Interest Rates, Market Power, and Financial Stability

David Martinez-Miera
UC3M and CEPR

Rafael Repullo
CEMFI and CEPR

March 2018

Preliminary and incomplete

Abstract

This paper analyzes the effects of policy rates on financial intermediaries' risk-taking decisions. We consider an economy where (i) intermediaries have market power in granting loans, (ii) intermediaries monitor borrowers which lowers their probability of default, and (iii) monitoring is not observable which creates a moral hazard problem. We show that lower policy rates lead to lower intermediation margins and higher risk-taking when intermediaries have low market power, but the result reverses for high market power. We also show that when intermediaries have high market power competition from (nonmonitoring) financial markets results in a U-shaped relationship between policy rates and risk-taking. The paper examines the robustness of these results to introducing heterogeneity in monitoring costs, entry and exit of intermediaries, and funding with deposits and capital.

JEL Classification: G21, L13, E52

Keywords: Bank monitoring, Cournot competition, intermediation margins, bank risk-taking, monetary policy.

We would like to thank Gerard Llobet and Joan Monras for helpful comments. Financial support from the Spanish Ministry of Economy and Competitiveness, Grants No. ECO2014-59262-P (Repullo) and ECO2013-42849-P (Martinez-Miera) is gratefully acknowledged. E-mail: david.martinez@uc3m.es, repullo@cemfi.es.

1 Introduction

Lax monetary conditions leading to low levels of real interest rates have been identified as a key factor originating financial crises. One common argument on the recent financial crisis is that low policy rates before 2007 were a main driver of the subsequent financial collapse. This paper analyzes, from a theoretical perspective, how policy rates can affect the risk-taking decisions of financial institutions. The main objective is to highlight the relevance of the market structure of the financial sector in shaping such relationship.

We show how the effect of policy rates on risk-taking decisions of financial institutions depends on the degree of market power of those institutions. In highly competitive loan markets the standard prediction obtains: lower rates result in higher risk-taking by financial institutions. However, in highly concentrated loan markets lower rates result in lower risk-taking. This result obtains because, although lower policy rates lead to lower funding costs for financial institutions, the intensity of the pass-through of financing rates to loan rates depends on the market structure. Hence, lower policy rates can lead to either lower or higher intermediation margins, which in turn determine higher or lower risk-taking incentives for financial institutions. We show that in fairly concentrated (competitive) markets lower funding rates result in higher (lower) intermediation margins which reduce (increase) the risk-taking incentives of financial institutions. Therefore, we conclude that, although lower policy rates result in lower loan rates and higher credit supply, the riskiness of such credit can vary depending on the underlying market structure of the financial sector.[1]

We model a one-period risk-neutral economy in which a fixed number of financial institutions raise uninsured funding from deep pocket investors and compete à la Cournot in providing loans to penniless entrepreneurs. Financial institutions privately decide the monitoring intensity of their loans, where higher monitoring results in lower probability of default. Crucially, we assume that the monitoring decision is unobservable, which creates a standard moral hazard problem between the financial institution and its financiers. The

[1]From an empirical perspective, papers like Jimenez et al. (2014) and Iannadou et al (2015) show how monetary policy affects banks' risk-taking decisions.

expected return that investors require for their funds is assumed to be equal to an exogenous policy rate, which is our proxy for the stance monetary policy.

We show that a decrease in the policy rate (lax monetary policy) leads financial institutions to increase their loan supply and reduce equilibrium loan rates. However, the intensity of the reduction in loan rates (pass-through), and hence the effect on the intermediation margin, depends on their market power. Since monitoring decisions are linked to the intermediation margin, it follows that the effect on risk-taking by financial institutions also depends on their market power. In particular, in fairly competitive markets lower policy rates translate into higher risk-taking, while in monopolistic markets the relationship reverses sign, that is lower policy rates translate into lower risk-taking. Moreover, in line with the traditional (charter value) literature on competition and financial stability,[2] we also show that higher competition results in higher risk-taking for any level of the policy rate.

After stating our main results linking interest rates, market structure, and financial stability, we analyze three relevant aspects of competition in the loan market: (i) the possibility of non-intermediated funding of entrepreneurs, (ii) cost asymmetries among financial institutions, and (iii) entry and exit of financial institutions.

We first consider a situation in which entrepreneurs also have the possibility of being directly funded by competitive investors that do not monitor their projects. We show that the equilibrium interest rate that financial institutions can charge is affected by the entrepreneurs' outside funding option. In particular, direct market finance imposes a constraint on equilibrium loan rates. We show that this constraint is more likely to bind in concentrated loan markets and when policy rates are low. This implies that, when entrepreneurs have the option to access such funding, fairly concentrated loan markets exhibit a U-shaped relationship between the policy rate and the risk-taking decisions of financial institutions. For low (high) levels of the policy rate decreasing such rate increases (decreases) the probability of loan default. In contrast, for fairly competitive loan markets the results of the basic setup do not change, since direct market finance is not a competitive threat for financial institutions, and therefore it does not affect the Cournot equilibrium outcome.

[2] See, for example, Keeley (1990), Allen and Gale (2000), Hellmann et al. (2000), and Repullo (2004).

We next analyze a situation in which financial institutions differ in their monitoring abilities. We assume that there are two types of institutions: those with high and those with low cost of monitoring entrepreneurs. We show that, in equilibrium, financial institutions with high monitoring costs have lower market shares and their loans have higher probabilities of default. We characterize a situation in which lower policy rates decrease (increase) the market share of those institutions with lower (higher) cost of monitoring and increase (decrease) the probability of loan default. Hence, we conclude that, in the presence of heterogenous monitoring costs, lower policy rates can have different impact in the risk of different institutions. By increasing the market share of those institutions with higher cost of monitoring (which grant riskier loans) lower policy rates also affect the equilibrium structure and risk of the financial sector.

We conclude our analysis of financial market structure by taking into account entry and exit decisions of financial institutions. We view these decisions as a longer run phenomenon compared to the decisions to grant and monitor loans. Hence, we see this analysis as shedding light on the widespread view that interest rates that are "too low for too long" are detrimental to financial stability. We model entry decisions by assuming that financial intermediaries have to pay an ex-ante fixed cost to operate. We show that allowing for entry results in higher competition in the loan market, adding an "entry effect" to our basic results on low policy rates, which increases the probability of loan default.

Our main setup analyzes a situation in which financial intermediaries are entirely funded with uninsured deposits. What happens when intermediaries can also be funded with inside capital,[3] that is funds provided by those responsible for the monitoring decisions? As Dell'Ariccia et al. (2014) point out, a relevant determinant of banks' risk-taking decisions is its capital structure which can be affected by policy rates. Contrary to their results, we find that when the leverage ratio of financial institutions is endogenously determined, market structure is still a relevant variable in shaping how policy rates affect their risk-taking. Our results differ from those of Dell'Ariccia et al. (2014) because, while they assume an infinitely elastic supply of (inside) equity at a constant mark up above the policy rate, we assume that

[3] Outside equity capital plays essentially the same role as uninsured deposits.

(inside) equity is increasingly costly to raise. We obtain that for concentrated markets lower policy rates increase leverage (as in their paper) but at the same time decrease (instead of increase) the probability of loan default.

Overall this paper shows that market power is a key determinant of the effects of policy rates on the risk-taking decisions of financial intermediaries. For highly competitive market structures, lower rates result in higher risk-taking, while the result is reversed for concentrated market structures.

Literature review TBC

Structure of the paper Section 2 presents the basic model of Cournot competition in the loan market with uninsured deposits and unobservable monitoring by intermediaries, and analyzes how market power affects the relationship between the safe rate (proxying the stance of monetary policy) and the equilibrium monitoring intensity, which determines the probability of default of the loans. Section 3 examines the robustness of our results when we incorporate three relevant aspects of competition in the loan market, namely the presence of competitive market lenders that do not monitor borrowers, heterogeneity in monitoring costs, and entry and exit decisions. Section 4 examines the robustness of our benchmark results when intermediaries compete à la Cournot in the deposit market, and when they can also be funded with equity capital. Section 5 contains our concluding remarks. Proofs of the analytical results are in the Appendix.

