets (high $n$), the relationship is still negative, that is lower safe rates translate into higher risk-taking. However, in contrast with the result in Section 2, in monopolistic markets (low $n$) the relationship is U-shaped: lower safe rates initially decrease banks' risk-taking, but below certain point they increase risk-taking. This result follows from the fact that, as shown in Figure 4, when the safe rate is low the equilibrium loan rate $R^*$ in monopolistic markets equals the market rate $\overline{R}$, so by (28) lower rates reduce monitoring, thereby increasing the probability of default of bank loans.

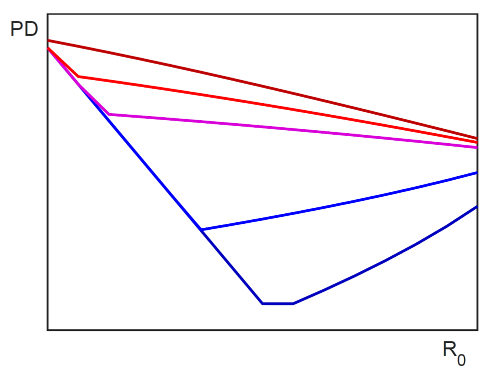


**Figure 5. Effect of the safe rate on the probability of loan default in the presence of direct market finance**

This figure shows the relationship between the safe rate and the probability of default for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks in the presence of direct market finance.

# 4 Dynamic Model with Bank Capital

This section introduces bank capital, and analyzes whether endogenizing leverage changes the results on the relationship between the safe rate and banks' risk-taking in our base model. The analysis is conducted in a discrete-time infinite horizon dynamic setup in which bank shareholders take into account the possibility of losing the bank's charter if it fails.

The sequence of moves at any date is as follows: First, each bank $j = 1, ..., n$ chooses its supply of one-period loans $l_j$, which determines the total supply of loans $L = \sum_{j=1}^{n} l_j$ and the loan rate $R(L)$ for this date. Then, it chooses its capital per unit of loans $k_j$, which is assumed to be observable to investors. Finally, it offers an interest rate $B_j$ to fund the remaining $1 - k_j$ fraction of its loan portfolio, and chooses the monitoring intensity of its loans $m_j$.

It is assumed that equity capital is provided by long-lived agents (shareholders) with a discount rate $R_0 + \delta$, where $\delta > 0$ is a standard excess cost of capital. It is also assumed that when a bank fails, a regulator withdraws its charter and a new bank enters the market, so the total number of banks is always $n$.

To characterize the equilibrium of this model, we proceed as before by backwards induction. Consider a bank that has chosen to supply $l$ loans and to have $k$ capital per unit of loans in a market where the loan rate is $R(L)$. Let $V$ denote the bank's charter value, which is lost with probability $p - m$, and $v = V/l$ the charter value per unit of loans. Then, the bank's borrowing rate $B(L, k, v)$ and monitoring intensity $m(L, k, v)$ is obtained by solving

$$m(L, v, k) = \arg\max_{m} \{(1-p+m)[R(L) - (1-k)B(L, k, v)] - k(R_0+\delta) - c(m) + (1-p+m)v\} \tag{29}$$

and

$$[1 - p + m(L, k, v)]B(L, k, v) = R_0. \tag{30}$$

Following the same steps as in Section 2, one can show that if

$$R(L) + v \geq \min_{m \in [0,p]} \left( \gamma m + \frac{(1-k)R_0}{1-p+m} \right), \tag{31}$$

then

$$m(L,v,k)=\frac{1}{2\gamma}\left[R(L)+v-\gamma(1-p)+\sqrt{[R(L)+v+\gamma(1-p)]^2-4\gamma(1-k)R_0}\right]. \quad (32)$$

Substituting (30) into (29), the optimal choice of the bank's capital per unit of loans is

$$k(L,v)=\arg\max_k\left[(1-p+m(L,k,v))R(L)-R_0-k\delta-c(m(L,k,v))\right]. \quad (33)$$

