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Bank Lending with Imperfect Competition and Spillover Effects*

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ABSTRACT

We examine bank lending decisions in an economy with spillover effects in the creation of new investment opportunities and asymmetric information in credit markets. We examine pricesetting equilibria with horizontally differentiated banks. If bank lending takes place under a weak corporate governance mechanism and is fraught with agency problems and ineffective bank monitoring, then an equilibrium emerges in which loan supply is strategically restricted. In this equilibrium, the loan restriction, the "under-lending" strategy, provides an advantage to one bank by increasing its market share and sustaining monopoly interest rates. The bank's incentives for doing so increase under conditions of increased volatility of lending capacities of banks, more severe borrower-side moral hazard, and lower returns on the investment projects. Although this equilibrium is not always unique, with poor bank monitoring and corporate governance, a more intense banking competition renders the bad equilibrium the unique outcome.

JEL Classification: E22; E62.

Keywords: Bank lending, threshold effects, underlending equilibria, interest rate competition.

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1 Introduction

A key problem in developing and transition economies is that of identifying and funding investment projects in sectors with high growth potential. Since banks have a comparative advantage in monitoring and screening firms, intermediated finance, i.e., mainly bank finance, will be the dominant form in such economies. Another feature of these economies is that the high growth potential sectors are likely to exhibit knowledge related spillover effects, or be marked with increasing returns at the sectoral level, as described by Romer (1986), so that their full potential will materialize only if the sector can attract a sufficiently large amount of capital. For developing and transition economies, this required amount of funding is likely to be beyond the means of any single bank. This will call for the coordination between banks in lending activities.

In this paper, we study this co-ordination problem using a model with a differentiated duopoly loan market, and a large number of small and cash-constrained firms, for which the banks are the only source of external finance. The sectoral increasing returns to scale is captured by the assumption that each firm's investment will bring a higher return if a sufficiently large number of firms can invest simultaneously. The main actors are the banks, which take a limited amount of funds that they control and decide whether to fund projects that will be highly profitable if the critical minimum level of investment is achieved, or to invest in safe but low return assets. Building on the framework developed in Altug et al. (2002), in this paper we emphasize the impact of imperfect competition and the role of price-setting behavior by banks.[1]

The critical role that banks have played in spurring growth through the direct finance of large-scale investment projects has long been emphasized.[2] Our contribution is to draw attention to the fact that, in many cases, banks assume that role in highly imperfectly competitive environments.[3] In addition, banks operate in environments with less developed legal systems and poor corporate governance structures. Consequently, they have to deal with debtors who divert the project returns, or misuse the borrowed funds to create private benefits for themselves. It is clear

[1]They model a sovereign government that borrows externally to finance a large-scale investment, which no individual lender can finance alone. They show that an endogenously created coordination failure among lenders leads to the project not being financed with probability one even if it is *ex post* feasible.

[2]Levine (1997) lists the role of financial intermediaries in the development process in terms of risk pooling and diversification, acquiring information about investments, and marshaling savings.

[3]See Fry (1995, p. 302) for imperfectly competitive banking sector in developing economies.

that imperfect competition leads to strategic behavior in banks' loan extension decisions and pricing of loan contracts. Our contribution is to show that the combined presence of sectoral spillover effects, and the moral hazard problems caused by weak corporate governance structures and insufficient contract enforcement, makes the banks resort to non-price strategic behavior (reduction of loan quantities), that substantially reduces the aggregate welfare.

Our focus on bank financing for new projects is consistent with the literature on the development of financial markets. A recent paper by Allen et al. (2005) confirms that bank loans and self fundraising are the main sources of financing for the early stage of development in emerging economies. In later stages of development, however, raising funds in the capital markets by issuing debt or equity become more important. Our model is particularly relevant for an economy in its early stages of development. However, our results are also relevant for sectors that have a potential of rapid growth via sectoral spillover effects, but have limited access to capital markets due to severe monitoring/screening problems.

In our model, the lending capacities of banks are subject to random fluctuations. This volatility is an important feature of the economic environment. Banks use non-price strategies to soften the price (loan rates) competition. The non-price strategy takes the form of an "under-lending" strategy. With randomly fluctuating lending capacities, a bank can increase its market share in the "good" state – when it has high lending capacity – by not making any loan offers in the "bad" state – when it has low lending capacity. If one bank can sustain the under-lending strategy, then in equilibrium, both banks will charge the interest rate that a monopoly bank would charge. In the under-lending equilibrium, ULE, no firm receives multiple loan offers: bank competition is completely eliminated, this is why both banks charge the monopoly interest rate. More importantly, in the ULE, the spillover effect fails to materialize even if there are sufficient funds in the banking system. Since the spillover effects materialize with much lower probability, the sector experiences lower and more variable growth rates.

Whether the under-lending strategy can be sustained in equilibrium, and raise the profit of the bank that pursues it, depends on a number of factors. This strategy is useful to the bank that adopts it, if the fundamentals are poor. By poor fundamentals we mean an economy in which: (i) the project returns are not very high even with the spill-over effect, (ii) firms have access to 'private benefit' projects that have low but divertible returns, and (iii) the probability that banks will have low lending capacities is large. The level of volatility in banks' lending capacities is also important. With large fluctuations in lending capacities, the under-lending strategy will lead to a substantial increase in market share and thus profits. Hence, it is not only the scarcity of funds, but also their variability that can be an obstacle for economic growth. We show that the fundamentals and the credit market structure interact. We establish a non-monotonic relationship between the incidence of under-lending and the degree of bank differentiation. Under normal circumstances, a lower degree of bank differentiation will stop the under-lending. In that sense more intense bank competition will eliminate the negative outcome of under-lending. However, if the fundamentals, especially those along the corporate governance dimension, are very poor, the under-lending equilibrium occurs with low degrees of bank differentiation. In fact, as we show, the under-lending equilibrium can be the unique equilibrium in those circumstances.

The remainder of the paper is organized as follows. Section 2 introduces the model and discusses its major assumptions within the context of the related themes from the banking literature. Section 3 characterizes the equilibria, and contains the formal results. Section 4 presents some numerical computations and comparative static results. Section 5 briefly considers some extensions to the model. Section 6 concludes. Longer proofs are in the Appendix.

2 The model

There are two banks, A and B, with random lending capacities. We let ω_i denote the lending capacity of Bank i, for $i = A, B$, that takes on two values, low and high, denoted by $\underline{\omega}_i$, and $\bar{\omega}_i$, respectively. The probability of low lending capacity is denoted by θ and is the same for both banks. The lending capacities are independent across banks, and private information. The productive sector consists of N identical firms, where N is large. Each firm seeks to raise funds to finance a highly profitable investment project, which we call the *good* project. We assume that firms must borrow from the banks; they cannot use direct debt. The *good* project requires a fixed-size investment of k_0, normalized to 1, and generates a gross return of either ρ_L or ρ_H, with $\rho_H > \rho_L$, depending on the number of firms that invest in the project.[4] Letting m denote the number of firms that invest in the *good* project, we make the following assumption.

[4]The entire investment must be financed with bank debt. We could also let firms finance a *fixed* proportion of the investment through their own funds. Provided that the share of the internal funds is not large, our results would go through.

Assumption 1 $\rho = \rho_H$ *if* $m \geq m^*$; $\rho = \rho_L$ *if* $m < m^*$.

Besides the *good* project, each firm has also access to a project with a gross return equal to 1.[5] The return from this project is not fully verifiable so that the firm can divert a fraction $\sigma \in (0,1)$ at zero cost. We refer to this as the *bad* project. As noted in Hart (2001), the owner of the firm can divert the project's returns, for example, "by setting up another firm, and choosing the terms of trade between the project and this firm to suck cash out of the project." Divertible cash flow is a specific case of "private benefits" due to poor corporate governance.[6]

We assume that bank monitoring cannot prevent the managers from switching between the "good" and "bad" projects once a loan is approved.[7] How much damage this inadequate monitoring will cause depends on the parameter σ. Hence, we can think of this parameter as a proxy for the degree of the monitoring skills/technology of the banks. With this interpretation, the bank's monitoring skills substitute for a proper corporate governance mechanism and prevent the insiders of the firm stealing from the creditors. We can also argue that given the bank's monitoring skills, the quality of the corporate governance environment determines σ.

Although these are two distinct aspects of bank monitoring, the ability to limit how much cash flow can be diverted vs. the inability to limit the firm's project choices, some positive correlation is likely. For example, if in an economy the enforcement of loan covenants is weak, i.e., firms can switch between the projects, then it is likely that in this economy a higher fraction of the cash flow can be diverted. To illustrate this point, let us consider a richer setting in which there is one *good* project, and K *bad* projects, with σ_k being the divertible fraction of the cash flow of the k^{th} *bad* project. It can be expected that the larger the project's σ, the easier to use a loan covenant or monitor the firm so that this particular *bad* project is not chosen. In this richer set-up, the bank's monitoring skills, together with the existing corporate governance structure, deter-

[5]This assumption is innocuous. We only need the verifiable return of the *bad* project to be low.