2 The Model

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 institutions which we refer to as banks. Investors are characterized by an infinitely elastic supply of funds at an expected return equal to R_0 (the safe rate). Entrepreneurs have projects that require a unit investment at $t = 0$ and yield a stochastic return at $t = 1$ given by

$$\widetilde{A}(X) = \begin{cases} A(X), & \text{with probability } 1 - p + m, \\ 0, & \text{with probability } p - m, \end{cases} \tag{1}$$

where X is the aggregate amount of investment, $p \in (0, 1)$ is the probability of failure in the absence of monitoring, and $m \in [0, p]$ is the monitoring intensity of the lending bank. While p is known, m is not observable, so there is a moral hazard problem.

The success return $A(X)$ is assumed to be a linearly decreasing function of X. Given that entrepreneurs are penniless and only receive funding from banks, the aggregate amount of investment X equals the aggregate supply of loans L. We can therefore write the success return of a project as

$$A(L) = a - bL, \tag{2}$$

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

Finally, it is assumed that project returns are driven by a single aggregate risk factor, so for any given level of monitoring m they are perfectly correlated.

Banks compete à la Cournot for loans. Specifically, each bank j 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 $A(L)$. Then, banks offer an interest rate $B(L)$ to the (uninsured) investors,[4] and finally they choose the monitoring intensity $m(L)$. Monitoring is costly, and the cost function is assumed to take the simple functional form

$$c(m) = \frac{\gamma}{2} m^2, \tag{3}$$

where $\gamma > 0$.

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

$$m(L) = \arg\max_{m} \left\{ (1 - p + m)[A(L) - B(L)] - c(m) \right\}. \tag{4}$$

[4] Since A is a monotonic function of L, we may write $B(A)$ instead of $B(L)$, that is the banks' borrowing rate as a function of their lending rate.

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

$$A(L) - B(L) = \gamma m(L). \tag{5}$$

Thus, the banks' monitoring intensity $m(L)$ will be proportional to the intermediation margin $A(L) - B(L)$.[5]

The investors' participation constraint is given by

$$[1 - p + m(L)]B(L) = R_0. \tag{6}$$

Solving for $B(L)$ in the participation constraint (6), substituting it into the first-order condition (5), and rearranging gives the key equation that characterizes the banks' intensity of monitoring

$$\gamma m(L) + \frac{R_0}{1 - p + m(L)} = A(L). \tag{7}$$

Let us define

$$\underline{A} = \min_{m \in [0,p]} \left(\gamma m + \frac{R_0}{1 - p + m} \right). \tag{8}$$

The following result shows the condition under which banks will be able to raise the required funds from investors.

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

$$m(L) = \max \left\{ m \in [0,p] \mid \gamma m + \frac{R_0}{1 - p + m} = A(L) \right\} \text{ and } B(L) = \frac{R_0}{1 - p + m(L)}. \tag{9}$$

Whenever monitoring is interior one can show that

$$m(L) = \frac{1}{2\gamma} \left[A(L) - \gamma(1 - p) + \sqrt{[A(L) + \gamma(1 - p)]^2 - 4\gamma R_0} \right]. \tag{10}$$

From here it follows that $A'(L) = -b < 0$ implies $m'(L) < 0$. Thus, higher total lending L (which translates into a lower loan rate $A(L)$) implies less incentives to monitor. Also, an increase in the expected return R_0 required by investors reduces banks' monitoring intensity (for a given value of L).

[5] We implicitly assume that the cost of monitoring is sufficiently high, so that $m(L) < p$.

Banks' profits per unit of loans are

$$\pi(L) = [1 - p + m(L)]A(L) - R_0 - c(m(L)), \tag{11}$$

where we have used the fact that $[1 - p + m(L)]B(L) = R_0$.

A symmetric Cournot equilibrium l^* is defined by

$$l^* = \arg\max_l \left[l\pi(l + (n-1)l^*)\right]. \tag{12}$$

Assuming that $\pi(L)$ satisfies $\pi'(L) < 0$ and $\pi''(L) < 0$, the symmetric Cournot equilibrium l^* is characterized by the first-order condition

$$L^*\pi'(L^*) + n\pi(L^*) = 0, \tag{13}$$

where $L^* = nl^*$.

The equilibrium probability of loan default is then given by $PD = p - m(L^*)$. We are interested in analyzing the effect on PD of changes in two parameter values, namely the expected return R_0 required by investors, and the number n of banks in the market, which proxies banks' market power.

The effect of changes in the number of banks n is straightforward. Differentiating the first-order condition (13) gives

$$\frac{dL^*}{dn} = -\frac{\pi(L^*)}{L^*\pi''(L^*) + (n+1)\pi'(L^*)} > 0, \tag{14}$$

where we have used the assumptions $\pi'(L) < 0$ and $\pi''(L) < 0$. But since $m'(L) < 0$, it follows that increasing the number of banks increases equilibrium total lending, which in turn lowers the monitoring intensity of the banks and hence increases the probability of loan default.

However, as illustrated in Figure 1, the effect of changes in the safe rate R_0 depends on the number of banks n. The horizontal axis in this figure represents the safe rate R_0, and the vertical axis represents the probability of default PD. The different lines show the relationship between PD and R_0 for different values of n. For fairly competitive markets (high n), the relationship is negative, that is higher safe rates translate into lower risk-taking.

This is essentially the same result in Martinez-Miera and Repullo (2017a), who consider the limit case of perfect competition. The novel result obtains for fairly monopolistic markets (low n), where the relationship reverses sign, that is higher safe rates translate into higher risk-taking.

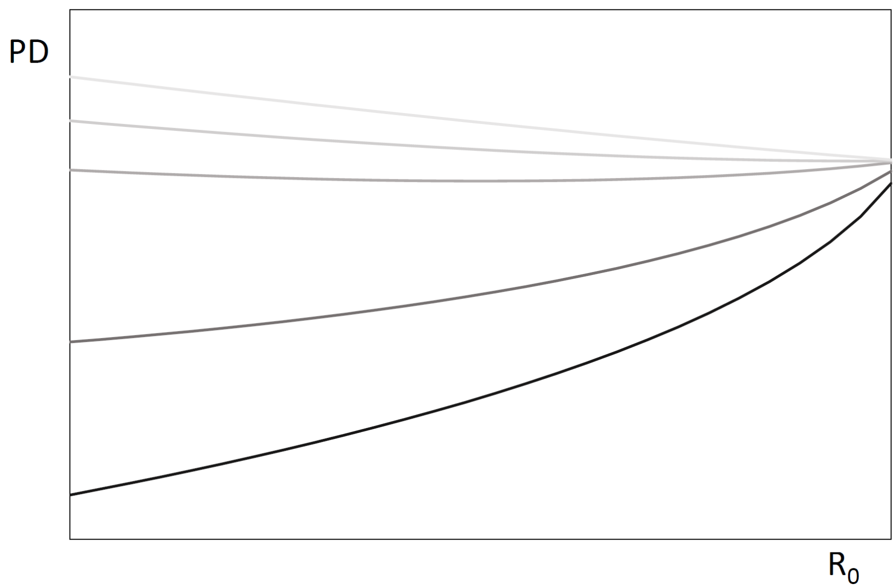

Figure 1. Effect of the safe rate on the probability of loan default

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

The intuition for these results is as follows. A reduction in the safe rate reduces banks' funding cost which translates into lower loan rates. In monopolistic markets this pass-through from financing costs to loan rates is not very intense and results in higher intermediation margins. This limited pass-through is crucial for our results as banks' monitoring (and risk-taking) decisions are determined by intermediation margins; see equation (5). In competitive markets the pass-through is more intense and results in lower intermediation margins and lower monitoring. Figure 2 illustrates the effect of changes in the safe rate R_0 on equilibrium intermediation margins $A - B$ for different values of the number of banks n.