To simplify the notation, let

$$m(L,v)=m(L,k(L,v),v). \quad (34)$$

Then, the bank's one-period profits per unit of loans may be written as

$$\pi(L,v)=(1-p+m(L,v))R(L)-R_0-k\delta-c(m(L,v)). \quad (35)$$

The symmetric Cournot equilibrium $l^*$ of the dynamic game is obtained by solving

$$l^*=\arg\max_l\left[l\pi(l+(n-1)l^*,V^*/l)+(1-p+m(l+(n-1)l^*,V^*/l))V^*\right], \quad (36)$$

where $V^*$ satisfies the Bellman equation

$$V^*=\frac{1}{R_0+\delta}\left[l^*\pi(L^*,V^*/l^*)+(1-p+m(L^*,V^*/l^*))V^*\right]. \quad (37)$$

Two limit cases are worth considering, namely the case where the excess cost of capital $\delta\to\infty$ and the case where the excess cost of capital $\delta=0$. In the first case, banks will have no capital ($k^*=0$) and their charter value $V^*$ will be zero. Hence, the results on the relationship between the safe rate $R_0$ and the probability of loan default $PD$ for different values of $n$ are identical to those of the base model represented in Figure 2.

In the second case, banks will be fully funded with equity capital ($k=1$), so the moral hazard problem disappears. In this case, Figure 6 shows that the relationship between the safe rate $R_0$ (in the horizontal axis) and the probability of loan default $PD$ (in the vertical axis) for different values of $n$ is qualitatively similar to the one in the base model. In particular, for sufficiently high $n$ the slope changes sign from positive to negative. The intuition for the underlying forces driving this result can be obtained by noting that for the case $\delta = 0$ equilibrium monitoring in (32) simplifies to

$$m(L, v, 1) = \frac{1}{\gamma}(R(L) + v). \tag{38}$$

Thus, a decrease in the safe rate $R_0$ affects bank monitoring by (i) decreasing the loan rate $R(L)$ and (ii) increasing the charter value per unit of loans $v$. In monopolistic environments (where $v$ is large) the second effect dominates, so lower rates translate into safer banks, while in competitive environments the opposite result obtains.

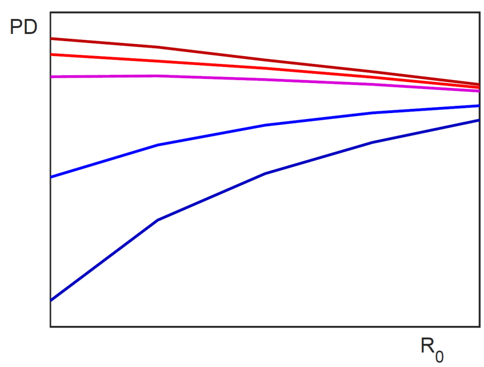


**Figure 6. Effect of the safe rate on the probability of loan default in a dynamic setup with no bank leverage**

This figure shows the relationship between the safe rate and the probability of default for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks in the presence of direct market finance.

The remaining question is what happens for $\delta > 0$, where (in general) bank equity $k$ depends on the safe rate $R_0$. In this case a reduction in $R_0$ has two effects illustrated in Figure 7: a *leverage effect* (in Panel A) that reduces the equilibrium capital per unit of loans $k^*$ and a *charter value effect* (in Panel B) that increases the equilibrium charter value per unit of loans $v^*$. The first effect tends to reduce monitoring, because of the lower skin in the game, while the second tends to increase it, because of the higher survival payoff.

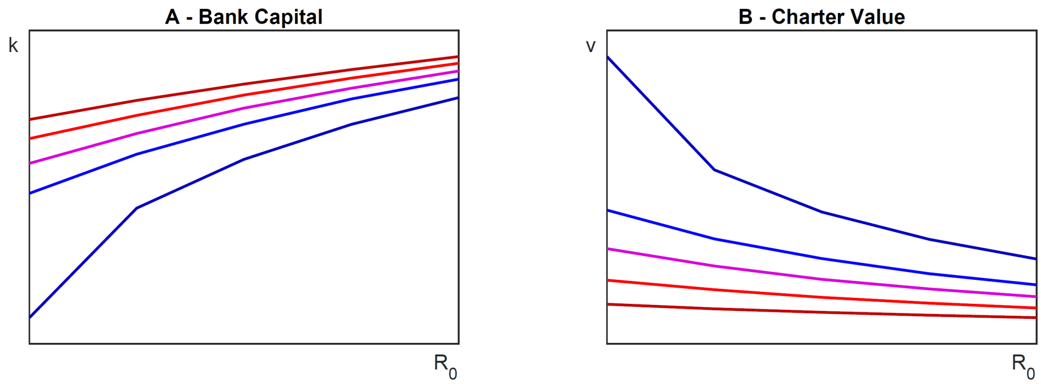


**Figure 7. Effect of the safe rate on bank leverage and charter value in a dynamic setup with endogenous leverage**

This figure shows the relationship between the safe rate and the equilibrium bank capital (Panel A) and charter value (Panel B) in the dynamic setup with endogenous leverage for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks.