[6]See the surveys by Shleifer and Vishny (1997) and Zingales (1998) for corporate governance issues in general, Johnson (2000) for the specific mechanisms used to divert project returns.

[7]Put differently, we assume that loan covenants are of limited use. In defense, we can argue that in an underdeveloped legal and financial system, the enforcement of loan covenants may be problematic. In addition, since the spill-over or threshold effects are the result of each firm learning from the investment of the other firms, it is likely that the projects will be quite complicated and difficult to fully describe *ex ante*. Here as well, the loan covenants will be quite ineffective.

mine the *bad* project with the largest σ that the firm can choose without being stopped by the bank. Thus we interpret a small value of σ as representing an environment where banks have better monitoring capabilities and the legal infrastructure provides better covenant design and enforcement.

In our model there is no direct debt or entry by new banks. Bank entry or direct debt can eliminate the scarcity of funds and change our main results. The absence of direct debt is justified if firms are poorly capitalized and the amount of collateral they can provide is limited. In Holmstrom and Tirole (1997), the amount of firm capital and monitoring serve as substitutes for dealing with firm-side incentive problems. They show that only well-capitalized firms are able to issue direct debt. Reasonably well-capitalized firms borrow from banks, and under-capitalized firms cannot invest at all. We can view the firms in our model as moderately capitalized firms of Holmstrom and Tirole, for which only bank lending is feasible. As for the assumption of no bank entry, we argue that the incumbent banks have much better *ex ante* screening abilities than the new entrants. Then entry by new banks, that lack such expertise, may not be feasible.[8] Entry will be difficult if developing expertise in screening and monitoring is costly and requires time and commitment. This will be the case in emerging market contexts with less developed legal and financial systems. Hence poor corporate governance will give the incumbent banks substantial monopoly power. Although overall funds may not be scarce, funding to this particular sector *will* be scarce. It will be controlled by the two banks that have the needed monitoring/screening abilities.

Besides lending to the sector, each bank can also invest in an alternative asset, and earn a gross return of R_0, which is the same for both banks. We assume that even if less than m^* firms invest in the *good* project, the project's return exceeds the banks' return on the alternative asset, which in turn exceeds the verifiable return on the *bad* project. We record this assumption relating R_0 and the returns in the productive sector below.

Assumption 2 $1 \leq R_0 < \rho_L < R_0 + \sigma < \rho_H$.

Our assumptions regarding the banks' lending capacities are as follows.

Assumption 3 *(i)* $\bar{\omega} < m^*$; *(ii)* $2\underline{\omega} < m^* \leq \bar{\omega}+\underline{\omega}$; *(iii)* $\bar{\omega}+\underline{\omega} = N < 2\bar{\omega}$.

[8]Morgan and Strahan (2003) give evidence that supports the assumption that entrants tend to use collateral in lieu of the screening and monitoring activities.

Part (i) states that no single bank is large enough to finance the critical minimum number of firms, m^*. Hence, a concerted effort is needed for the spillover effect to be realized. Part (ii) states that the critical amount of funding can be achieved as long as one bank has high lending capacity. Part (iii) states that banks compete for firms only if both banks have high lending capacities. In that case, there will be an excess of loan offers if both banks intend to fully use their capacities to lend to the sector. Then, some loan offers will be declined by firms, and there will be a struggle for market share between the banks.

We model this competition as follows: Let $\tau > 0$ denote the degree of differentiation between banks.

Assumption 4 *If a firm has a loan offer from both banks, with R_i being the interest rate offered by Bank i, for $i = A, B$, it will accept Bank A's offer with probability 1 if $R_A < R_B - \tau$, with probability 0 if $R_A > R_B + \tau$, and with probability $p_A = \frac{1}{2} + \frac{R_B - R_A}{2\tau}$, if $|R_A - R_B| \leq \tau$.*

Assumption 4 states that banks are horizontally differentiated. The banks are symmetric in this regard: If $R_A = R_B$, the probability that a given firm will accept Bank A's offer is 1/2. A firm may have a preference for Bank A, or for B. At the time of the loan offer, banks do not know the true preferences of the loan applicant, but have a probabilistic assessment about it.[9] The assumption of differentiated banks is very common in the literature and quite reasonable.[10] Loan customers may not be completely indifferent between identical loan contracts offered by different banks. Differentiation can be due to relationship banking (Rajan 1992, Petersen and Rajan 1995), differences across banks in non-loan services (Evans 1997), geographic location (Schargrodsky and Sturzenegger 2000), or perceived stability and safety.

The time line of events is given below. Since the firms do not behave strategically, the strategic interaction between the banks occurs at stage 3, and is essentially a simultaneous move game with asymmetric information. We will find the Bayesian Nash equilibria of this game.

We assume that in stage 2 all firms apply to both banks for a loan. Since loan application is assumed to be costless, there is no harm in this assumption. At stage 3, the banks make loan offers as follows: Firms are numbered from 1 to N. Once Bank A decides how many loan offers to make, say l_A, it starts with firm number firm #1 and goes up to firm $\#l_A$ (recall that the size of the investment, hence the size of the loan, is

[9] In the appendix, we derive Assumption 4 using Hotelling's linear city model.

[10] See Villas-Boas and Schmidt-Mohr (1999), Besanko and Thakor (1992), Chiappori et al., (1995), and Economides et al. (1996).

stage 1	stage 2	stage 3	stage 4	stage 5
Each bank learns its lending capacity	Firms apply to banks for loans	Banks set interest rates and choose the number of loan offers	Firms take out loans and choose the project	Banks invest remaining funds in the alternative asset

Table 1: The time line of events

normalized to 1, therefore l_A denotes both the total quantity of lending by Bank A and the number of loans it makes); once Bank B decides how many loan offers to make, say l_B, it starts with firm $\#(N - l_B + 1)$ and goes up to firm $\#N$. This loan granting process minimizes the overlap in loan offers. It is intuitively clear that given the loan offers of Bank B, Bank A is always better off with minimizing the overlap in loan offers.[11] The strategy set of the Bank i consists of the interest rate (R_i) and the number of loans (l_i) as a function of its lending capacity (ω_i).

The information structure is as follows: The lending capacities of banks are private information. At stage 3 the banks make their loan offers simultaneously, therefore, neither the number of loan offers Bank A makes, nor the interest rate it offers, can be observed by Bank B, and vice versa. The assumption that the lending capacities of banks are private information is important for our results. Because the banks make their loan offers simultaneously, a bank does not know if the loan applicant has also an offer from the rival bank. Otherwise, the uncertainty about the banks' lending capacities can be resolved during the loan application-loan granting process, and some of our results will change. In stage 4, when the firms choose their projects, they know the total number of firms that have a loan. We comment on this assumption in the next section.

3 Equilibria with interest rate competition

We begin our analysis by characterizing the representative firm's project choice under the following assumptions: (i) Banks cannot observe the type of the project the firm chooses. This assumption was introduced in the preceding section. (ii) The individual firm that has a loan learns how many other firms also have a loan before choosing its project. To justify the second assumption, we argue that one can think of these firms as being organized in a "chamber of commerce" type organization that

[11]The assumption also rules out coordination failures such as the same $\bar{\omega}$ firms receiving a loan offer from both banks, whereas the remaining $N - \bar{\omega}$ firms receiving no offer at all.

facilitates the communication and exchange of information among firms, helping them to develop common strategies and enabling the creation of the spill-over effects. As a member of this organization, each firm is likely to find out approximately how many loans are made and at what terms. We simplify and assume that firms have perfect information on this.

The objective of the firm is profit maximization, where profits equal the project return less the debt repayment. Under the standard debt contract, if the firm chooses the *good* project, its profit will be $min\{\rho - R, 0\}$, where R denotes the debt repayment, and ρ denotes the project return. If the firms chooses the *bad* project, the firm gets σ by appropriating the non-verifiable part of the project's return and the bank gets $1 - \sigma$, the verifiable part of the project's return. Therefore, regardless of the interest rate the bank charges, the firm can guarantee a profit of σ by choosing the *bad* project. This implies that a firm that has a loan offer will always take that loan; and the only choice the firm makes is which type of project to implement. This decision depends on the level of aggregate lending and the interest rate of the loan contract, and is described in Lemma 1. The lemma shows that because the firm's project choice in unobservable, debt finance creates a moral hazard problem, and higher interest rates distort the firm's project choice towards the low return project with divertible returns.[12] To state the lemma, we define $\bar{R} \equiv \rho_H - \sigma$.