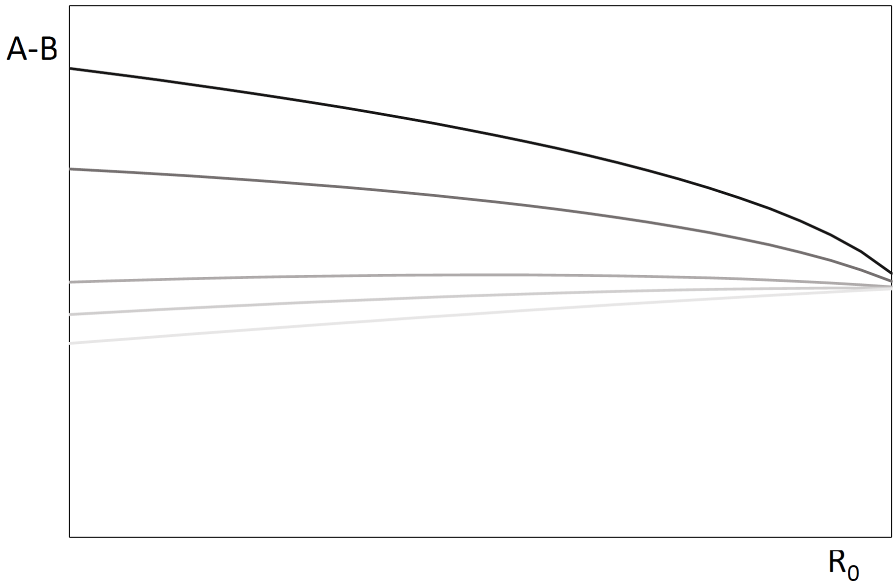

Figure 2. Effect of the safe rate on intermediation margins

This figure shows the relationship between the safe rate and the equilibrium intermediation margin for loan markets with 1 (bold line), 2, 5, 7, and 10 (light line) banks.

3 Market Structure

This section reviews our previous results on the relationship between interest rates and banks' risk-taking when we incorporate three relevant aspects of competition in the loan market. First, we consider the effect of the presence of competitive market lenders that do not monitor borrowers but limit the amount of rents that banks can capture. Second, we look at the effect of banks' heterogeneity in monitoring costs. Finally, we discuss the longer run effects that obtain when we allow for entry (or exit) of banks in the loan market.

3.1 Market Finance

Consider a variation of our model in which entrepreneurs can obtain funding for their projects from banks and also directly from investors. It is assumed that investors are not able to monitor entrepreneurs's projects (because they may be dispersed and subject to a free rider problem). They are also assumed to be competitive in the sense that they are willing to lend at a rate $\overline{R}$ that satisfies the participation constraint

$$(1-p)\overline{A} = R_0. \tag{15}$$

The presence of market lenders imposes a constraint on banks' lending, since the loan rate $A(L)$ cannot exceed the market rate $\overline{A}$. This means that the inverse loan demand function (2) now becomes

$$A(L) = \min\{a - bL, \overline{A}\}. \tag{16}$$

Clearly, the upper bound will be binding whenever the equilibrium in the absence of the bound is such that $A(L^*) > \overline{A}$. In such case the candidate equilibrium lending will be $\overline{L}$ such $A(\overline{L}) = \overline{A}$. By our previous results the banks' borrowing rate and monitoring intensity will be given by $B(\overline{L})$ and $m(\overline{L})$, respectively. The question is: will a bank j want to deviate when the other $n-1$ banks choose $\bar{l} = \overline{L}/n$?

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 $\overline{\pi} = \pi(\overline{L})$. Second, setting $l_j > \bar{l}$ is not profitable either since $\pi'(L) < 0$ and $\pi''(L) < 0$ imply

$$\bar{l}\pi'(\overline{L}) + \pi(\overline{L}) < \bar{l}\pi'(\bar{l} + (n-1)l^*) + \pi(\bar{l} + (n-1)l^*) < l^*\pi'(L^*) + \pi(L^*) = 0,$$

where the first inequality follows from the fact that $\bar{l} > l^*$ and

$$\bar{l}\pi''(\bar{l} + (n-1)l) + \pi'(\bar{l} + (n-1)l) < 0,$$

the second from the fact that

$$l\pi''(l + (n-1)l^*) + \pi'(l + (n-1)l^*) < 0,$$

and the equality is just the equilibrium condition in the absence of market finance.

Hence, we conclude that whenever the upper bound $\overline{A}$ is binding, the equilibrium amount of loans will be $\overline{L}$. Figure 3 shows the effect of introducing market finance on equilibrium interest rates for different values of the safe rate R_0 and the number of banks n. The horizontal axis represents the safe rate R_0, and the vertical axis represents the equilibrium loan rate A. The different lines show the relationship between A and R_0 for different values of n. The upper bound is binding for fairly monopolistic markets (low n) and for low values of the safe rate R_0.

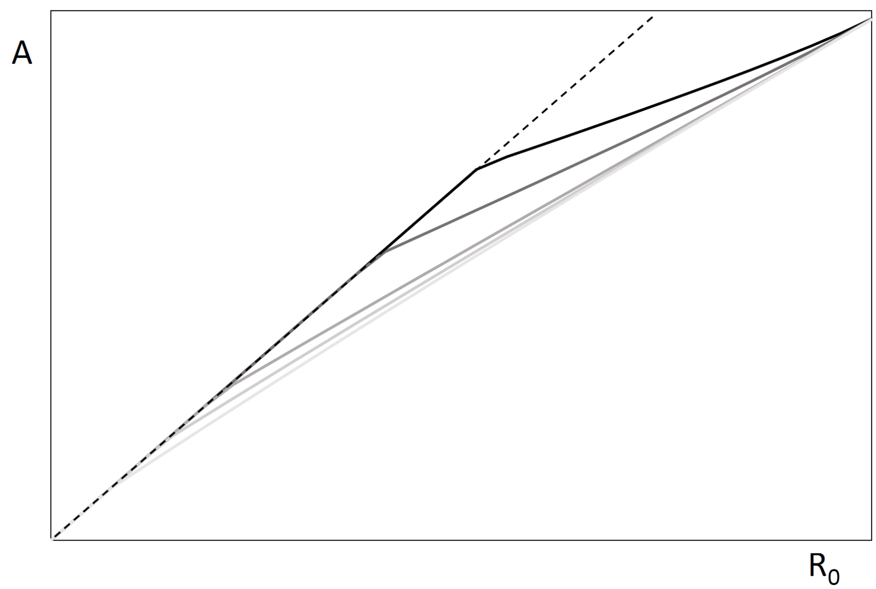

Figure 3. Effect of the safe rate on loan rates in the presence of market finance

This figure shows the relationship between the safe rate and the equilibrium loan rate for markets with 1 (bold line), 2, 5, 7, and 10 (light line) banks. The dashed line represents the loan rate under direct market finance.

Figure 4 shows the effect of introducing market finance on the equilibrium probability of loan default PD for different values of the safe rate R_0 and the number of banks n. The horizontal axis represents the safe rate R_0, and the vertical axis represents the probability of loan default PD. The different lines show the relationship between PD and R_0 for different values of n. For fairly competitive markets (high n), the relationship is still negative, that is higher safe rates translate into lower bank risk-taking. However, in contrast with the result in Section 2, in fairly monopolistic markets (low n) the effect 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 3, in these markets when the safe rate is low the loan rate A is bounded above by the market rate $\overline{A}$, which lowers intermediation margins and monitoring intensities, thereby increasing the probability of default.

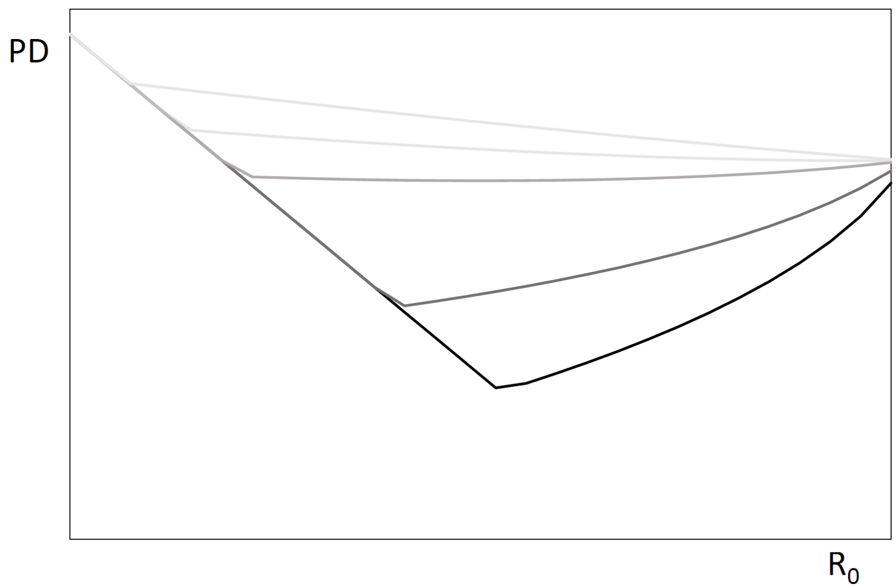

Figure 4. Effect of the safe rate on the probability of loan default in the presence of market finance

This figure shows the relationship between the safe rate and the probability of default for loan markets with 1 (bold line), 2, 5, 7, and 10 (light line) banks and competition from market lenders.