Figure 8 shows that the dominant effect depends on the number of banks $n$. An increase in the number of banks $n$ leads to a reduction in the slope of the relationship between the safe rate $R_0$ (in the horizontal axis) and the probability of loan default $PD$ (in the vertical axis). For sufficiently high $n$ the slope changes sign from positive to negative, exactly as in the base model. The intuition for this result relies on the fact that in monopolistic markets charter values are larger and their effect on the equilibrium choice of monitoring is more important.[22]

We conclude that endogeneizing leverage does not essentially change our results on the effect of safe rates on banks' risk-taking in our base model: low interest rates have a negative impact on financial stability when banks' market power is low, and a positive impact when their market power is high.

[22]It should be noted that in the case of a transitory change in the safe rate (only lasting for one period), the charter value effect would disappear, in which case the higher leverage associated with lower safe rates would lead to higher risk-taking, as in Dell'Ariccia et al. (2014).

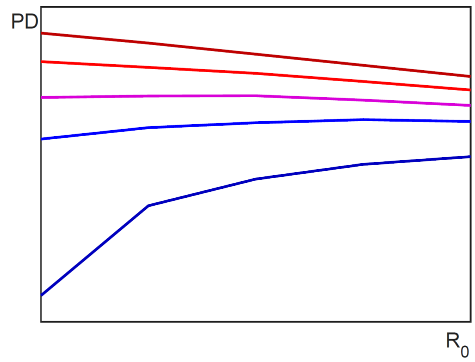


**Figure 8. Effect of the safe rate on the probability of loan default in a dynamic setup with endogenous bank leverage**

This figure shows the relationship between the safe rate and the probability of default in the dynamic setup with endogenous leverage for loan markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks.

# 5 Extensions

This section discusses the robustness of our previous results to incorporating three relevant aspects of bank competition. First, we analyze the effect of introducing heterogeneity in banks' monitoring costs. Second, we consider the effect of replacing uninsured by insured deposits. Finally, we analyze the effect of assuming that banks also compete à la Cournot in the deposit market. To simplify the discussion, the analysis will be conducted in the context of the base model presented in Section 2.

## 5.1 Heterogeneous monitoring costs

Suppose that there are two types of banks that differ in the parameter $\gamma$ of their monitoring cost function (4): $n_1$ banks have high monitoring costs, characterized by parameter $\gamma_1$, while $n_0 = n - n_1$ banks have low monitoring costs, characterized by parameter $\gamma_0 < \gamma_1$. It is assumed that a bank's type is observable to investors, so they can adjust the rates at which they are willing to fund them.

To characterize the equilibrium of the model with heterogeneous banks, note first that the critical values $\underline{R}_0$ and $\underline{R}_1$ which are defined by setting $\gamma$ in (12) equal to $\gamma_0$ and $\gamma_1$, respectively, satisfy $\underline{R}_0 < \underline{R}_1$. From here it follows that whenever the total supply of loans $L$ is such that $\underline{R}_0 < R(L) < \underline{R}_1$, only the low monitoring cost banks operate.

By our results in Section 2, if $R(L) \geq \underline{R}_j$ the monitoring intensity chosen by a bank of type $j = 0, 1$ is

$$m_j(L) = \frac{1}{2\gamma_j}\left[R(L) - \gamma_j(1-p) + \sqrt{[R(L) + \gamma_j(1-p)]^2 - 4\gamma_j R_0}\right], \tag{39}$$

and the corresponding borrowing rate is

$$B_j(L) = \frac{R_0}{1 - p + m_j(L)}. \tag{40}$$

One can show that $m_0(L) > m_1(L)$,[23] which implies $B_0(L) < B_1(L)$. Thus, low monitoring cost banks choose a higher monitoring intensity, and consequently are able to borrow from investors at lower rates. We can also show that

$$\begin{aligned}
\pi_0(L) &= [1 - p + m_0(L)][R(L) - B_0(L)] - \frac{\gamma_0}{2}(m_0(L))^2 \\
&> [1 - p + m_1(L)][R(L) - B_0(L)] - \frac{\gamma_0}{2}(m_1(L))^2 \\
&> [1 - p + m_1(L)][R(L) - B_1(L)] - \frac{\gamma_1}{2}(m_1(L))^2 = \pi_1(L).
\end{aligned} \tag{41}$$

Thus, low monitoring cost banks have higher profits per unit of loans.