Lemma 1 *Let m be the number of firms that have a loan. If a firm has a loan from Bank i, such that $R_i > \bar{R}$, it will choose the bad project regardless of m. If $R_i \in (\rho_L - \sigma, \bar{R}]$, it will choose the good project if $m \geq m^*$; the bad project, if $m < m^*$. If $R_i \leq \rho_L - \sigma$, it will choose the good project regardless of m.*

Proof. Omitted. ■

We have $R_0 > \rho_L - \sigma$ by Assumption 2. Hence, no bank will lend at $R_i < \rho_L - \sigma$. Then, by Lemma 1, whether or not the moral hazard problem will materialize depends on the level of aggregate lending. Firms will misuse the funds in low return projects with divertible returns, only if the aggregate lending is low, so that the threshold level of aggregate investment of m^* firms cannot be achieved.[13]

[12] This is the well-known "asset-substitution" proposition of Jensen and Meckling (1976). See Hart's (2001) survey for more on this and debt financing in general.

[13] It should be noted that more sophisticated financial contract that makes the debt repayment contingent on the project returns can change this result. If $R(\rho) = \rho - \sigma$, if the firm always gets a profit of σ regardless of the level of aggregate lending with the *good* project, so that it never chooses the *bad* project. We comment more on this in Section 5.

Next, in Proposition 1, we give the necessary condition for *a* lending equilibrium to exist. We define:

$$R_{min} \equiv \frac{R_0 - \theta(1-\sigma)}{1-\theta}. \tag{3.1}$$

This is the lowest interest rate a bank would be willing to accept for a loan in the hypothetical situation in which the borrower firm invests in the *bad* project with probability θ, and thus repays only $1-\sigma$, and invests in the *good* project with probability $1-\theta$, and repays R_{min} as stated in the loan contract. Then the bank's expected return will be R_0.

Proposition 1 *There is no lending equilibrium if $R_{min} > \bar{R}$.*

Proof. See the appendix. ■

The intuition for Proposition 1 is as follows. Given the moral hazard problem, the maximum interest rate at which a firm will always choose the *good* project is $\rho_L - \sigma$. By Assumption 2 we have $R_0 > \rho_L - \sigma$, so, banks will not lend at $\rho_L - \sigma$; they will demand a higher interest rate. But, if they demand $R > \rho_L - \sigma$, they face a more severe risk: now firms will choose the *bad* project if there is insufficient lending. Since banks do not know each other's lending capacity, a bank that has low lending capacity itself cannot be sure if aggregate lending will be sufficiently high, so it demands at least R_{min} to be compensated for that risk. If $R_{min} > \bar{R}$, this cannot be done, because the interest rate must exceed R_{min} to be acceptable to the bank, but if R exceeds R_{min} then it also exceeds $\bar{R}$, and by Lemma 1, at this interest rate the firms choose the *bad* project for sure. Then a bank that has low lending capacity will drop out of the loan market. If that happens, then this time a bank that has high lending capacity cannot be sure either if aggregate lending will be sufficiently high. It will demand at least R_{min} and if $R_{min} > \bar{R}$. Hence, banks will drop out of the loan market regardless of their lending capacities.

To insure that a lending equilibrium exists, we will assume $\bar{R} \geq R_{min}$, equivalently,

Assumption 5 $R_0 \leq \theta + (1-\theta)\rho_H - \sigma$.

3.1 An example: Lending under severe conditions

By Proposition 1 and the condition given in Assumption 5, whether or not a lending equilibrium exists depends on a number of factors, that we term as the "fundamentals": (i) ρ_H, the return on the *good* project *with* the spillover effects, (ii) σ, the severity of cash diversion–expropriation that firms can engage in, and (iii) θ, the probability that the banks will have low lending capacity–the scarcity of bank funds. If a lending equilibrium exists, its structure will depend on a larger set of factors that also includes the degree of volatility of lending capacities, and the degree of bank differentiation.

We will now describe an economy with very poor fundamentals so that a lending equilibrium barely exists in the sense that a worsening in any one of the three fundamental parameters will destroy it. For this economy, the only lending equilibrium is an asymmetric one in which (i) bank lending is extremely volatile, (ii) the spill-over effects materialize with very low probability, (iii) loan interest rates are high, and (iv) firms quite frequently engage in cash diversion–expropriation.

Example 1 $\rho_H = 1.20$, $\sigma = 0.05$, $\theta = 0.20$, $N = 100$, $m^* = 80$, $\bar{\omega} = 65$, $\underline{\omega} = 35$.

For this economy, a lending equilibrium exists if $R_0 \leq 1.11$; we let $R_0 = 1.11$. The structure of the lending equilibrium depends on the bank differentiation parameter, τ. Since banks engage in Bertrand competition and are subject to capacity constraints, one would conjecture that a minimum degree of bank differentiation is needed for a pure strategy equilibrium. It turns out that there is a unique pure strategy equilibrium even if $\tau = 0$, furthermore, it remains the unique pure strategy equilibrium for $\tau \leq 0.01$; $\tau = 0.01$ means that the firm that has the strongest preference for Bank i will switch to Bank j, for an interest rate margin of 1%.

The unique pure strategy equilibrium is the following: Bank A sets $R_A = \bar{R} = 1.15$ and uses its entire lending capacity to make loans if its lending capacity is 65–all offers are accepted, does not lend at all if its lending capacity is 35. Bank B sets $R_B = \bar{R} = 1.15$, but makes only $N - \bar{\omega} = 35$ loans regardless of its lending capacity. Again, all offers are accepted.

We will name this equilibrium *the under-lending equilibrium.* Bank A increases its market share in the "good" state– when it has high lending capacity, by not making any loan offers in the "bad" state–when it has low lending capacity. In this equilibrium, both banks charge the highest incentive compatible interest rate, because no firm receives multiple loan offers: competition is completely eliminated. More importantly, the spill-over effect fails to materialize even if aggregate bank lending capacities are sufficiently large. Under Assumption 3 the spill-over effect can materialize if one bank has high lending capacity, i.e., with probability

$1-\theta^2$. In contrast, in the under-lending equilibrium, the spill-over effects will materialize only if both banks have high lending capacities, i.e., with probability $(1-\theta)^2$.

As this example illustrates, with weak economic fundamentals, the only lending equilibrium will be the *under-lending equilibrium*, if banks are not differentiated. When firms choose their banks mainly based on the loan interest rates offered, i.e., when bank competition is very severe, the loan quantities are restricted and interest rates are very high.

In the next section we give the general conditions for the existence of the under-lending equilibrium.

3.2 The under-lending equilibrium

The under-lending equilibrium exists if the economic environment is characterized by high degree of volatility in banks' lending capacities, and by poor fundamentals, as described in the preceding section. We start with the volatility of the lending capacities of the banks, the magnitude of the difference $\bar{\omega} - \underline{\omega}$.

Assumption 6 *The number of firms required to undertake the good project, m^*, satisfies the following relation: $\bar{\omega} - \underline{\omega} > N - m^*$.*

In this equilibrium, Bank A is the under-lender, it doesn't make any loans if its lending capacity is $\underline{\omega}$. Bank B, on the other hand, makes $N - \bar{\omega}$ loans regardless of its lending capacity. If Assumption 6 doesn't hold, then Bank A, even if its lending capacity is low, can contribute enough loans to achieve the spill-over effect. That is, if $N - \bar{\omega} + \underline{\omega} \geq m^*$, it cannot refrain from making loans also if it has $\underline{\omega}$. This will destroy the equilibrium. The second assumption concerns the profitability of lending to the sector, it is precisely the assumption of poor fundamentals. It states that the expected return to banks from lending to the sector is not much larger than the return on the alternative asset.

Assumption 7 $\theta(1-\sigma) + (1-\theta)\left(\frac{\bar{R} + R_0}{2}\right) < R_0.$

When Bank A under-lends, Bank B knows that if it makes an additional loan offer beyond $N - \bar{\omega}$, this offer will be accepted with probability 1 if Bank A has $\underline{\omega}$, and thus is not making any loan offers, and with probability 1/2 if Bank A has $\bar{\omega}$, and thus is using its entire lending capacity to make loan offers. In the former case, Bank B's return on the additional loan will be $1-\sigma$, in the latter case it will be $\bar{R}$, but only if it is accepted, which happens with probability 1/2. Under Assumption 7, this scenario is sufficiently severe to deter Bank B from expanding its loan offers beyond $N - \bar{\omega}$ if it has $\bar{\omega}$, while keeping its loan interest rate at $\bar{R}$.

However, if Bank B lowers its loan interest rate, its additional loan offer will be accepted with probability greater than $1/2$, depending on the degree of bank differentiation. Therefore, the third condition concerns the degree of bank differentiation. To state the condition, we first define $\lambda = (N - \bar{\omega})/(2\bar{\omega} - N)$, which is an index for the volatility of the lending capacities. Under Assumption 3, we have $\lambda > 0$, and smaller values of λ represent a higher degree of volatility. Next, we note that if the banks are only slightly differentiated, Bank B can make a small interest rate cut, and substantially increase the probability that its loan offers beyond $N - \bar{\omega}$ will be accepted. As Bank B deviates and offers an interest rate cut on the additional loan offers, it also must give the same reduction on the loans it extends to the $N - \bar{\omega}$ 'captive' firms. Hence the required minimum τ will depend on the number of captive firms, $N - \bar{\omega}$, as well as on the additional loans Bank B can make which is $2\bar{\omega} - N$.