3.2 Heterogenous Monitoring Costs

Suppose now that there are two types of banks that differ in the parameter γ of their monitoring cost function (3): n_H banks have high monitoring costs, characterized by parameter γ_H, while $n_L = n - n_H$ banks have low monitoring costs, characterized by parameter $\gamma_L < \gamma_H$. It is assumed that a bank's type is observable to investors, so they can adjust their rates accordingly.

To characterize the equilibrium of the model with heterogeneous banks, note first that the critical values $\underline{A}_L$ and $\underline{A}_H$ defined in (8) by setting γ equal to γ_L and γ_H, respectively, satisfy $\underline{A}_L < \underline{A}_H$, except in the corner case where $\underline{A}_L = \underline{A}_H = R_0/(1-p)$.[6] From here it follows that whenever the total supply of loans L is such $\underline{A}_L < A(L) < \underline{A}_H$, only the low monitoring cost banks will operate.

By our results in Section 2, if $A(L) \geq \underline{A}_j$ the monitoring intensity chosen by bank $j = L, H$ is

$$m_j(L) = \frac{1}{2\gamma_j}\left[A(L) - \gamma_j(1-p) + \sqrt{[A(L)+\gamma_j(1-p)]^2 - 4\gamma_j R_0}\right], \tag{17}$$

and the corresponding borrowing rate is

$$B_j(L) = \frac{R_0}{1-p+m_j(L)}. \tag{18}$$

One can show that $m_L(L) > m_H(L)$, which implies $B_L(L) < B_H(L)$. That is, low monitoring cost banks will choose a higher monitoring intensity, and consequently will be able to borrow from investors at lower rates.

Banks' profits per unit of loans for $j = L, H$ are then

$$\pi_j(L) = [1-p+m_j(L)]A(L) - R_0 - c_j(m_j(L)). \tag{19}$$

Clearly, we have $\pi_L(L) > \pi_H(L)$.

A Cournot equilibrium is defined by a pair of strategies (l_L^*, l_H^*) that satisfy

$$\begin{aligned} l_L^* &= \arg\max_l \left[l\pi_L(l + (n_L - 1)l_L^* + n_H l_H^*)\right], & (20)\\ l_H^* &= \arg\max_l \left[l\pi_H(l + (n_H - 1)l_H^* + n_L l_L^*)\right]. & (21) \end{aligned}$$

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

$$\begin{aligned} L_L^*\pi_L'(L^*) + n_L\pi_L(L^*) &= 0, & (22)\\ L_H^*\pi_H'(L^*) + n_H\pi_H(L^*) &= 0, & (23) \end{aligned}$$

[6] This case obtains when $R_0 \leq \gamma_L(1-p)^2$

where $L_L^* = n_L l_L^*$, $L_H^* = n_H l_H^*$, and $L^* = L_L^* + L_H^*$.

Figure 5 shows the effect of changes in the safe rate R_0 on equilibrium lending by low and high monitoring cost banks, L_L^* and L_H^*, 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 $s = L_L^*/L^*$, increases with the safe rate, reaching 100% for high values of R_0.

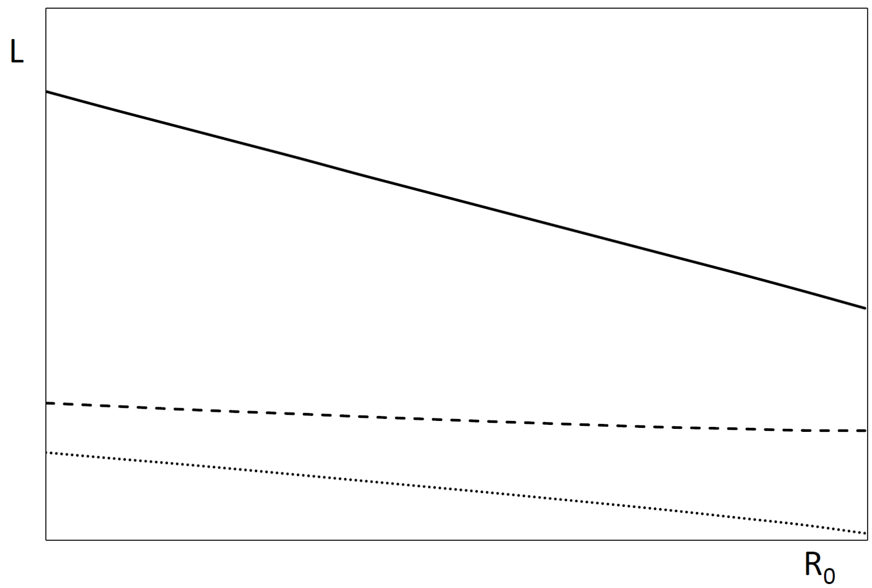

Figure 5. Effect of the safe rate on loan supply with heterogeneous monitoring costs

This figure shows the relationship between the safe rate and the aggregate supply of loans (bold line), and the supply of loans by banks with low (dashed line) and high monitoring costs (dotted line).

Since low monitoring cost banks choose a higher monitoring intensity, their loans have a lower probability of loan default. But since the market share of these banks increases with the safe rate, it follows that the average probability of loan default will get closer to that of the low monitoring cost banks. Figure 6 illustrates the effect of changes in the safe rate R_0

on the probability of loan default of low and high monitoring cost banks, $PD_L = p - m_L(L^*)$ and $PD_H = p - m_H(L^*)$, as well as on the average probability of default defined by

$$PD = sPD_L + (1-s)PD_H. \tag{24}$$

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. But due to the effect of increases in R_0 on the market share of the latter, the average probability of loan default PD goes down, approaching PD_L for large values of R_0.

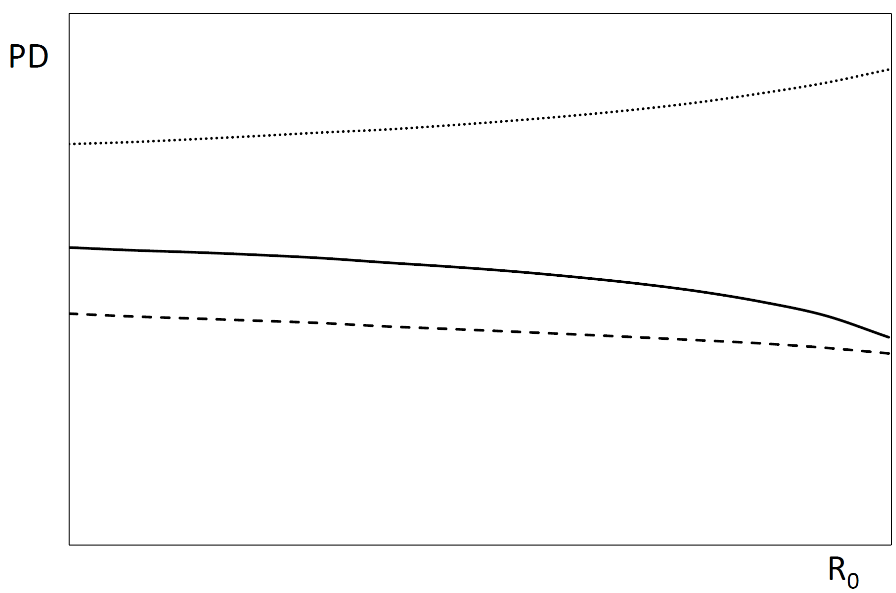

Figure 6. Effect of the safe rate on the probability of loan default with heterogeneous monitoring costs

This figure shows the relationship between the safe rate and the average probability of default (bold line), and the probability of default of loans by banks with low (dashed line) and high monitoring costs (dotted line).

