Lending Competition and Endogenous Credit Supply: A General Equilibrium Theory of Loan Sales*

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Abstract

We develop a general equilibrium theory of loan sales based on bank competition. We show how credit shortage can arise endogenously in response to an increase in bank competition for lending, and how such credit shortage can motivate loan sales as a means to financing risky yet potentially profitable projects that would otherwise be rationed. On a general level, by demonstrating the rudimentary role of lending competition in motivating off-balance-sheet activities, our theory provides a novel account for the fundamental shift, over the past two decades or so, in the lending practice of U.S. and European banks, from the traditional 'originate to hold' model of credit provision, towards the 'originate to distribute' approach for credit extension, or, the emergence of the 'shadow banking system'.

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1 Introduction

The past twenty years or so have observed a fundamental shift in the lending practice of U.S. banks, from the traditional 'originate to hold' model of credit provision, where banks used deposits to fund loans that they then kept on their balance sheets until maturity, towards the so-called 'originate to distribute' approach for credit extension, under which banks sell loans that they originate, either in whole or in part, to investors, rather than fund them with deposit liabilities.[1] A similar transformation has also occurred in the European banking system.[2]

The recent financial crisis and ensuing recession have raised concerns about the implications of these off-balance-sheet activities for the safety and soundness of the financial system. A main concern is that potential incentive misalignments in the application of the OTD model could lead to weakening of lending standards, which is widely accepted as a root cause for the recent crisis. This concern is shared by not only academic researchers, but also policymakers.[3] As a matter of fact, this is an issue singled out by the U.S. President's Working Group on Financial Markets in its efforts to identify the sources of the financial turmoil during the onset of the crisis, and discussed in length by the U.S. Federal Reserve Chairman Ben Bernanke in his speeches at the World Affairs Council of Greater Richmond's Virginia Global Ambassador Award Luncheon on April 10, 2008, and at the Conference Co-sponsored by the Center for Economic Policy Studies and the Bendheim Center for Finance at Princeton University on September 24, 2010. In the European Union, the Economic and Financial Affairs Council mandated the European Central Bank, in cooperation with the Banking Supervision Committee, to assess "…how the so-called 'originate and distribute' model …has impacted on the incentive structures of credit markets, in a context characterized by a shift from the more traditional retail to interbank

[1] The secondary market (where loans are sold after origination) for direct sales of individual loans grew from a mere $8 billion in 1991, to $154.8 billion in 2004, $176 billion in 2005, $238.6 billion in 2006, and further to $342 billion in 2007. The syndicated loan market (where loans are sold at origination) rose from $339 billion in 1988 to $2.2 trillion in 2007. The growth of the market for securitization of pooled loans had also been spectacular in the years leading up to the financial crisis of 2007. These facts are documented by Lucas et al. (2006), Drucker and Puri (2009), Ahn (2010), and Bord and Santos (2012), among others. See, also, Duffie [1] and Loutskina and Strahan [2] for related facts.

[2] See, for example, ECB (2008).

[3] See, among others, Ashcraft and Schuermann (2008), ECB (2008), Mian and Sufi (2009), Keys, Mukherjee, Seru, and Vig [13], CRS Report for Congress (2010), Demyanyk and van Hemert (2011), and Bord and Santos (2010, 2012) for some comprehensive and in-depth discussions of this issue.

borrowing."

To address this issue, and to assess the broad implications of this recently developed shadow banking system, one needs to better understand the incentives of banks in using the OTD model. One strand of the literature has focused on loan sales as a risk transfer tool.[4] If banks sell loans mainly to transfer risk, the potential for misalignment of incentives among market participants would be a major weakness of the OTD model for the policymakers to address. Reflections on the recent financial crisis are mainly along this line of thinking, which also is a mission set out in the 2008 ECB Eurosystem Report, as well as in the plan for regulatory reform proposed in 2009 by the U.S. Committee on Capital Markets Regulation.