The condition can now be stated as:

$$\frac{1-\theta}{\theta}\left\{\frac{1}{2\tau}\left[\left(\frac{\bar{R}-R_0+\tau}{2}\right)^2 - (\tau\lambda)^2\right] + \lambda\left[\tau(\lambda+\frac{1}{2}) - \left(\frac{\bar{R}-R_0}{2}\right)\right]\right\} < R_0 - (1-\sigma). \tag{3.2}$$

Proposition 2 characterizes the under-lending equilibrium. The equilibrium strategies for the banks are as follows: Bank A offers loans to firms $\#1$ to $\#\bar{\omega}$, at the interest rate $R_A = \bar{R}$ if its lending capacity is $\bar{\omega}$, it offers no loans if its lending capacity is $\underline{\omega}$. Bank B offers loans to firms $\#(\bar{\omega}+1)$ to $\#N$, a total of $\underline{\omega}$ loans, at $R_B = \bar{R}$ for both levels of its lending capacity. In this equilibrium, if both banks have high lending capacity, all firms receive one and only one loan offer. Firms numbered $\#(\bar{\omega}+1)$ to $\#N$ never receive a loan offer from Bank A, and firms numbered $\#1$ to $\#\bar{\omega}$ never receive a loan offer from Bank B. The interest rate is $\bar{R}$, the monopoly interest rate, regardless of the level of aggregate bank lending capacities.

Bank A makes no loans if its lending capacity is $\underline{\omega}$, whereas Bank B makes $\underline{\omega}$ loans if its lending capacity is $\underline{\omega}$. For Bank B there is some chance that these loans will payoff: they will pay off if Bank A's lending capacity is $\bar{\omega}$. For Bank A these loans will never payoff: Bank B only makes $\underline{\omega}$ loans, so, Bank A cannot provide the remaining $m^* - \underline{\omega}$ loans needed for the spillover effects if it has low lending capacity. There is also another equilibrium in which the roles of the banks is reversed.

For the purposes of the proposition, we define:

$$\tilde{R} = \frac{\bar{R}+R_0}{2}+\tau\left(\frac{1}{2}+\lambda\right), \tag{3.3}$$

$$R_\theta = \theta(1-\sigma)+(1-\theta)\bar{R}. \tag{3.4}$$

Proposition 2 *Let Assumptions 6 and 7 hold. There is an equilibrium in which Bank A sets $R_A = \bar{R}$ if it has $\bar{\omega}$ and lends $\bar{\omega}$, does not lend if it has $\underline{\omega}$, and Bank B sets $R_B = \bar{R}$ and lends $N-\bar{\omega}$ regardless of ω, (i) if $\tilde{R} < \bar{R}-\tau$ and $\theta(1-\sigma)+(1-\theta)(\bar{R}-\tau) < \frac{\lambda}{1+\lambda}R_\theta + \frac{1}{1+\lambda}R_0$, (ii) if $\tilde{R} \in [\bar{R}-\tau, \bar{R}]$, and Condition 3.2 holds, or (iii) if $\tilde{R} \geq \bar{R}$.*

Proof.
BANK A.

Given Bank B's lending strategy ($R_B = \bar{R}$, and loan offers: $\underline{\omega}$ for both levels of its lending capacity), Bank A will not make any loans if it has $\underline{\omega}$: Since $2\underline{\omega} < m^*$, loans of Bank A will bring $1-\sigma$ with probability 1. Similarly, since Bank B only lends to the $\underline{\omega}$ firms, and we have $N = \underline{\omega}+\bar{\omega}$ by assumption, none of the loan offers that Bank A makes if it has $\bar{\omega}$ will face competition from Bank B, therefore it is optimal for Bank A to set $\bar{R}$ for these loans. This shows that Bank A will not deviate from its equilibrium strategy.

BANK B.

- Suppose Bank B's lending capacity is $\underline{\omega}$. Given Bank A's lending strategy ($R_A = \bar{R}$, and loan offers: $\bar{\omega}$ if its lending capacity is $\bar{\omega}$; 0 if its lending capacity is $\underline{\omega}$), Bank B's payoff per loan for the first $\underline{\omega}$ loans as a function of R_B is $\theta(1-\sigma)+(1-\theta)R_B$. This is maximized at $R_B = \bar{R}$ and at $R_B = \bar{R}$ the payoff exceeds R_0 by Assumption 5. Therefore, Bank B will make $N-\bar{\omega}$ loans at $R_B = \bar{R}$ for both levels of its lending capacity ω_B.

- Now, suppose Bank B's lending capacity is $\bar{\omega}$. Suppose Bank B deviates and makes additional loans at $R_B \leq \bar{R}$. Let l_+ be the number of additional loan offers. Let p_B denote the probability that Bank B's loan offer will be accepted by a firm that has loan offers from both banks with $R_A = \bar{R}$ and R_B. Then, Bank B's total payoff from this deviation is given by

$$\begin{aligned}(N-\bar{\omega})[\theta(1-\sigma)+(1-\theta)R_B]+(2\bar{\omega}-N-l_+)R_0+\\ l_+[\theta(1-\sigma)+(1-\theta)(p_BR_B+(1-p_B)R_0)].\end{aligned} \tag{3.5}$$

Maximizing (3.5) with respect to l_+ and R_B is equivalent to maximizing $(N-\bar{\omega})(1-\theta)R_B + l_+\theta(1-\sigma-R_0) + l_+(1-\theta)p_B(R_B-R_0)$. Given $R_A = \bar{R}$, we rewrite it as

$$(N-\bar{\omega})(1-\theta)R_B + \\ l_+\left[\theta(1-\sigma-R_0) + (1-\theta)\left(\frac{1}{2} + \frac{\bar{R}-R_B}{2\tau}\right)(R_B-R_0)\right]. \tag{3.6}$$

The value of R_B that maximizes (3.6) depends on l_+. Lemma A.1 in the Appendix shows that the best deviation in loan offers is $l_+ = 2\bar{\omega} - N$. The most profitable deviation for Bank B is to use its entire lending capacity to make loans. The best interest rate cut is the R_B that maximizes (3.6) with $l_+ = 2\bar{\omega} - N$.

Differentiating (3.6) and setting it equal to zero and solving for R_B yields $\tilde{R} = \tau\lambda + (\bar{R} + R_0 + \tau)/2$.

- If τ is "too large", $\tilde{R}$ can exceed $\bar{R}$; in that case, the best deviation is with $R_B = \bar{R}$. Simple algebra shows that this happens if

  $$\tau > \frac{\bar{R}-R_0}{1+2\lambda} \equiv \tau_2.$$

  This deviation will not be profitable if Assumption 7 holds.

- A second possibility is that τ is "too small", so that $\tilde{R}$ is less than $\bar{R}-\tau$; in that case, the best deviation is with $R_B = \bar{R}-\tau$. Simple algebra shows that this happens if

  $$\tau < \frac{\bar{R}-R_0}{2\lambda+3} \equiv \tau_1.$$

  This deviation will not be profitable, if $\theta(1-\sigma) + (1-\theta)(\bar{R} - \tau) < \frac{\lambda}{1+\lambda}R_\sigma + \frac{1}{1+\lambda}R_0$, where $R_\sigma \equiv \theta(1-\sigma) + (1-\theta)\bar{R}$.

- Finally, if τ is neither "too small", nor "too large", i.e., if $\tau \in [\tau_1, \tau_2]$, $\tilde{R}$ is the best deviation. Bank B's average payoff per loan with $\tilde{R}$ is

  $$\frac{\lambda}{1+\lambda}\Big\{\theta(1-\sigma) + (1-\theta)\tilde{R} + \theta(1-\sigma) \\ +(1-\theta)\frac{1}{2\tau}\left[\left(\frac{\bar{R}-R_0+\tau}{2}\right)^2 - (\tau\lambda)^2\right] + R_0\Big\}. \tag{3.7}$$

The deviation will not be profitable, if (3.7) is smaller than $\frac{\lambda}{1+\lambda}[\theta(1-\sigma)+(1-\theta)\bar{R}]+\frac{1}{1+\lambda}R_0$, which yields condition (3.2) in the text.

■

The intuition is as follows. The best deviation for Bank B is to increase its loans in the high lending capacity state from $\underline{\omega}$ to $\bar{\omega}$. The best interest rate cut that goes with it is either (i) $\bar{R}$: no interest rate cut at all, or (ii) $\bar{R}-\tau$: the smallest cut that steals the firm with probability 1, or (iii) somewhere in between, i.e., $\tilde{R}$. For case (i), Assumption 7 is sufficient. For cases (ii) and (iii) we compare the equilibrium profits with the profits from the deviation. For case (ii) this condition becomes $\theta(1-\sigma)+(1-\theta)(\bar{R}-\tau)<\frac{\lambda}{1+\lambda}R_\theta+\frac{1}{1+\lambda}R_0$: Bank B makes more profit with offering loans to $N-\bar{\omega}$ firms at $R_B=\bar{R}$ rather than offering loans to $\bar{\omega}$ firms at $R_B=\bar{R}-\tau$. For case (iii) the comparison of profits is given by Condition 3.2.