3.3 Bank Entry

We next consider the longer run effects of changes in the safe rate when we allow for entry (and exit) of banks into (out of) the loan market. In this manner, we intend to shed light on the widespread view that interest rates that are "too low for too long" are detrimental to financial stability.

In order to endogenize the number of banks, we assume that each bank incurs a fixed cost to operate. Banks may have different fixed costs. In particular, let f_j denote the fixed cost of bank $j = 1, 2, 3, ...$, and assume that $f_{j+1} = f_j + z$, for all j, with $z \geq 0$. We consider two possible cases: one where all banks have the same fixed cost ($z = 0$), and another one in which the fixed cost is increasing in the number of banks ($z > 0$).

Let π_n^* denote the equilibrium level of profits (before subtracting the fixed costs) in a market in which n otherwise identical banks operate. Ignoring integer constraints,[7] the free entry equilibrium is characterized by a number n of banks that satisfy a zero net profit condition for the marginal bank, namely $\pi_n^* - f_n = 0$.

In what follows we analyze the effect of introducing either constant or increasing fixed costs on the relationship between the safe rate R_0 and the probability of loan default PD. The benchmark for this analysis will be the monopoly case ($n = 1$), in which as shown in Section 2 lower rates translate into lower probabilities of default.

Figure 7 shows the effect of introducing fixed costs on the equilibrium number of banks n for different values of the safe rate R_0. The horizontal axis represents the safe rate R_0, and the vertical axis represents the number of banks n. The horizontal solid line corresponds to the monopoly benchmark case, the dashed line is the constant fixed cost case, and the dotted line is the increasing fixed cost case. As expected, with lower rates there will be entry which will be more pronounced for constant fixed costs.

We have shown that increasing the number of banks increases equilibrium total lending, lowers the monitoring intensity of the banks and hence the probability of loan default. Since

[7] This implies that the fixed cost for arbitrary $n > 1$ is $f_n = f_1 + (n - 1)z$.

there will be more entry with lower rates, we have

$$\frac{\partial PD}{\partial R_0} + \frac{\partial PD}{\partial n}\frac{dn}{\partial R_0} < \frac{\partial PD}{\partial R_0}, \tag{25}$$

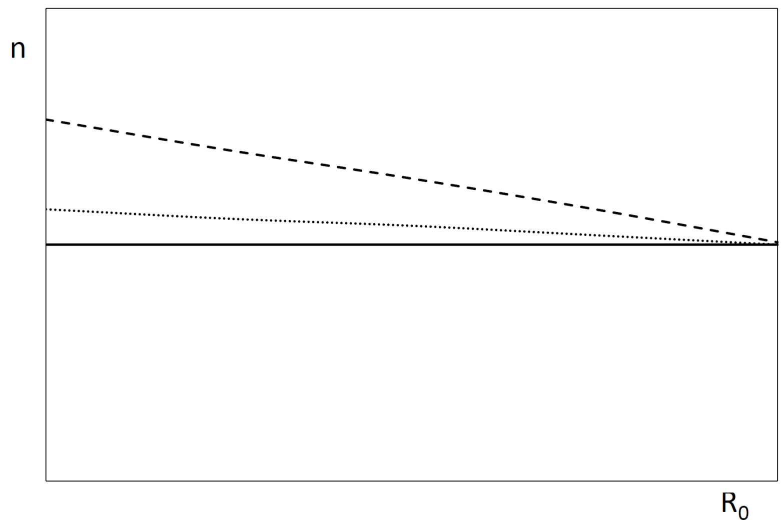

Figure 7. Effect of the safe rate on the intensity of competition

This figure shows the relationship between the safe rate and the equilibrium number of banks for a constant fixed cost (dashed line) and an increasing fixed cost of entry (dotted line). The bold line represents the benchmark with a fixed number of banks.

where the first term in the left-hand side shows the direct effect for a fixed number of banks, and the second term the indirect effect through bank entry. It follows that entry will tend to strengthen our previous results on the negative relationship between safe rates and bank risk-taking in fairly competitive markets, and possibly reverse our previous results on the positive relationship between safe rates and bank risk-taking in fairly monopolistic markets.

Figure 8 illustrates the latter results. The horizontal axis represents the safe rate R_0, and the vertical axis represents the probability of loan default PD. The solid line corresponds to the monopoly benchmark case, the dashed line is the constant fixed cost case, and the dotted line is the increasing fixed cost case. The effect of entry (the second term in the left-hand side of (25)) is clearly more pronounced for the constant than for the increasing fixed costs.

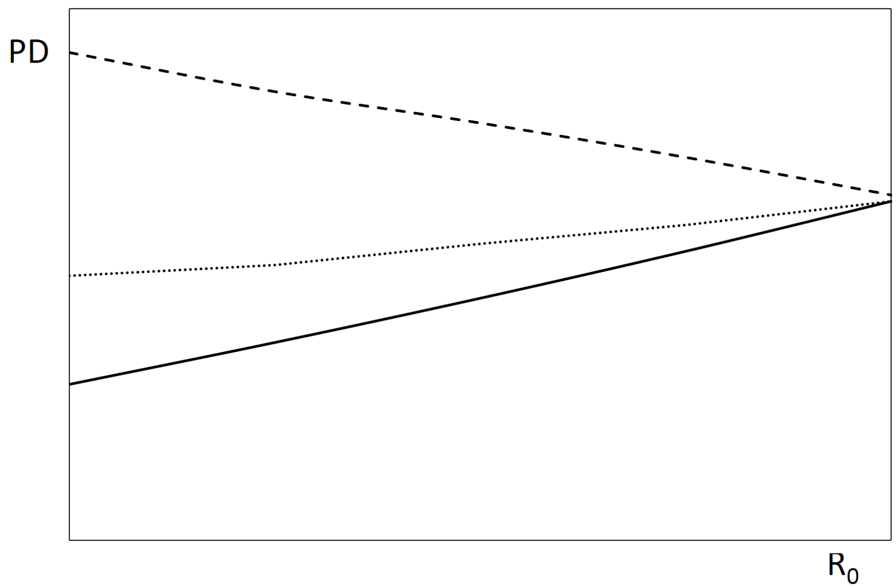

Figure 8. Effect of the safe rate on the probability of loan default with endogenous entry

This figure shows the relationship between the safe rate and the probability of default for a constant fixed cost (dashed line) and an increasing fixed cost of entry (dotted line). The bold line represents the benchmark with a fixed number of banks.

4 Banks' Funding Sources

This section analyzes the robustness of our results to incorporating two relevant aspects of banks' funding costs. First, we consider the effect on the relationship between interest rates and banks' risk-taking of banks competing à la Cournot in the deposit market. Second, we introduce bank capital, and analyze whether endogeneizing banks' leverage decision changes the relationship between interest rates and banks' risk-taking.

4.1 Endogenous Deposit Rates

TBC

4.2 Bank Leverage

We next consider the effects of changes in the safe rate when financial intermediaries can adjust their leverage. As highlighted by Dell Ariccia et al (2014) leverage decisions are an important driver of the risk taking effects of monetary policy. It is important to highlight that in our model equity should be seen as internal equity, i.e. funds provided by agents that either (i) make the unobservable risk taking decisions or (ii) have no conflict of interest with those that take them.

In order to endogenize banks' leverage decisions we assume that each bank operates with some amount of (inside) equity K_j that is costly to raise.[8] In particular we first solve a situation in which the amount of equity is fixed and then we analyze a situation in which we assume that in order to raise K amount of (inside) equity the banker has to incur a cost $G(K)$ where $G'(K) > 0$ and $G''(K) \geq 0$.[9]. Throughout our analysis we define as $k_j = K_j/l_j$ the (inside) equity ratio of bank j, where, given the balance sheet constraint, higher equity ratios result in lower leverage.

4.2.1 Fixed Equity

In line with our previous analysis we first solve the model for a fixed amount of bank equity, $K_j = \bar{K}$, and in the following subsection we analyze a situation in which K is endogenously determined. We do so in order to acknowledge that bank's (internal) equity might not be easy to raise specially in the short run. Interestingly, even when bank equity is fixed, we find that banks' leverage reacts to safe rates in the same qualitative manner that in Dell'Ariccia et al (2014): Lower safe rates result in an increase in banks supply of loans which, given the fixed equity, results in higher bank leverage. However, our results regarding loans' probability of

[8]It should be noted that in a setup like ours if equity would not be costly to raise banks would be totally funded with equity as this would allow to alleviate the moral hazard problem and increase bank's profits.