Recent empirical studies do not seem to suggest risk transfer as the main thrust for loan sales. The evidence provided by Keys, Mukherjee, Seru, and Vig [13], Greenlaw, Hatzius, Kashyap, and Shin [14], Gordon [15], and Berndt and Gupta [16] suggests that the application of the OTD model actually increases the risk faced by loan originators. More direct evidence based on U.S. bank holding company data from 2001 to 2007 is provided by Sarkisyan, Casu, Clare, and Thomas [17], who find that banks use loan sales mainly as a financing strategy, rather than a risk transfer tool. This conforms to the finding by Drucker and Puri (2009) based on four different data sources that banks sell loans mainly for the purpose of increasing their credit supply.[5]

To be consistent with these empirical findings, a theory about loan sales should also provide a coherent account for what might have propelled banks into a state of credit shortage so they felt the need to increase their credit supply in the first place. Such joint account shall also help predict how bank decisions and the financial system may respond to changing economic conditions and policy reforms looking forward. To meet this challenge, it is essential to endogenize credit supply in tandem with bank decisions of selling loans in a general equilibrium environment.

We provide such a joint account based on a general equilibrium theory of bank competition. We demonstrate how credit shortage can arise endogenously in response to an increase in bank competition for lending opportunities, and how such credit shortage can motivate

[4] See, among others, Allen and Carletti [10], Allen and Gale [11], and Wagner and March [12]).

[5] Consistent evidence can be found in the earlier study by Cebenoyan and Strahan (2004), which shows that the chief benefit of loan selling is greater bank credit availability but not lower bank risk. Corroborating evidence can also be found in Faulkender and Petersen (2006) and Sufi (2006).

loan sales as a means to financing an additional set of potentially profitable projects that would otherwise be rationed. As we show below, the mechanism of our model is supported by empirical evidence.

One crucial and relevant observation is that much of the past two decades that has experienced the aforementioned growth in loan sales has also witnessed increased bank competition for lending opportunities, as technological advance, and deregulation and globalization weakened geographic boundaries and encouraged interstate (U.S.) and cross-border (Europe) banking.[6] The increased competitive pressure has been widely perceived as reflecting a permanent shift in the loan market.[7] Our theory suggests that the observed surge in loan sales over the past twenty years could be an equilibrium response to this increase in lending competition. The prediction of our model is also consistent with the empirical evidence based on micro-level data that banks facing more intense competition are more likely to sell loans.[8]

A bank in our model plays the dual role, of channeling funds from households to entrepreneurs, who rely on external sources to finance their risky projects, and of screening and monitoring the risky projects. The lending practice generates proprietary information about the entrepreneurs, which is not observable by third parties.[9] This gives the bank a comparative advantage in originating loans, which is suggested by empirical evidence as a primary motivation for loan sales[10] A defining feature of the model is that, both sides of the bank's balance sheet are endogenously determined and affected by macroeconomic conditions.[11] The joint presence of the proprietary information and the endogenous credit supply of banks generates a trade-off facing entrepreneurs, between interest rate on loans

[6]The technological and regulatory changes also weakened product boundaries and encouraged an "all-finance" practice in the lending business, and thus opened up other sources of interbank competition and competition from non-bank financial institutions and the capital market.

[7]See, for example, the Senior Loan Officer Opinion Survey on Bank Lending Practices (1997-2006), conducted quarterly by the Board of Governors of the U.S. Federal Reserve System. See, also, Boot and Schmeits [4], Hakenes and Schnabel [5], Ahn and Breton [6], and Ahn [7].

[8]See, for example, DeYoung (2007) for a survey of the related literature.

[9]This assumption, as is commonly made in the banking literature (e.g., Rajan, 1992), is supported by empirical evidence (e.g., Lummer and McConnell, 1989). It captures the intuition that the screening process can be time consuming and thus may not be conducted in sequel by a competing bank before the entrepreneur misses the profit opportunity (e.g., Dell'Ariccia, 2000), and that an important part of the information acquired by the bank may be soft in nature and thus cannot be credibly communicated to outsiders (e.g., Parlour and Plantin, 2008).