The under-lending strategy of Bank A reduces the profitability of making more than $\underline{\omega}$ loans for Bank B. Additional loan offers beyond the first $\underline{\omega}$ offers will be accepted with a higher probability when the repayment is low, and will be accepted with a lower probability when the repayment is high. This is the result of Bank A making no loans if it has low lending capacity and many loans if it has high lending capacity. Therefore, Bank B becomes less aggressive in competing with Bank A when it has high lending capacity. Since the interest rate in the under-lending equilibrium is $\bar{R}$, Bank B will limit its loans only if $\bar{R}$ is sufficiently low. This is essentially the inequality in Assumption 7. The condition is more likely to hold in economies that have high value of σ, high values of θ, and low values of ρ_H. Therefore, the under-lending equilibrium is supported in economies with these inferior characteristics.

3.3 The full lending equilibrium

In the full lending equilibrium, FLE, for both levels of lending capacities, $\underline{\omega}$ and $\bar{\omega}$, banks offer their entire funds as loans. If both banks have $\bar{\omega}$, then each bank will make $\bar{\omega}$ loan offers, but only $N/2$ will be accepted. For any other realization of lending capacities, all loan offers will be accepted. The critical mass of investment, m^* firms, will be financed, if this is *ex post* feasible. Each bank will offer $\bar{R}$ in the low lending capacity state and a more competitive rate, R^*, in the high lending capacity state.

If $R^* \geq \bar{R}$ then banks charge $\bar{R}$ in both states.

$$R^* = R_0 + \tau \left(\frac{1 + \theta + 2\lambda}{1 - \theta} \right), \tag{3.8}$$

For a given τ, banks lower interest rates more if they anticipate that the other bank has a higher probability of having $\bar{\omega}$. Since $\lambda \equiv (N - \bar{\omega})/(2\bar{\omega} - N)$, they will also lower the interest rate more if $2\bar{\omega} - N$ is large, which means in the event that both banks have $\bar{\omega}$ the fight for market share will be significant.

The formal statement of the full lending equilibrium, Proposition A.1, is in the appendix. Here we offer an intuitive discussion. It exists if Assumption 5, the necessary condition for a lending equilibrium, holds and if the degree of bank differentiation is sufficiently large. In the Bertrand model with no product differentiation and no capacity constraints, the equilibrium prices converge to the firm's marginal costs. Here, R_0 can be thought as the banks' marginal cost. If there is product differentiation, then, as the Hotelling model shows, the equilibrium prices equal marginal cost plus the degree of differentiation. With random capacity constraints, the equilibrium interest rates equal R_0 plus τ, the degree of differentiation, where τ is multiplied by an expression that contains the probability of tighter capacity constraints, θ. Furthermore, a sufficiently large degree of differentiation is required for the existence of a pure strategy equilibrium.[14] If, however, the degree of bank differentiation is very large, bank competition will be ineffective, and banks will quote $\bar{R}$ regardless of their funds, the rate that a monopoly bank would charge. This is why we need the complicated expressions for the threshold values for τ.

4 The FLE vs. the ULE: Numerical results

Summarizing the preceding sections, the *full lending equilibrium* exists if R_0 is low enough to satisfy Assumption 5–without which no lending equilibrium exists, and if the banks are sufficiently differentiated. In contrast, the *under-lending equilibrium* exists if R_0 is not much smaller than the

[14]Otherwise, we will run into the Edgeworth Cycles problem. Banks start with high Rs, then undercutting each other they will lower their rates almost to R_0. Since each bank then can be a monopoly over the residual market, one bank will switch to $\bar{R}$, and re-start the process. See Levitan and Shubik (1972), Kreps and Scheinkman (1983), and Maskin and Tirole (1988).

largest R_0 that satisfies Assumption 5. Depending on the fundamentals, it can exist with much lower degrees of bank differentiation than the *full lending equilibrium*. In certain economic environments the two equilibria can co-exist. In this section we identify the conditions under which there are multiple equilibria. If this happens, we also identify conditions under which the *under-lending equilibrium* is more profitable for the bank that assumes the role of the under-lender.

Table 1 describes four economic environments that differ by the profitability of the *good* project *with* the spill-over effect, ρ_H in column 1, the divertible fraction of the *bad* project's return, σ in column 2, and the probability that bank lending capacities will be low, θ in column 3. We set $R_0 = 1.10$, $\tau = 0.1$, and fix the size of the sector at $N = 100$. The lending capacities of banks take on values of $\bar{\omega} = 65$ or $\underline{\omega} = 35$. The minimum critical number of firms required for the spill-over effect is $m^* = 80$. For all four cases, Assumption 5 holds so that a lending equilibrium exists.

							min τ such that	
	ρ_H	σ	θ	$\bar{R}$	$maxR_0$	$minR_0$	FLE exists	ULE exists
Case 1	1.25	0.05	0.25	1.20	1.1375	1.100	0.0166	0.0300
Case 2	1.20	0.05	0.20	1.25	1.1100	1.090	0.0070	0.0058
Case 3	1.50	0.10	0.50	1.40	1.1500	1.075	0.0340	0.0460
Case 4	1.40	0.10	0.40	1.30	1.1400	1.080	0.0270	0.0308

Table 2: ULE and FLE in different economic environments

Column 5 reports the values of $maxR_0$, which is the highest R_0 for which banks continue to lend to the firms. A higher value for $maxR_0$ represents an environment that is conducive to lending to firms. It means that banks will continue to lending to sector even if the risk-free return on the alternative asset is higher. Column 6 reports the values of $minR_0$: the ULE exists if $R_0 > minR_0$. If R_0 is very low, then lending to the firms is relatively very profitable. In those cases the ULE cannot exist. Hence we have multiple equilibria if $R_{max} \geq R_0 \geq R_{min}$. The last two columns report the lowest values of τ for which the pure strategy equilibrium exists. As mentioned earlier, a minimum degree of bank differentiation is needed for a pure strategy equilibrium.

Given the benchmark values of $\tau = 0.1$, and $R_0 = 1.10$, both the FLE and ULE exist in all four cases. Since $\tau = 0.1$ is quite large, banks set $R = \bar{R}$ in the FLE for all realization of the lending capacities.

In Cases 1 and 3 the ULE is eliminated by any arbitrarily small improvement in any one of the fundamentals, e.g., by an increase in ρ_H, a decline in θ, or a decline in σ. In Cases 2 and 4, in contrast, the ULE can be eliminated only by a sufficiently large improvement in the fundamentals.

The impact of bank differentiation, parameter τ, is quite interesting. A decline in τ eliminates the ULE but only if the environment is sufficiently conducive to lending, that is, if the fundamentals are sufficiently strong. The sufficiency is captured by the size of the difference between $maxR_0$ and R_0. When $maxR_0$ is lower, the ULE becomes more resilient to declines in τ. This can be seen by comparing Cases 1 and 2 and noting that $min\,\tau$ for the ULE is much smaller for Case 2. Furthermore, in Case 1 a steady decline in τ from its initial level of 0.1 will first destroy the ULE. In Case 2 a similar decline will first destroy the FLE. Note that Case 2 is very similar to the example with bad economic conditions that we discussed in section 3.1. Case 1 represents a better environment, as reflected by the higher value of $maxR_0$. It is an encouraging result that for Case 1 the gradual decline in τ first destroys the inefficient ULE. As each bank has less monopoly power over firms, as competition by lower interest rates becomes more severe, the inefficient equilibrium disappears. For Case 2, however, the opposite result obtains: as τ declines gradually, the efficient FLE disappears first and the ULE remains. Whether the inefficient equilibrium can be eliminated with increased competition depends very much on the underlying parameters of profitability, scarcity of bank funds and banks' ability to monitor firms to prevent diversion of the project returns.

Next, we identify conditions that make the ULE more profitable for the bank that engages in under-lending. We observe that in all four cases, if the volatility in banks' lending capacities, the difference $\bar{\omega} - \underline{\omega}$, is large, the ULE is more profitable regardless of other factors such as the profitability of the *good* project, the magnitude of cash diversion by the firms, or the degree of bank differentiation. These factors matter only if volatility is low. When they matter, a worsening in any one of them makes the ULE relatively more profitable.