[9]The setup of Dell'Ariccia et al (2014) would be a special case of this setup in which $G'(K) = R_0 + \delta$.

failure differ from those of Dell'Ariccia et al (2014) as we find that for, fixed equity, lower safe rates result in higher leverage and lower (higher) risk taking in a concentrated (competitive) financial market.

Bank's maximization problem is now altered by its leverage decision. Taking into account that bank's profits per unit of loans can now be written as

$$\pi_j(L) = [1 - p + m_j(L)]\,(R(L) - (1 - k_j)B(L)) - c_j(m_j(L)) - k_j.$$

where, recall, $k_j = K_j/l_j$, we can rewrite bank's maximization problem as

$$\underset{l_j,k_j}{Max}\ l_j\pi_j(L)$$

Subject to bank's incentive compatibility constraint

$$m(L,k) = \arg\max_m \left\{(1 - p + m)[R(L) - (1 - k_j)B(L,k)] - c(m)\right\},$$

investors' participation constraint

$$(1 - p + m(L))\,B(L,k) \geq R_0,$$

and bank's participation constraint

$$l_j\pi_j(L) \geq 0.$$

Where given that investors have deep pockets we have $(1 - p + m(L))\,B(L,k) = R_0$. In general the participation constraint of the banks will be slack.

Following the same steps as in our basic setup we can show how the monitoring intensity chosen by bank j is

$$m_j(L,k) = \frac{1}{2\gamma}\left[R(L) - \gamma(1-p) + \sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma((1-k)R_0 - R(L)(1-p))}\right], \tag{26}$$

and the corresponding borrowing rate is

$$B_j(L) = \frac{R_0}{1 - p + m_j(L,k)}. \tag{27}$$

We can observe how higher capital per unit of loans, k, leads to higher monitoring and, therefore, lower bank funding rates. Given that, in this setup, banks have a fixed supply of internal capital they use all their equity in granting loans as this reduces their moral hazard problem which allows for cheaper funding and higher profits.[10]

Figure 9 shows the relationship between safe rates and banks' (inside) equity for a monopolistic (duopolistic) market where the solid (dashed) line represents the monopolistic (duopolistic) market. The horizontal axis are different values of the safe rate and the vertical axis represents banks' (inside) equity ratio. We can observe how higher safe rates increases banks equity ratio, the reason being that higher safe rates reduces banks supply of loans which in turn increases banks equity ratio. Given that we have fixed the amount of capital of each bank, in a duopolistic market the equity ratio increases as each bank supplies a lower amount of loans.[11]

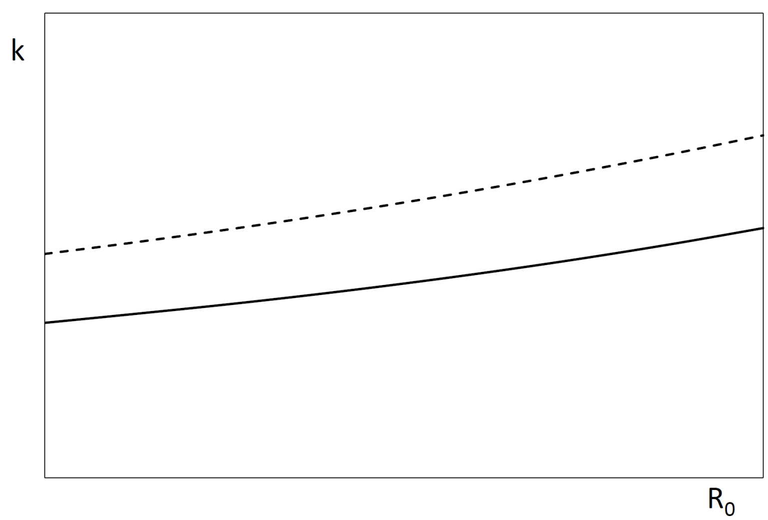

Figure 9. Effect of the safe rate on bank leverage with fixed equity

Figure 10 represents the relationship between safe rates and the probability of loan failure, PD, in a monopolistic (bold line) and duopolistic market (dashed line). We can observe that

[10] In the next subsection we analyze a setup in which banks have the option of raising aditional equity at a cost.

[11] If in order to maintain the aggregate amount of capital in the economy fixed we would fix the equity of each banks in the duopolistic market to be half of the monopolistic, bank the equity ratio in the duopolistic market would be smaller as banks would increase the aggregate supply of loans.

when the (inside) equity is fixed the relationship between safe rates and banks' risk taking decisions depends on market structure as it is increasing in a monopolistic banking market but decreasing in a duopolistic market. Interestingly, although equity ratios in the duopolistic market are higher, we observe how a more competitive and less leveraged banking market sector results in higher PD, which points to competition being a relevant factor even in the presence of banks' leverage decisions.

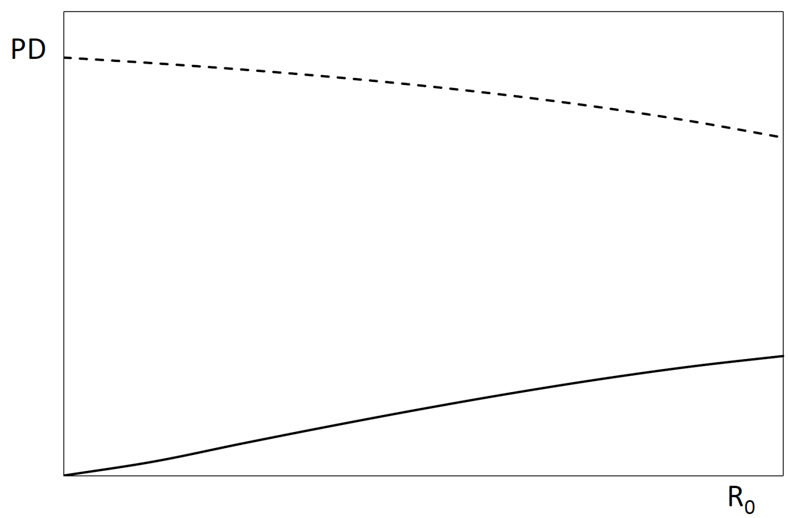

Figure 10. Effect of the safe rate on loan default probability with fixed equity

4.2.2 Endogenous equity

We now analyze a setup in which the aggregate amount of (inside) equity that each bank has, K_j, can adjust. We do so by assuming that $G'(K_j) > 0$ and $G''(K_j) \geq 0$. We show how the exact functional form of the cost of raising equity is a crucial driver of the relationship between safe rates and the probability of loan failure. For any given cost of raising equity function, we find that leverage goes up when safe rates decrease, but when $G''(K)$ is high enough, the sign of the relationship between safe rates and the probability of loan failure depends on banks' competitive intensity. It is also interesting to note that we obtain that the "cost of equity premium", $G(K) - R_0$, depends on the level of the safe rate. When safe rates are high banks are more willing to raise equity which increases the (inside) equity premium resulting in a positive relationship between the "cost of equity premium" and safe rates. Hence our model predicts that the "cost of equity premium" is correlated with safe rates.[12]

Taking into account that bank's profits per unit of loans can now be written as

$$\pi_j(L) = [1 - p + m_j(L)]\left(R(L) - (1 - k_j)B(L)\right) - c_j(m_j(L)) - G(K_j)/l_j.$$

and that $k_j = K_j/l_j$, we can rewrite bank's maximization problem as

$$\underset{l_j, K_j}{Max}\ l_j \pi_j(L)$$

Subject to bank's incentive compatibility constraint

$$m(L,k) = \arg\max_m \{(1 - p + m)[R(L) - (1 - k_j)B(L,k)] - c(m)\}$$

investors' participation constraint

$$(1 - p + m(L,k))\, B(L,k) \geq R_0$$

and bank's participation constraint

$$l_j \pi_j(L) \geq 0.$$

Where given that investors have deep pockets we have $(1 - p + m(L,k))\, B(L,k) = R_0$. In general the participation constraint of the banks will be slack.