[10]See, for example, Pavel and Phillis [21], and Demsetz [22].

[11]The idea that the effects of changes in banks' balance sheets on the supply of credit might be important for understanding the functioning of the shadow banking system is also emphasized by Shin [25].

and probability of obtaining the loans.

An increase in competition for lending opportunities among banks in this environment lowers interest rate on loans and, thus, interest rate on deposits by households falls too. In consequence, returns to banks' assets fall relative to their costs of funds in the presence of a regulatory capital requirement, given that equity is more costly than debt. This leads to a fall in deposits and a decline in on-balance-sheet supply of credit, and, therefore, a rationing of potentially profitable projects. This creates an incentive for the banks to use the OTD model to extend the size of their profitable investments, even if such innovations may be costly. The banks may even originate risky investments with negative expected returns and sell them to other investors, in order to fully explore their comparative advantages in loan origination to maximize their total profits.

In our model, loans that are originated and sold to other investors are sold at their par values, as is consistent with the empirical evidence presented in Drucker and Puri (2009), and a "skin-in-the-game" constraint addresses potential adverse selection and moral hazard problems associated with this off-balance-sheet activity. Thus our results in this paper show how lower lending standards and sub-prime loans can arise from the application of the OTD model due to increased bank competition, without misalignment of incentives, mis-perception of risks, or mis-pricing of assets. However, one should not take this as suggesting that these latter problems are not important issues concerning the off-balance-sheet activity. Clearly, they are. Rather, we view our results as highlighting a fundamental role of lending competition in motivating loan sales, under which weakening lending standards and rising aggregate risk are equilibrium responses of the economy to increased bank competition for lending opportunities.

As discussed above, the fact that the supply of credit responds endogenously to changes in the general economic conditions plays a central role in our analysis. In this spirit our paper is related to Shin [25]. This defining feature of our model helps generate a number of testable implications, which are verified by exiting empirical studies. This is in contrast to a few recent papers that use partial equilibrium models with exogenous supply of credit to study the role of bank competition in asset sales.[12]

Our central mechanism also differs from the traditional models of bank loan sales that appeal to evolution of capital requirement regulation as a motivation for this off-balance-

[12] See, for example, HS [5], AB [6], and Ahn [7].

sheet activity.[13] Whereas the bank capital requirement that is kept at a constant level in our model does make on-balance-sheet intermediation more costly, it does not create a large enough regulatory arbitrage opportunity for banks to engage in costly loan sales in the absence of lending competition. Instead, it is the increase in competition for lending, through creating an endogenous credit shortage, that triggers widespread loan sales. Therefore, our model may help explain why enormous growth in loan sales had already occurred even before the U.S. adopted the Basel II Accord in 2005.

This is related to another contribution of our paper. While some models have the feature that banks with more opportunities in originating loans are more likely to adopt the OTD practice, such loan originating opportunities are mostly treated as exogenous in the existing studies.[14] In this paper, in contrast, bank competition for lending serves as a mechanism to endogenize loan originating opportunities, and the endogeneity of credit supply acts as the nexus between the two. Therefore, our model may help explain why there was the tremendous growth in loan origination opportunities in the first place during the past two decades, as increased bank competition resulted in excess demand for credit.

As stated earlier, the predictions of our model are consistent with broad empirical evidence: the prediction that increased lending competition may result in a shortage of credit for funding risky investments that require careful screening and monitoring is supported by the empirical findings of Petersen and Rajan [9], Rajan and Zingales (1998), Cetorelli and Gambera (2001), and Bonaccorsi and Dell'Ariccia (2004); that lower interest rates and growth in loan sales may arise in tandem is confirmed by the empirical study of Guner (2006);[15] and that increased bank competition may lead to a decline in lending standards conforms to the empirical facts reported in Dell'Arrica, Igan, and Laeven [3] as well as those documented in the U.S. Federal Reserve's Senior Loan Officer Opinion Survey on Bank Lending Practices (1997-2006).[16]

[13] See, for example, Pennacchi [18], Duffee and Zhou [19], and Calomiris and Mason [20].