A Cournot equilibrium is defined by a pair of strategies $(l_0^*, l_1^*)$ for the two types of banks that satisfy

$$l_0^* = \arg\max_l \left[l\pi_0(l + (n_0 - 1)l_0^* + n_1 l_1^*)\right], \tag{42}$$

$$l_1^* = \arg\max_l \left[l\pi_1(l + (n_1 - 1)l_1^* + n_0 l_0^*)\right]. \tag{43}$$

From here it follows that the Cournot equilibrium will be characterized by the first-order conditions

$$L_0^*\pi_0'(L^*) + n_0\pi_0(L^*) = 0, \tag{44}$$

$$L_1^*\pi_1'(L^*) + n_1\pi_1(L^*) = 0, \tag{45}$$

[23] This can be proved by total differentiation of (11), noting that by Proposition 1 the derivative of the left-hand side with respect to $m(L)$ is positive.

where $L_0^* = n_0 l_0^*$, $L_1^* = n_1 l_1^*$, and $L^* = L_0^* + L_1^*$.

Figure 9 illustrates the effect of changes in the safe rate $R_0$ on equilibrium lending by low and high monitoring cost banks, $L_0^*$ and $L_1^*$, and equilibrium total lending $L^*$. Increases in the safe rate $R_0$ reduce lending by both types of banks, but the effect is more significant for high monitoring cost banks. In particular, the market share of low monitoring cost banks, denoted $\lambda = L_0^*/L^*$, increases with the safe rate, reaching 100% for high values of $R_0$.

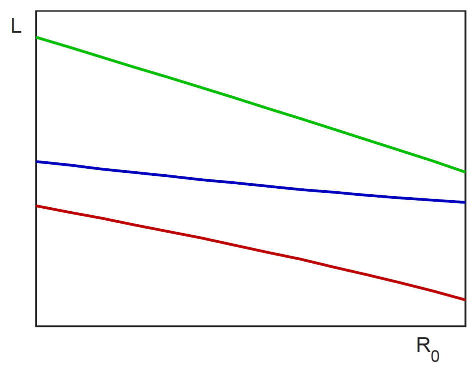


**Figure 9. Effect of the safe rate on loan supply with heterogeneous monitoring costs**

This figure shows the relationship between the safe rate and the aggregate supply of loans (green), and the relationship between the safe rate and the supply of loans by banks with low (blue) and high monitoring costs (red).

Figure 10 illustrates the effect of changes in the safe rate $R_0$ on the probability of loan default of low and high monitoring cost banks, $PD_0 = p - m_0^*$ and $PD_1 = p - m_1^*$, as well as on the average probability of default defined by

$$\overline{PD} = \lambda PD_0 + (1 - \lambda) PD_1. \tag{46}$$

When heterogeneity in monitoring costs is sufficiently high (as is the case in Figure 10), increases in the safe rate $R_0$ translate into increases in the probability of default of the loans granted by high monitoring cost banks, and decreases in the probability of default of the loans granted by low monitoring cost banks. These latter type of banks become safer because higher safe rates increase their comparative advantage relative to the high monitoring cost banks. In particular, the intermediation margin $R(L) - B_0(L)$ of the low monitoring cost banks goes up, while the intermediation margin $R(L) - B_1(L)$ of the high monitoring cost banks goes down, which explains the differential effects on monitoring incentives.[24] Moreover, Figure 10 also illustrates that, due to the increase in the market share $\lambda$ of low monitoring cost banks, the average probability of loan default $\overline{PD}$ goes down, approaching $PD_0$ for large values of $R_0$.