Following the same steps as before we can show how the monitoring intensity chosen by bank j is

$$m_j(L,k) = \frac{1}{2\gamma}\left[R(L) - \gamma(1-p) + \sqrt{[R(L) + \gamma(1-p)]^2 - 4\gamma((1-k)R_0 - R(L)(1-p))}\right], \tag{28}$$

[12] This would not be the case in a setup in which the cost of raising equity is always a premium over the risk free rate as is the case in Dell'Ariccia et al (2014).

and the corresponding borrowing rate is

$$B_j(L) = \frac{R_0}{1 - p + m_j(L, k)}. \tag{29}$$

Figure 11 shows the relationship between safe rates and leverage for a monopolistic bank with high (solid line) and low (dashed line) equity adjustment costs (high and low $G''(K)$). We can observe how in both cases bank's (inside) equity ratio,k, (inverse of bank leverage) decreases with higher safe rates, but it does so more aggressively when the incremental cost of raising equity are lower (low $G''(K)$).

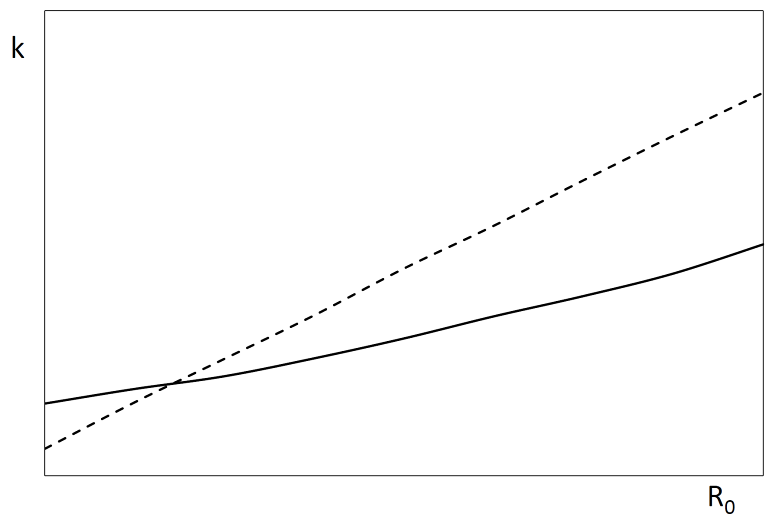

Figure 11. Effect of the safe rate on a monopolistic bank's leverage with costly equity

Figure 12 shows the relationship between safe rates and probability of loan failure,PD, for a monopolistic bank with high (solid line) and low (dashed line) incremental cost of raising equity. We can observe how in the case of high (low) incremental cost of raising equity, lower safer rates results in lower (higher) probability of loan failure. This results point to the fact that understanding how (inside) equity accumulates in the banking sector and how it interacts with market structure is a crucial determinant of the relationship between bank risk taking incentives and safe rates.

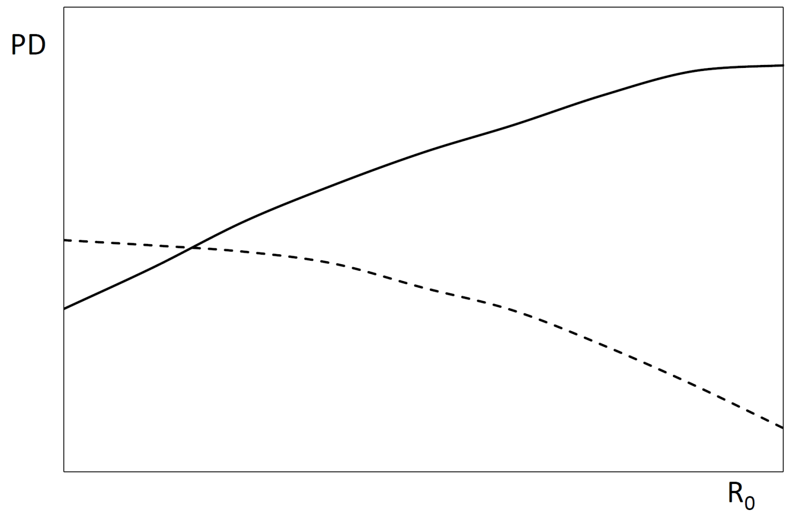

Figure 12. Effect of the safe rate on loan default probability of a monopolistic bank with costly equity

5 Extensions

This section analyzes two canonical cases: (i) the case in which banks operate only with insured deposits and (ii) the case in which there is no moral hazard (banks operate with uninsured deposits but with an observable and contractible risk choice). We show how in this two cases the results differ from our basic setup. When deposits are insured (no moral hazard) higher safe rates unambiguosly increase (decrease) the probability of default of the loans.

5.1 Insured deposits

Assume our benchmark model presented in section 2 in which deposits are insured and supplied at the rate R_0.

In such case banks objective function can be written as

$$\underset{l_j,m_j}{Max}\; l_j\left[(1-p+m)[A(L)-R_0]-c(m_j)\right].$$

Where the first order condition with respect to the supply of loans which determines the supply of loans of bank j, l_j, is

$$[(1-p+m)[A(L)-R_0]-c(m)]+l_j(1-p+m)[A'(L)]=0$$

Applying symmetry $L=nl$ and, using the linear function for $A(L)=A-BL$ we can obtain that

$$[(1-p+m)[A-bnl-R_0]-c(m)]-l_j(1-p+m)b=0$$

where using the implicit function theorem and the envelope theorem

$$\begin{aligned}-(1-p+m)nbdl-dl(1-p+m)b-(1-p+m)dR_0 &= 0\\ \frac{dl}{dR_0} &= -\frac{1}{(n+1)b}\end{aligned}$$

From here we can obtain that the intermediation margin $A(L)-R_0$ varies negatively with the safe rate

$$\frac{dA(L)-R_0}{dR_0}=\frac{n}{(n+1)}-1<0$$

Hence higher safe rates unambigously decrease the intermediation margin which in turn unambigously increases the probability of loan failure. Note that the optimal monitoring decision of the bank is given by the first order condition with respect to m_j

$$[A(L)-R_0]=c'(m_j)$$

We can conclude that in a setup in which the funding of the financial intermediary is insured lower rates will result in a lower probability of bank failure.

5.2 No moral hazard setup

Assume our benchmark model presented in section 2 in which there is no moral hazard between depositors and the managers of the financial institution. We assume that depositors are supplied at an expected return equal to R_0.

In such case banks objective function can be written as

$$\underset{l_j,m_j}{Max}\ l_j\left[(1-p+m)A(L)-R_0-c(m_j)\right].$$

Where the first order condition with respect to the supply of loans which determines the supply of loans of bank j, l_j, is

$$[(1-p+m)A(L)-R_0-c(m)]+l_j(1-p+m)[A'(L)]=0$$

Applying symmetry $L=nl$ and, using the linear function for $A(L)=A-BL$ we can obtain that

$$[(1-p+m)[A-bnl]-R_0-c(m)]-l(1-p+m)b=0$$

where using the implicit function theorem and the envelope theorem

$$\begin{aligned}-(1-p+m)nbdl-dl(1-p+m)b-dR_0 &= 0\\ \frac{dl}{dR_0} &= -\frac{1}{(1-p+m)(n+1)b}\end{aligned}$$

From here we can obtain that the return in case of success $A(L)$ varies positively with the safe rate

$$\frac{dA(L)}{dR_0}=\frac{n}{(1-p+m)(n+1)}>0$$

Hence higher safe rates unambigously increase thereturn in case of success $A(L)$ which in turn unambigously decreases the probability of loan failure. Note that the optimal monitoring decision of the bank is given by the first order condition with respect to m_j

$$A(L)=c'(m_j)$$

We can conclude that in a setup in which there are no moral hazard issues from financial intermediaries lower rates will result in a higher probability of bank failure.

5.3 Moral hazard + uninsured setup

This subsection is just as an "appendix" to highlight the underlying mechanism of our basic setup. Assume our benchmark model presented in section 2..