To illustrate we consider the profitable environment of Case 3. With $\bar{\omega} = 60$, $\underline{\omega} = 40$, both equilibria exist and the FLE is more profitable. If we weaken the fundamentals, e.g., raise σ to 0.1145, or lower ρ_H to 1.466, the ULE becomes more profitable. For Case 2, the ULE is more profitable, even with a low volatility in lending capacities. Hence, if the return on the *good* project is low, or degree of expropriation are high, as they are in Case 2, the ULE will be profitable even with low levels of volatility.

5 Extensions

In our analysis we assumed that banks use simple debt contracts: the firm borrows 1 unit of capital, promises to repay R units back. Banks can offer more sophisticated contracts by which the debt repayment is tied to the project returns. For instance, a bank can set $R(\rho) = \rho - \sigma$, where ρ denotes the project return, and insure that the firm always chooses the *good* project. The return to the bank will be $\theta\rho_L + (1-\theta)\rho_H - \sigma$. This is larger than the maximum return a bank can achieve with a simple debt contract, which is $\theta + (1-\theta)\rho_H - \sigma$, because $\rho_L > 1$ by Assumption 2. As a result, *a* lending equilibrium will exist for a larger set of parameter values. The conditions for the ULE will also change. In the inequality of Assumption 7, $\theta(1-\sigma)$ will be replaced by $\theta(\rho_L - \sigma)$, hence the left-hand side of the inequality will increase so that the condition is less likely to hold. Our main results, however, continue to hold with this new set-up. A lending equilibrium exists if $R_0 \leq \theta\rho_L + (1-\theta)\rho_H - \sigma$, and the ULE exists if $R_0 \geq \theta(\rho_L - \sigma) + (1-\theta)(\frac{\rho_H - \sigma + R_0}{2})$, this is the necessary condition for the ULE to exist with the new loan contract. It is easily verified that these two inequalities can hold simultaneously, although the range of R_0 values for which they hold is now smaller than it was with the simple debt contract. Hence the sophisticated loan contract by itself cannot eliminate the ULE. The intuition of the basic model still applies. Even though with the new debt contract the *bad* project is never chosen, the possibility that it *could* be chosen, hence the parameter σ, limits how much profits banks can make from the firms hence the likelihood that the ULE will exist.

Another assumption we made is that the banks demand the same repayment from all loan applicants. Since in equilibrium the banks know which firms receive only one loan offer and which firms receive two, they could demand a higher repayment from the "single-offer" firms. Our results will not change, if we allow banks to do "price discrimination" in this way, although the conditions needed for the *ULE* will change. It will be more difficult to sustain the ULE. The intuition is that when Bank B deviates and makes additional loan offers beyond $N - \bar{\omega}$, it will only reduce R_B on these additional offers. Thus there will be more profitable deviations from the ULE when differential interests rates are allowed. Without price discrimination, when Bank B deviates, and offers an interest rate cut on the additional loan offers, it must give the same reduction on the loans it extends to the $N - \bar{\omega}$ 'captive' firms. Thus, it will be more costly for Bank B to break-away from the ULE.

Entry by more banks can change our results. If it reduces the probability that aggregate bank lending capacities will be less than m^* it will solve the problem of strategic under-lending. It can, however, also intensify the bank competition. The increase in market share of Bank A in the ULE is $\bar{\omega} - N/2$, therefore, the relative profitability of the ULE will be larger if $\bar{\omega} - N/2$ is larger. With more banks, say with three banks, the increase in market share of the bank that pursues the under-lending strategy will be $\bar{\omega} - N/3$, so the strategic advantage of the under-lending strategy will become more pronounced. This may increase the probability that the banks will coordinate on the ULE.

An interesting possibility is that the aggregate welfare (total profits of the banks and the firms) will be higher if the banks are allowed to form a monopoly. The firms will be worse off in comparison to the FLE, since they will pay a higher interest rate, but the increase in bank profits will more than compensate for this loss. In the monopoly equilibrium, the bank will lend in all states of the world except when both subdivisions have low lending capacities. The *bad* project will never be implemented, and the spill-over effect will be realized whenever it is feasible. That a monopoly is more efficient than a duopoly comes from the simple structure of our model: since there is no firm heterogeneity, a monopoly bank doesn't reduce the loan quantity to an inefficient level. If they are not allowed to form a monopoly, the banks may consider other forms of cooperation, such as sharing information about their lending capacities. With information sharing the ULE will be eliminated, but the interest rates in the FLE will be lower. Banks will not make loans if they both have low lending capacities, and avoid the low returns of $1-\sigma$. We conjecture that if θ is large, so that the competition with both banks with high lending capacities very likely and if τ is small, so that bank competition leads to very low interest rates, banks will not be willing to share information about their lending capacities.

6 Concluding remarks

Many developing and transition countries at times offer conflicting views of their long-term prospects. If the sources of aggregate risk in the economy could be eliminated, their growth potential would be unleashed, and their macroeconomic prognosis would improve. Governments with good intentions design economic policies to that effect. In many instances, however, the actual measure of risks depends on the behavior of economic agents responding to exogenous conditions and market imperfections. Without an understanding of such behavior, government policies will not have their intended consequences. Endogenously created risks that are over and above the risk due to observable fundamentals may explain why certain groups of countries have failed to perform as well as expected, while others, similar in observable fundamentals, have fared substantially better.

Our paper is helpful for understanding these phenomenon in the context of bank finance. We use a model that is rich in institutional details, including considerations of imperfect market competition among banks, firms' project choice, corporate governance issues, agency problems and monitoring. We study lending equilibria when there exist spillover effects in the generation of productive investment projects, random fluctuations in bank lending capacities and moral hazard issues due to inadequate bank monitoring. We show that if bank lending takes place under a weak corporate governance mechanism and is fraught with agency problems and ineffective bank monitoring, then an equilibrium emerges in which loan supply is strategically restricted.

A key insight of our analysis is that various adverse outcomes in the economy, whether they arise directly from fundamentals or from market structure, can become compounded and magnified as a result of uncompetitive lending behavior among banks. We find that strategic under-lending becomes more profitable when the fundamentals are poor. As such, our results suggest that competition is not the quick fix for all problems. Simple financial deregulation measures such as freeing interest rates (as has been advocated in recent financial liberalization programs in developing countries), may not improve the functioning of the credit market under volatile conditions. Allowing banks to compete in interest rates in those cases will not guarantee a more efficient outcome. If the profitability in the productive sector is low, and bank monitoring and corporate governance structure is ineffective, banks will pursue the under-lending strategy rather than lowering interest rates.

A major factor leading to under-lending is the excessive volatility in lending capacities. With increased volatility, banks still face the risk of poor returns in the low lending capacity state but the competition is more intense in the high lending capacity state which increases the profitability of the under-lending strategy. Volatility is especially relevant for developing economies because lending capacities often depend on foreign borrowing, and systemic risk induces high deposit variability or unexpected fluctuations in bank capital. One of the impacts of recent financial liberalization programs has been the increase in the volatility of bank lending capacities.

Our analysis illustrates that factors arising from the objective environment and factors arising from strategic behavior jointly determine whether a sector that can become the driving source of rapid growth obtain the required funding. The required coordination in lending is achieved in equilibrium *if* the fundamentals are sound. Policies designed to increase bank competition under less favorable circumstances may not improve the chances for project finance. To the contrary, they may lead to under-lending.

A Appendix

Derivation of Assumption 4 from Hotelling's linear city model. Let x_i denote the *type* of firm i. The type is not known to the banks. Banks assume that each x_i is uniformly distributed on $[0, 1]$. If a firm of type x borrows from Bank A, it incurs a cost of τx, if it borrows from Bank B, it incurs a cost of $\tau(1-x)$. Here, τ is the well-known transportation cost in the Hotelling model, or the taste parameter. Given the interest rates offered by Bank A and B, R_A and R_B, the firm with type x will borrow from Bank A if and only if $-R_A - \tau x \leq -R_B - \tau(1-x)$, $\Leftrightarrow x \leq 1/2 + (R_B - R_A)/2\tau$. Since Bank A doesn't know the true value of x, it assigns probability $1/2 + (R_B - R_A)/2\tau$ to its loan offer being accepted by the firm.