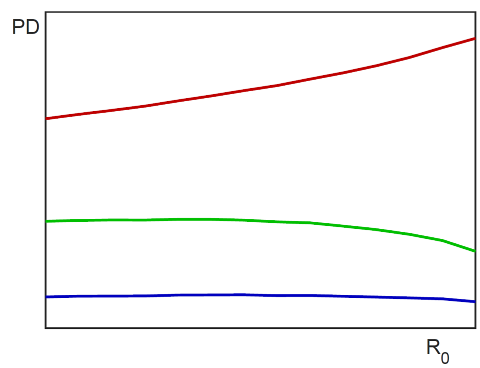


**Figure 10. Effect of the safe rate on the probability of loan default with heterogeneous monitoring costs**

This figure shows the relationship between the safe rate and the average probability of default (green), and the relationship between the safe rate and the probability of default of loans by banks with low (blue) and high monitoring costs (red).

[24] For low heterogeneity in monitoring costs the differential effects may not obtain, since in the limit of homogeneous costs both relationships will be either increasing or decreasing, depending on market power. However, as the safe rate increases, the intermediation margin of the low monitoring cost banks will always increase more (or decrease less) than that of the high monitoring cost banks.

## 5.2 Insured deposits

When deposits are insured banks can borrow from investors at the safe rate $R_0$, since when they fail the insurer pays investors the promised return.[25] Hence, the banks' choice of monitoring is given by

$$m(L) = \arg\max_{m} \left\{(1-p+m)[R(L)-R_0] - c(m)\right\}. \tag{47}$$

The first-order condition that characterizes an interior solution to this problem is

$$R(L) - R_0 = \gamma m(L). \tag{48}$$

This result together with (4) implies that banks' profits per unit of loans may be written as

$$\pi(L) = (1-p)[R(L)-R_0] + \frac{1}{2\gamma}[R(L)-R_0]^2. \tag{49}$$

Hence, $R'(L) = -b < 0$ by (3) implies $\pi'(L) < 0$.

Following the same steps as in Section 2, the first-order condition that characterizes a symmetric Cournot equilibrium is (17). Differentiating the first-order condition, assuming as before that parameter values satisfy (20), and using the expression for $\pi(L)$ in (49) we get

$$\frac{\partial L^*}{\partial R_0} = -\frac{L^*\pi''(L^*) + n\pi'(L^*)}{b\left[L^*\pi''(L^*) + (n+1)\pi'(L^*)\right]} < 0. \tag{50}$$

Hence, an increase in the safe rate $R_0$ reduces equilibrium lending $L^*$. From here it follows that the effect on the intermediation margin is

$$\frac{\partial}{\partial R_0}\left[R(L^*) - R_0\right] = -b\frac{\partial L^*}{\partial R_0} - 1 = -\frac{\pi'(L^*)}{L^*\pi''(L^*) + (n+1)\pi'(L^*)} < 0. \tag{51}$$

But then by (48) a decrease in the intermediation margin leads to a decrease in monitoring, so $\partial m^*/\partial R_0 < 0$.

We conclude that *when deposits are insured, an increase in the safe rate $R_0$ always leads to an increase in the probability of loan default $PD$*, regardless of the number of banks $n$.[26]

[25] To simplify the analysis, we assume that such insurance is provided at a flat rate equal to zero.

[26] Note than in the limit case of perfect competition we have $R(L) - R_0 = 0$, which by (48) implies $m(L) = 0$. Thus, in this case we have $PD = p$ for all values of the safe rate $R_0$.

## 5.3 Endogenous deposit rates

We now consider the effects of changes in the safe rate when banks also have market power in raising deposits. In particular, we assume that banks compete à la Cournot in a deposit market characterized by a linear inverse supply function of the form

$$R_D(D) = R_0 - c + dD, \tag{52}$$

where $D$ is the aggregate supply of deposits, $R_D$ is the expected return of bank deposits, and $c > 0$ and $d > 0$. In this setup, the safe rate $R_0$ may be interpreted as the rate that depositors could obtain by investing in a safe asset such as government bonds.