In such case banks objective function can be written as

$$\underset{l_j, m_j}{Max}\ l_j \left[(1-p+m)A(L) - R_0 - c(m_j)\right].$$

Where the first order condition with respect to the supply of loans which determines the supply of loans of bank j, l_j, is

$$[(1-p+m)A(L) - R_0 - c(m)] + l_j(1-p+m)[A'(L)] = 0$$

Applying symmetry $L = nl$ and, using the linear function for $A(L) = A - BL$ we can obtain that

$$[(1-p+m)[A - bnl] - R_0 - c(m)] - l(1-p+m)b = 0$$

where using the implicit function theorem and the envelope theorem (hence we are focussing in situations with interior m)

$$\begin{aligned} -(1-p+m)nbdl - dl(1-p+m)b - dR_0 &= 0 \\ \frac{dl}{dR_0} &= -\frac{1}{(1-p+m)(n+1)b} \end{aligned}$$

From here we can obtain that the return in case of success $A(L)$ varies positively with the safe rate

$$\frac{dA(L)}{dR_0} = \frac{n}{(1-p+m)(n+1)} > 0$$

The intermediation margin $A(L) - B$ on the other hand has no definite sign as we have that

$$\frac{dA(L) - B}{dR_0} = \frac{n}{(1-p+m)(n+1)} - \frac{dB}{dR_0}$$

Where

$$\frac{dB}{dR_0} = \frac{1}{(1-p+m)} - \frac{R_0}{(1-p+m)^2}\frac{dm}{dR_0}$$

Hence

$$\begin{aligned}
\frac{dA(L)-B}{dR_0} &= \frac{n}{(1-p+m)(n+1)} - \frac{1}{(1-p+m)} + \frac{R_0}{(1-p+m)^2}\frac{dm}{dR_0} \\
\frac{dA(L)-B}{dR_0} &= \underbrace{-\frac{1}{(1-p+m)(n+1)}}_{<0} + \underbrace{\frac{R_0}{(1-p+m)^2}\frac{dm}{dR_0}}_{>0}
\end{aligned}$$

It is useful ot recall that in an interior equilibrium we have that

$$A(L) - B = c'(m)$$

which allows us to obtain the following condition

$$\frac{dA(L)-B}{dR_0} = c''(m)\frac{dm}{dR_0}$$

Replacing such condition on the above expression we can obtain that

$$\begin{aligned}
\frac{dA(L)-B}{dR_0} &= -\frac{1}{(1-p+m)(n+1)} + \frac{R_0}{c''(m)(1-p+m)^2}\frac{dA(L)-B}{dR_0} \\
\frac{dA(L)-B}{dR_0} &= -\frac{1}{(1-p+m)(n+1)} + \frac{R_0}{c''(m)(1-p+m)^2}\frac{dA(L)-B}{dR_0} \\
\frac{dA(L)-B}{dR_0}\left[1 - \frac{R_0}{c''(m)(1-p+m)^2}\right] &= -\frac{1}{(1-p+m)(n+1)} \\
\frac{dA(L)-B}{dR_0} &= \frac{-\frac{1}{(1-p+m)(n+1)}}{\left[1 - \frac{R_0}{c''(m)(1-p+m)^2}\right]} \\
\frac{dA(L)-B}{dR_0} &= \frac{-\frac{1}{(1-p+m)(n+1)}}{\frac{c''(m)(1-p+m)^2 - R_0}{c''(m)(1-p+m)^2}} = -\frac{c''(m)(1-p+m)}{(n+1)\left[c''(m)(1-p+m)^2 - R_0\right]}
\end{aligned}$$

Hence the sign of $\frac{dA(L)-B}{dR_0}$ is given by the following expresion

$$\left[c''(m)(1-p+m)^2 - R_0\right]$$

Note that the previous expression will be positive as long as

$$\begin{aligned}
\left[c''(m)(1-p+m)^2 - R_0\right] &> 0 \\
(1-p+m)^2 &> \frac{R_0}{c''(m)} \\
m &> \sqrt{\frac{R_0}{c''(m)}} - (1-p)
\end{aligned}$$

Which given that$m$ is higher with lower$n$ and $c'''(m) \geq 0$ it is more prone to be positive for low n.

Hence we can conclude that

$$\frac{dA(L) - B}{dR_0} = -\frac{c''(m)(1-p+m)}{(n+1)\left[c''(m)(1-p+m)^2 - R_0\right]} < (>)0 \text{ if } \left[c''(m)(1-p+m)^2 - R_0\right] > (<)0$$

Taking into account that $A(L) - B = c'(m)$ we can conclude that lower rates will result in a safer banking system when $[c''(m)(1-p+m)^2 - R_0] > 0$ which is more prone to happen in a less competitive environment as long as $c'''(m) \geq 0$.

6 Conclusion

This paper presents a static model of the connection between safe rates, credit spreads, and the monitoring decisions of the financial sector. Banks intermediate between a set of entrepreneurs that are in need of financing and a set of investors who provide funding. We assume that all agents are risk-neutral and that banks can decide the monitoring intensity of entrepreneurs' projects at a cost, but this is not observed by investors. This moral hazard problem is the key friction that drives the results of the model. Our main focus is to show how the market structure of the financial sector, empashizing the competitive structure of the sector, is a key driver of the underlying relathionship between safe rates and financial stability.

We first characterize the equilibrium of the model assuming Cournot competition among financial intermediaries. We show that when the competition between financial intermediaries is high (low), high (low) number of financial intermediaries, lower rates result in a higher (lower) probability of loan default. This result highlights that the effects of lower rates on financial stability depend on the underlying competitive intensity of the financial sector. In an extension of the model we endogeneize the competitive intensity of the financial intermediary sector and show how lower rates result in an increase in compètition which increases the probability of loan failure. We conclude that the overall relationship between safe rates and financial stability also depends on how much the competitive structure reacts to lower rates as when competition reacts a lot to safe rates lower rates always result in higher probability of loan failure, but this is not the case when the elasticity of competition to loan rates is not high.

Once we establish our result regarding the relevance of competitive intensity between financial intermediaries, we show how the existence of perfectly competitive direct market finance also affects the relationship between safe rates and the probability of loan default. When direct market finance is an option for entrepreneurs we obtain a U-shape relationship between safe rates and financial stability when financial intermediaries are not very competitive: when safe rates are low, lower rates result in a higher probabilties of default(as direct market finance pushes the spreads downwards) but when rates are high lower rates result in lower probabilities of default(as direct market finance is not a competitive threat to financial intermediaries).

We also show how there can be assymetric effects of lower rates when banks are heterogeneous on their monitoring costs and how our main results regarding the importance of market structure on the relationship between safe rates and probability of bank failure are robust to the introduction of leverage decisions by banks intermediaries.

Overall our results provide a theoretical explanation of why the financial market structure, with a focus on competitive intensity, leverage decisions and assymetric costs of monitoring, can lead to assymetric effects of safe rates on financial stability.

Appendix

Proof of Proposition 1[13] To simplify the notation, let A denote $A(L)$. If $A < \underline{A}$, for any $m \in (0, p]$ we have

$$A - \frac{R_0}{1-p+m} - \gamma m < 0,$$

which implies that the bank has an incentive to reduce m. But for $m = 0$ we have

$$A - \frac{R_0}{1-p} < 0,$$

which violates the banks' participation constraint $B \leq A$.

If $A \geq \underline{A}$, by the convexity of the function in the right-hand side of (8) there exist an interval $[m^-, m^*] \subset [0, p]$ such that

$$A - \frac{R_0}{1-p+m} - \gamma m \geq 0 \quad \text{if and only if} \quad m \in [m^-, m^*].$$

By our previous argument, for any $m \in (0, p]$ for which

$$A - \frac{R_0}{1-p+m} - \gamma m < 0,$$

the bank has an incentive to reduce m. Similarly, for any $m \in [0, p)$ for which

$$A - \frac{R_0}{1-p+m} - \gamma m > 0,$$

the bank has an incentive to increase m. Hence, there are three possible values of monitoring in the optimal contract: $m = m^*$, $m = m^-$, and $m = 0$ (when $m^- > 0$).

To prove that the bank prefers $m = m^*$, notice that our assumptions on the monitoring cost function together with the definition of m^* imply

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

for $m < m^*$. Hence, we have

$$(1-p+m^*)A - R_0 - c(m^*) > (1-p+m)A - R_0 - c(m),$$

for either $m = m^-$ or $m = 0$ (when $m^- > 0$), which proves the result. □

[13] The proof is almost identical to the proof of Proposition 1 in Martinez-Miera and Repullo (2017)

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