Proof. (Proposition 1) The existence of a lending equilibrium. No bank will lend at $R_i \leq \rho_L - \sigma$. To see this, note that if $R_i \leq \rho_L - \sigma$, the firm will choose the *good* project regardless of m, so the bank's return will be R_i with probability 1. Since $R_0 > \rho_L - \sigma$ by Assumption (2), $R_i \leq \rho_L - \sigma$ is not high enough for the bank. No bank will lend at $R_i > \bar{R}$ either, because then the firm will choose the *bad* project regardless of m, and the bank's return will be $1 - \sigma$. Since this is less than R_0 by Assumption (2), in a lending equilibrium $\rho_L - \sigma < R_i \leq \bar{R}$ must hold. (i) Consider a bank with $\underline{\omega}$. R_i must satisfy $\rho_L - \sigma < R_i \leq \bar{R}$. Then the bank faces the risk of low returns of $1 - \sigma$, because the firm that borrows from the bank will choose the *bad* project if $m < m^*$. Given that the bank has $\underline{\omega}$, the probability that $m < m^*$ will occur is θ. [$m < m^*$ occurs if the other bank also has $\underline{\omega}$.] The bank's expected return is $\theta(1-\sigma) + (1-\theta)R_i$, and the bank will lend if $\theta(1-\sigma) + (1-\theta)R_i \geq R_0$, equivalently, if $R_i \geq R_{min}$. Since $R_{min} > \bar{R}$ by assumption, there is no R_i at which the bank with $\underline{\omega}$ will lend. (ii) Now consider a bank with $\bar{\omega}$. If $R_{min} > \bar{R}$, it knows that a bank with $\underline{\omega}$ will not lend. Then the bank with $\bar{\omega}$ is in the same situation and faces the same risk that the bank with $\underline{\omega}$ was facing. So, if $R_{min} > \bar{R}$, there is no R_i at which a bank with $\bar{\omega}$ will lend. Therefore, there is no lending equilibrium if $R_{min} > \bar{R}$. ■

The following Lemma is used in the proof of the under-lending equilibrium.

Lemma A.1 *The best deviation for Bank B sets $l_+ = 2\bar{\omega} - N$ and $R_B = \tilde{R}$.*

Proof. Suppose the deviation $\tilde{R}$, $l_+ = 2\bar{\omega} - N$ is not profitable, but there is another deviation, $l'_+ < 2\bar{\omega} - N$, and some other interest rate, $R' \neq \tilde{R}$, which is. Given R', if l'_+ is a profitable deviation then l_+ is even a more profitable deviation. But given $l_+ = 2\bar{\omega} - N$, Bank B's payoff is maximized at $\tilde{R}$, hence a contradiction. ■

We now state the proposition that characterizes the full lending equilibrium. R^* is defined in the text in equation (3.8). In addition, we also define two threshold values for τ:

$$\begin{aligned} \tilde{\tau}_1 &\equiv 2(\bar{R} - R_0)\frac{(1-\theta)(\lambda+\theta)}{(1+\theta+2\lambda)^2}, \\ \tilde{\tau}_2 &\equiv (\bar{R} - R_0)\frac{1-\theta}{1+\theta+2\lambda}. \end{aligned}$$

Proposition A.1 (The full lending equilibrium) *If $\tau < \tilde{\tau}_1$, there is no FLE in pure strategies. If $\tilde{\tau}_2 \geq \tau \geq \tilde{\tau}_1$, the following is the unique FLE. Both banks set $R = \bar{R}$ if they have $\underline{\omega}$, Bank A offers loans to firms #1 to #$\underline{\omega}$, Bank B offers loans to firms #$(N - \underline{\omega} + 1)$ to #N. They set $R = R^*$ if they have $\bar{\omega}$, Bank A offers loans to firms #1 to #$\bar{\omega}$, Bank B offers loans to firms #$(N - \bar{\omega} + 1)$ to #N. If $\tau > \tilde{\tau}_2$, the following is the unique FLE. Both banks set $R = \bar{R}$ regardless of their ω. If they have $\underline{\omega}$, Bank A offers loans to firms #1 to #$\underline{\omega}$, Bank B offers loans to firms #$(N - \underline{\omega} + 1)$ to #N. If they have $\bar{\omega}$, Bank A offers loans to firms #1 to #$\bar{\omega}$, Bank B offers loans to firms #$(N - \bar{\omega} + 1)$ to #N.*

The proof is done by a series of lemmas. In a full lending equilibrium, the spill-over effect is materialized if at least one of the banks has high lending capacity. This means that a bank that has high lending capacity faces no risk of low returns, $(1 - \sigma)$, hence it will use its entire lending capacity to make loans. It may want to charge a lower interest rate than $\bar{R}$. A bank that has low lending capacity faces the risk of low returns, but if the condition in Assumption 5 is satisfied, it will also use its entire lending capacity to make loans. Since there will be competition for firms only if both banks have high lending capacity, a bank that has the low lending capacity will set $\bar{R}$. Since the loan quantities are determined fairly easily, the lemmas that follow try to pin down the interest rate that a bank with high lending capacity will charge in the full lending equilibrium. Suppose Bank B charges R_B if it has high lending capacity. Then, if Bank A has high lending capacity, it chooses R_A to maximize

$$\theta\bar{\omega}R_A+(1-\theta)\left\{(N-\bar{\omega})R_A+(2\bar{\omega}-N)[p_A R_A+(1-p_A)R_0]\right\},\text{(A.1)}$$

subject to $R_A \leq \bar{R}$. Here, p_A is the probability that a firm with loan offers from both banks will accept Bank A's offer. It is a linear decreasing function of R_A– see Assumption 4, if the difference between R_A and R_B is less than τ, it is constant and equal to 0 (equal to 1) if R_A exceeds R_B (R_B exceeds R_A) by more than τ. We let $BR(R_B)$ denote Bank A's best response, i.e., the maximizer of (A.1). $BR(R_B)$ can equal $\bar{R}$, or $R_B - \tau$, these are the 'corner solutions', or $\widehat{BR}(R_B)$, which is obtained as follows. We differentiate (A.1), set it equal to zero:

$$\theta\bar{\omega}+(1-\theta)(N-\bar{\omega})+(1-\theta)(2\bar{\omega}-N)\left[\frac{dp_A}{dR_A}(R_A-R_0)+p_A\right]=0.$$

Solving this yields $\widehat{BR}(R_B)$:

$$\widehat{BR}(R_B)=\frac{R_B}{2}+\frac{R_0}{2}+\frac{\tau}{2}\left(\frac{1+\theta+2\lambda}{1-\theta}\right). \tag{A.2}$$

We let R^* be defined by $\widehat{BR}(R^*)=R^*$. We have

$$R^*=R_0+\tau\left(\frac{1+\theta+2\lambda}{1-\theta}\right). \tag{A.3}$$

Lemma A.2 *If $\tau<\tilde{\tau}_1$, $BR(R_B)=\bar{R}$ for all $R_B \leq R^*$.*

Proof. We first verify that $\tau<\tilde{\tau}_1$ implies $\bar{R}-R^*>\tau$. We manipulate $\bar{R}-R^*>\tau$ to show that it is equivalent to

$$\left(\frac{\bar{R}-R_0}{2}\right)\left(\frac{1-\theta}{1+\lambda}\right)>\tau. \tag{A.4}$$

To verify that (A.4) is implied by $\tau<\tilde{\tau}_1$, we let $\tau=\tilde{\tau}_1$ in (A.4) and simplify. This yields the condition

$$1/4>\frac{\lambda+\theta+\theta^2+\theta\lambda}{(1+\theta+2\lambda)^2}.$$

But this always holds because we have $\theta<1$ and $\lambda>0$ by assumption. Since $\tau<\tilde{\tau}_1$ implies $\bar{R}-R^*>\tau$, if Bank B sets $R_B=R^*$ and Bank A's sets $R_A=\bar{R}$, Bank A's payoff will be $(N-\bar{\omega})\bar{R}+(2\bar{\omega}-N)R_0$. (Since $\bar{R}>R^*+\tau$, all firms with multiple offers will choose Bank B with probability 1.) Now, using simple algebra and comparing Bank

A's payoff verifies that its payoff with $\bar{R}$ is larger than its payoff with $R_A = R^*$, and its payoff with R^* is larger than its payoff with $R^* - \tau$. These comparisons show that the best response R_A to $R_B = R^*$ is $\bar{R}$. But if $\bar{R}$ is best response to $R_B = R^*$, then it will also be best response to all R_B that are smaller than R^*. To see this suppose Bank B sets $R_B < R^*$. Bank A's payoff from $\bar{R}$ will be as before, but there will be a decline in the payoff to $R_B - \tau$, and in the payoff to $\widehat{BR}(R_B)$, this is because $\widehat{BR}(R_B)$ is monotone increasing in R_B. So, $\bar{R}$ is still the best response against $R_B < R^*$. ■

Lemma A.3 *If $\tau < \tilde{\tau}_1$, and if $BR(R_B) < \bar{R}$ at $R_B = R^o$, then $BR(R_B) < \bar{R}$ for all $R_B \geq R^o$.*

Proof. We first show that $\tau \leq \tilde{\tau}_1$ implies $\widehat{BR}(R_B) < \bar{R}$ for all $R_B \leq \bar{R}$. Here, we do not need to assume $BR(R^o) < \bar{R}$ for some R^o. We start with

$$\widehat{BR}(R_B) = \frac{R_B}{2} + \frac{R_0}{2} + \frac{\tau}{2}\left(\frac{1+\theta+2\lambda}{1-\theta}\right), \tag{A.5}$$

and substitute the formula for $\tilde{\tau}_1$ and simplify to obtain

$$\widehat{BR}(R_B) = \frac{R_B}{2} + \frac{R_0}{2} + (\bar{R} - R_0)\frac{\lambda+\theta}{1+\theta+2\lambda}. \tag{A.6}$$