The inverse supply function (52) can be derived from a model in which depositors differ in a liquidity premium associated with bank deposits. Specifically, suppose that there is a measure $c$ of atomistic risk-neutral depositors with wealth $1/d$ characterized by a liquidity premium $s$ associated with bank deposits that is uniformly distributed in $[0, c]$.[27] An investor of type $s$ will deposit her wealth in a bank offering a return $R_D$ if

$$R_D + s \geq R_0. \tag{53}$$

From here it follows that the aggregate supply of deposits $D$ will be equal to the wealth of depositors with a liquidity premium $s \geq R_0 - R_D$, that is

$$D = \frac{c - (R_0 - R_D)}{d}. \tag{54}$$

Solving for $R_D$ in this equation gives the inverse supply function (52).

Banks compete à la Cournot for loans and deposits. Specifically, each bank $j = 1, ..., n$ chooses its supply of loans $l_j$ and its demand for deposits $d_j$ subject to the balance sheet constraint $l_j = d_j$. Given this constraint, in what follows we will simply denote by $l_j$ the size of the balance sheet of bank $j$.

The individual bank decisions determine the total supply of loans $L = \sum_{j=1}^{n} l_j$ and the loan rate $R(L)$, as well as the total demand for deposits $D = L$ and the required expected

[27] The liquidity premium could also be interpreted as an individual-specific cost $s/d$ of accessing the government bond market.

return of deposits $R_D(L)$. After $R(L)$ and $R_D(L)$ are determined, bank $j$ offers a deposit rate $B_j(L)$, and once the lending and the funding rates are set it chooses the monitoring intensity of its loans $m_j(L)$. As before, we drop the subindex $j$ and simply write $B(L)$ and $m(L)$.

To characterize the equilibrium of this model we first determine the banks' deposit rate $B(L)$ and monitoring intensity $m(L)$ as a function of the total supply of loans $L$ (and demand for deposits $D = L$). The banks' choice of monitoring is given by

$$m(L) = \arg\max_{m} \left\{(1 - p + m)[R(L) - B(L)] - c(m)\right\}. \tag{55}$$

and the depositors' participation constraint is now

$$[1 - p + m(L)]B(L) = R_D(L). \tag{56}$$

Following the same steps as in Section 2, one can show that if $L$ is such that

$$R(L) \geq \min_{m \in [0,p]} \left(\gamma m + \frac{R_D(L)}{1 - p + m}\right), \tag{57}$$

then we have

$$m(L) = \frac{1}{2\gamma}\left[R(L) - \gamma(1 - p) + \sqrt{[R(L) + \gamma(1 - p)]^2 - 4\gamma R_D(L)}\right] \tag{58}$$

and

$$B(L) = \frac{R_D(L)}{1 - p + m(L)} \tag{59}$$

From (58) it follows that

$$\frac{dm(L)}{dL} = -b\frac{\partial m(L)}{\partial R(L)} + d\frac{\partial m(L)}{\partial R_D(L)} < 0. \tag{60}$$

The second term in this expression is new, relative to our previous setup characterized by an infinitely elastic supply of funds at the safe rate $R_0$. This term amplifies the negative impact of total lending on bank monitoring, via the additional reduction in the intermediation margin $R(L) - B(L)$, due to the increase in the expected return of deposits $R_D(L)$, and hence in the deposit rate $B(L)$.

A Cournot equilibrium is defined as in the base model, with $m(L)$ and $B(L)$ in (58) and (59) replacing the previous expressions in (15). Solving the first-order condition (17) gives the equilibrium amount of lending $L^*$ (and deposit taking $D^* = L^*$). As before, the equilibrium loan rate is $R^* = R(L^*)$, the deposit rate is $B^* = B(L^*)$, and the probability of loan default is $PD = p - m(L^*)$.

Figure 11 illustrates that the qualitative effects of changes in the safe rate $R_0$ on the probability of loan default $PD$ for different values of $n$ are similar to the ones in Figure 2. Increasing the number of banks $n$ leads to a reduction in the slope of the relationship between the safe rate $R_0$ (in the horizontal axis) and the probability of loan default $PD$ (in the vertical axis). For sufficiently high $n$ the the slope changes sign from positive to negative.