The fraction that multiplies $(\bar{R} - R_0)$ is less than $1/2$, hence $\widehat{BR} < \bar{R}$. To find Bank A's best-response to R^o, we need to consider two cases. First, we let $R^o > \bar{R} - \tau$. Since $\widehat{BR}(R^o) < \bar{R}$ Bank A's profits will decrease as we increase R_A for $R_A \in (\widehat{BR}(R^o), \bar{R})$. Here we use the fact that $R^o > \bar{R} - \tau$. Hence $R_A = \bar{R}$ cannot be the best response for Bank A. Secondly, we let $R^o < \bar{R} - \tau$. Here the argument is slightly more involved, so we need to use the assumption that Bank A's best response to $R_B = R^o$ is less than $\bar{R}$. Now we raise R_B by a small amount, say ϵ, so that $R^o + \epsilon < \bar{R} - \tau$. Bank A's payoff to $R_A = \bar{R}$ will not change, but the payoff to $R_A = R_B - \tau$ and to $R_A = \widehat{BR}$ will increase. This shows that for all R_B such that $R^o < R_B < \bar{R} - \tau$ the best response is less than $\bar{R}$. ■

The preceding two lemmas imply that there can be no pure strategy symmetric equilibrium, that is, an equilibrium in which both banks charge the same R when they have high lending capacities. The next lemma shows that there can be no asymmetric equilibrium either.

Lemma A.4 *If $\tau < \tilde{\tau}_1$, there is no asymmetric equilibrium in pure strategies.*

Proof. We first show that there can be no asymmetric equilibrium with $R_A^* < \bar{R}$, and $R_B^* < \bar{R}$. So, to the contrary, suppose there is. Then we must have $|R_A^* - R_B^*| = \tau$. Without loss of generality, we let $R_B^* = R_A^* - \tau$ and $R_A^* < \bar{R}$. Then Bank A's equilibrium R_A must satisfy the first order condition given by equation A.2, so it must be

$$R_A^* = R_0 + \tau\left(\frac{1+\theta+2\lambda}{1-\theta} - 1\right). \tag{A.7}$$

Also, since we have $R_B^* = R_A^* - \tau$, the solution to Bank B's first order condition which is

$$\frac{R_A^*}{2} + \frac{R_0}{2} + \tau\left(\frac{1+\theta+2\lambda}{1-\theta}\right) \tag{A.8}$$

must be less than $R_A^* - \tau$. Simple algebra show that this is impossible. Therefore, in an asymmetric equilibrium one bank must set $R = \bar{R}$, and the other must set $R < \bar{R}$. The preceding lemmas show that for Bank A, $\bar{R}$ becomes the best response when Bank B sets lower values of R_B. In an equilibrium with $R_A = \bar{R}$, the lowest interest rate Bank B will consider is $\bar{R} - \tau$. But, Lemma A.4 shows that Bank A's best response to $R_B = \bar{R} - \tau$ is not $\bar{R}$. So there can be no such asymmetric equilibrium. ∎

The following two lemmas deal with the case where $\tau > \tilde{\tau}_2$, that is, when the degree of bank differentiation is large so that the equilibrium interest rate is $\bar{R}$ regardless of the level of lending capacities.

Lemma A.5 *If $\tau > \tilde{\tau}_2$, there is no R_B such that $R_A = R_B - \tau$ is best response R_B.*

Proof. We start with $R_B = \bar{R}$. Bank A's payoff to $R_A = \bar{R} - \tau$ is $\bar{\omega}(\bar{R} - \tau)$; its payoff to $R_A = \bar{R}$ is

$$(N - \bar{\omega})\bar{R} + (2\bar{\omega} - N)\left\{\theta\bar{R} + (1-\theta)[(\bar{R} + R_0)/2]\right\}. \tag{A.9}$$

Simple algebra verifies that the payoff to $R_A = \bar{R}$ is larger if

$$\tau > \left(\frac{1-\theta}{1+\lambda}\right)\left(\frac{\bar{R} - R_0}{2}\right). \tag{A.10}$$

This is implied by $\tau > \tilde{\tau}_2$, therefore, $\bar{R} - \tau$ is not the best response to $R_B = \bar{R}$. Now, consider a slightly lower R_B, say $R_B = \bar{R} - \epsilon$. The payoff to $R_A = R_B - \tau$ declines by exactly $\bar{\omega}\epsilon$, whereas the payoff to $\bar{R}$ declines by less than $\bar{\omega}\epsilon$, showing that $R_B - \tau$ is going to be dominated by $R_A = R_B$, and thus is not going to be best response. We can apply the same argument for all values of R_B until $R_B = R_0 + \tau$ to verify that $R_B - \tau$ is not the best response to R_B, if $R_0 + \tau \leq R_B \leq \bar{R}$. For $R_B < R_0 + \tau$, setting $R_A = R_B - \tau$, means setting R_A lower than R_0, which is clearly not optimal. ■

Lemma A.6 *If $\tau > \tilde{\tau}_2$, $BR(\bar{R}) = \bar{R}$, and $BR(R_B) > R_B$ if $R_B < \bar{R}$.*

Proof. If $\tau > \tilde{\tau}_2$, simple algebra verifies that $\widehat{BR}(R_B) > R_B$ for all $R_B \leq \bar{R}$, and Lemma A.5 shows that $R_B - \tau$ can never be a best response. These imply that $BR(R_B) > R_B$ for all $R_B < \bar{R}$. The *BR-function* can intersect the 45^o-line only when $R_B = \bar{R}$. Simple algebra shows that $\tau > \tilde{\tau}_2$ implies $BR(\bar{R}) = \bar{R}$ ■

Now we put the lemmas together and prove the proposition for the full lending equilibrium.

Proof. The full lending equilibrium

Lemmas A.2 - A.4 show that if $\tau < \tilde{\tau}_1$, no pure strategy equilibrium exists. By Lemma A.2, if $\tau < \tilde{\tau}_1$, Bank A's best response to $R_B = R^*$ is not R^*; it is $\bar{R}$. It also shows that if $\tau < \tilde{\tau}_1$, then $BR(R_B) = \bar{R}$ for all $R_B < R^*$. Then, together with Lemma A.3, Lemma A.2 implies that if $\tau < \tilde{\tau}_1$, Bank A's *best response function* consists of two disjoint segments, one above the 45^o-line, and this part is for the lower values of R_B, the other below the 45^o-line, and this part is for the higher values of R_B. There is a critical value of R_B, say $\tilde{R}_B$, such that $BR(R_B) = \bar{R}$ if $R_B \leq \tilde{R}_B$, and $BR(R_B) < R_B$ if $R_B > \tilde{R}_B$; in the latter case $BR(R_B)$ is either $\widehat{BR}$, or $R_B - \tau$. These lemmas also show that this critical value for R_B is strictly larger than R^*. Starting at $R_B = R_0$ and gradually increasing R_B, the switch from $\bar{R}$ to $\widehat{BR}_A$ or $R_B - \tau$ occurs with a downward jump at a value of R_B that is strictly larger than R^*. So, if $\tau < \tilde{\tau}_1$, the *best response function* will not intersect the 45^o-line. Then the only candidate for a pure strategy equilibrium is an asymmetric equilibrium, in which one bank sets $R = \bar{R}$, and the other $R < \bar{R}$. Lemma A.4 rules that out.

On the other hand, if $\tau > \tilde{\tau}_2$, Lemmas A.5 and A.6 below show that $BR(R_B) > R_B$ for all $R_B < \bar{R}$, and $BR(\bar{R}) = \bar{R}$. This implies that the unique pure strategy equilibrium both banks set $R_A = R_B = \bar{R}$ when they have high lending capacity.

Finally, if $\tau \in [\tilde{\tau}_1, \tilde{\tau}_2]$, we have $\widehat{BR}(R^*) = R^*$, the first order condition holds, simple algebra verifies that $R^* \leq \bar{R}$, and therefore, $BR(R^*) = R^*$: $R_A = R_B = R^*$ is *an* equilibrium. We now show that it is also the unique equilibrium. If there is another equilibrium, it must be an asymmetric one. Lemma A.4 above shows that no asymmetric equilibrium exits with $R_A, R_B < \bar{R}$. Hence, if there is an asymmetric equilibrium, in that equilibrium Bank i sets $R_i = \bar{R}$, Bank j sets $R_j < \bar{R}$. Straightforward algebra verifies that if $\tau < \tilde{\tau}_2$, the best response to $\bar{R} - \tau$ is not $\bar{R}$. It is easily verified that the derivative of (A.1) with respect to R_A at $R_B = \bar{R} - \tau$, $R_A = \bar{R}$ is negative–this means Bank A is better off by reducing R_A a little bit below $\bar{R}$. Since no asymmetric equilibrium exits, the equilibrium with $R_A = R_B = R^*$ is the unique equilibrium. ■

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