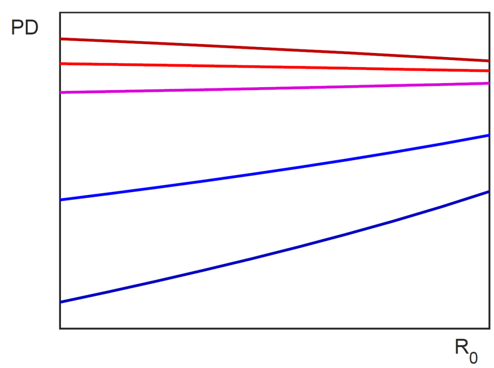


**Figure 11. Effect of the safe rate on the probability of loan default with Cournot competition for deposits and loans**

This figure shows the relationship between the safe rate and the probability of default for markets with 1 (dark blue), 2, 5, 7, and 10 (dark red) banks that compete à la Cournot for both deposits and loans.

The conclusion is that imperfect competition in the deposit market does not essentially change the results on the relationship between the safe rate and banks' risk-taking in our base model: low interest rates have a negative impact on financial stability when banks' market power is low, and a positive impact when market power is high.

# 6 Concluding Remarks

Are low interest rates driven by lax monetary conditions conducive or detrimental to financial stability? This question has received ample attention both from academic and policy circles and generated a large, mostly empirical, literature. This paper sheds light on this question from a theoretical perspective. We present a model that highlights the relevance of the market structure of the financial sector to assess the effect of safe rates on financial intermediaries' risk-taking decisions.

Our base model features a fixed number of intermediaries that raise uninsured funding from risk-neutral investors and compete à la Cournot in providing loans to penniless entrepreneurs. The expected return required by investors is assumed to be equal to an exogenous safe rate, which is taken as a proxy for the stance of monetary policy. Intermediaries choose the monitoring intensity of their loans, which reduces the probability of default, but monitoring is unobservable, so there is a moral hazard problem between intermediaries and investors. Under our parameterization, in equilibrium monitoring will be proportional to the intermediation margin. Thus, the higher the margin, the lower the probability of default. It follows from here that to assess the effect of low rates on risk-taking decisions it is key to understand their effect on the intermediation margin.

We first show that in monopolistic loan markets the pass-through from funding costs to loan rates is weak, so lower rates result in higher intermediation margins and hence lower risk-taking by intermediaries. In contrast, in competitive markets the pass-through is strong, so lower rates result in lower intermediation margins and hence higher risk-taking by intermediaries. This implies that the slope of the relationship between the safe rate and probability of default goes down with an increase in the number of banks, changing from positive to negative as we move from monopoly to perfect competition.

Our analysis provides other novel testable implications. In particular, when intermediaries' market power is constrained by the possibility of firms borrowing directly from (non-monitoring) investors, which we show is more prone to happen in monopolistic markets, we predict a U-shaped relationship between the safe rate and the probability of default. We also predict that, when banks are heterogeneous in their monitoring technologies, lower safe rates increases the market share of intermediaries with high monitoring costs, a composition effect that moves the overall results in the direction of the competitive benchmark. Finally, we predict that a higher proportion of insured liabilities (which can be proxied by insured deposits, but due to implicit government guarantees might exceed them) makes it more likely that low safe rates translate into higher intermediation margins and hence lower risk-taking.

The results of the base model are robust to the introduction of (inside) equity capital, provided by long-lived shareholders that require a spread over the safe rate. We show that lower safe rates have two opposite effects. On the one hand, they increase leverage, which leads to higher risk-taking. On the other hand, they increase charter values, which leads to lower risk-taking. In monopolistic markets the charter value effect dominates, so lower rates translate into safer banks, while in competitive markets the leverage effect dominates, so lower rates translate into riskier banks.

Thus, our theoretical model provides a rich set of novel testable predictions regarding how different market and financial intermediaries' characteristics can affect the relationship between interest rates and risk-taking in the financial sector. However, it should be noted that our setup abstracts from other possible effects of monetary policy on aggregate credit demand or deposit supply, which can introduce further non-trivial interactions left for future research.

# Appendix

**Proof of Proposition 1** We have shown that the values of $m$ that satisfy equation (11) are such that, for a given loan rate $R(L)$, banks maximize their payoff and investors get the opportunity cost of their funds. Since the function in the left-hand side of (11) is convex in $m$, there are three possible cases. If $R(L) < \underline{R}$, equation (11) has no solution, so the banks will not able to fund their lending. If $R(L) = \underline{R}$, $m(L)$ will be the unique solution to equation (11). And if $R(L) = \underline{R}$, there will be one or two solutions to equation (11) for $m \geq 0$. If $R_0/(1-p) < R(L)$, $m(L)$ will be the unique positive solution to equation (11). If $R_0/(1-p) \geq R(L)$, let $\widehat{m}$ and $m^*$ denote the two solutions to equation (11), with $\widehat{m} < m^*$. To show that the banks' payoff is higher with $m^*$ it suffices to note that

$$\frac{d}{dm}\left[(1-p+m)R - R_0 - c(m)\right] = R - \gamma m > R - \gamma m^* = B^* > 0,$$

for $m < m^*$, which implies

$$(1-p+m^*)R - R_0 - c(m^*) > (1-p+\widehat{m})R - R_0 - c(\widehat{m}).$$

which completes the proof of the result. □

**Proof of Proposition 2** The effect of changes in the safe rate $R_0$ on equilibrium lending $L^*$ is obtained by differentiating the first-order condition (17), which gives

$$\frac{\partial L^*}{\partial R_0} = -\frac{\frac{\partial}{\partial R_0}[L^*\pi'(L^*) + n\pi(L^*)]}{L^*\pi''(L^*) + (n+1)\pi'(L^*)}.$$

Since we have assumed that $L\pi''(L) + (n+1)\pi'(L) < 0$, we need to show that

$$\frac{\partial}{\partial R_0}[L^*\pi'(L^*) + n\pi(L^*)] = L^*\frac{\partial \pi'(L^*)}{\partial R_0} + n\frac{\partial \pi(L^*)}{\partial R_0} < 0.$$

Starting with the second term, using the expressions for $\pi(L)$ and $m(L)$ in (18) and (14) we have

$$\frac{\partial \pi(L^*)}{\partial R_0} = \gamma[1-p+m(L)]\frac{\partial m(L^*)}{\partial R_0} = -\frac{\gamma[1-p+m(L)]}{\sqrt{[R(L)+\gamma(1-p)]^2 - 4\gamma R_0}} < 0.$$

With regard to the first term, by (19) we need to sign

$$\frac{\partial \pi'(L^*)}{\partial R_0} = \gamma[1 - p + m(L)]\frac{\partial m'(L^*)}{\partial R_0} + \gamma m'(L)\frac{\partial m(L^*)}{\partial R_0}.$$

For this, we first note that using (14) we can write

$$1 - p + m(L) = \frac{1}{2\gamma}\left[R(L) + \gamma(1-p) + \sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}\right].$$

Hence, using (3) and (14) we have

$$\begin{aligned}
&\gamma[1 - p + m(L)]\frac{\partial m'(L^*)}{\partial R_0} \\
&= \gamma[1 - p + m(L)]\frac{\partial}{\partial R_0}\left[-\frac{b}{2\gamma}\left(1 + \frac{R(L) + \gamma(1-p)}{\sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}}\right)\right] \\
&= -\frac{b}{2}[1 - p + m(L)]\frac{2\gamma[R(L) + \gamma(1-p)]}{[[R(L) + \gamma(1-p)]^2 - 4\gamma R_0]^{3/2}} \\
&= -\frac{b}{2}\left[\frac{[R(L) + \gamma(1-p)]^2}{[[R(L) + \gamma(1-p)]^2 - 4\gamma R_0]^{3/2}} + \frac{R(L) + \gamma(1-p)}{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}\right] < 0.
\end{aligned}$$

Next, we have

$$\begin{aligned}
&\gamma m'(L)\frac{\partial m(L^*)}{\partial R_0} \\
&= \frac{b}{2}\left[1 + \frac{R(L) + \gamma(1-p)}{\sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}}\right]\frac{1}{\sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}} \\
&= \frac{b}{2}\left[\frac{1}{\sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}} + \frac{R(L) + \gamma(1-p)}{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}\right] > 0.
\end{aligned}$$

Putting together the two previous expressions we conclude

$$\begin{aligned}
\frac{\partial \pi'(L^*)}{\partial R_0} &= -\frac{b}{2}\left[\frac{[R(L) + \gamma(1-p)]^2}{[[R(L) + \gamma(1-p)]^2 - 4\gamma R_0]^{3/2}} - \frac{1}{\sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma R_0}}\right] \\
&= -\frac{2\gamma R_0 b}{[[R(L) + \gamma(1-p)]^2 - 4\gamma R_0]^{3/2}} < 0,
\end{aligned}$$

as required. □

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