[14] See, for example, Gordon and Pennacchi [23], and Parlour and Plantin [24].

[15] As a corroborating evidence, for much of the past two decades that has witnessed the increased bank competition for lending and growth in loan sales, bank prime loan rate has also been low, when compared with its level in much of the two preceding decades. This is not to exclude other factors, such as loose monetary policy and global imbalances, that could also have contributed to generating the low interest rates in this more recent episode.

[16] Almost all surveyed domestic and foreign respondents (from investment and commercial banks, as well as other financial intermediaries) cited more aggressive competition from other banks or non-bank lenders as the most important reason for easing their lending standards and terms. As a result, more than 20 percent of the banks eased lending standards for Commercial and Industrial loans, and around 50 percent

Methodologically, this paper is related to the literature of directed search. Our baseline model of bank competition is adapted from the framework used in Peters [28] and Burdett, Shi, and Wright [32] (BSW) for modeling capacity-constrained Bertrand competition. There is a unique symmetric mixed strategy equilibrium in the present model, as in Peters [28] and BSW [32].[17] Implication of this equilibrium is what this paper is focused on. This allows us to show our main results in a most transparent way, without any unessential complications added to the analysis.

2 Basic Environment

The economy takes place at infinitely many dates, $t = 0, 1, 2, ...$, and is populated by overlapping generations of two-period lived households, with a unit measure of each generation, and of a large number of entrepreneurs, along with a smaller number of banks. Young households are endowed with 1 unit of labor that is supplied inelastically, but old households receive no labor endowment.

There are two goods in the economy, a final good, which also serves as the numeraire of the economy, and an intermediate good. The final good can be directly consumed by households, stored through a storage technology, or invested in projects operated by entrepreneurs to get transformed into an intermediate good in the next period. The intermediate good and labor can then be combined to produce the final good according to $y_t = F(m_t, l_t; z)$, where y_t is date-t output of the final good, z represents the aggregate level of technology, l_t is date-t labor input, and m_t is date-t input of the intermediate good, which is transformed from date-$(t-1)$ final good, except for the initial period $t = 0$ in which an initial amount of intermediate good m_0 is owned by the initial old households. The production function F is of constant returns to scale with respect to the two inputs, and is strictly increasing, strictly quasi-concave, and twice continuously differentiable in both of these two variables. There is perfect competition in this production sector, so the price of intermediate good q and the wage rate of labor service w are determined by their respective marginal products. With the inelastic labor supply, the production function can be expressed in an intensive form as $f(m_t; z) \equiv F(m_t, 1; z)$. Each initial old household

of the banks decreased spreads on loan pricing.

[17] In addition to a symmetric mixed strategy equilibrium, this type of model may also allow for existence of other equilibria, such as one with price dispersion. See Arnold [33], Shi [34], and Camera and Selcuk [35]) for examples.

consumes $c_0^o = q_0 = f'(m_0; z) \equiv F_1(m_0, 1; z)$.

Each young household of generation t supplies its 1 unit of labor endowment inelastically and allocates its wage income w_t to finance its consumption when young, c_t^y, and its consumption when old, c_{t+1}^o, to maximize $u(c_t^y) + \beta \mathrm{E}_t u(c_{t+1}^o)$, where $\beta \in (0, 1)$ is a discount factor, and E_t denotes the conditional expectations operator. The period utility function u is strictly increasing, strictly concave, twice continuously differentiable, and satisfies the property that $\lim_{c \to 0^+} u(c) \to +\infty$.

At each date t a new set of a measure N of continuous entrepreneurs emerges with the new generation of households. These entrepreneurs have no internal funds but are endowed with projects that may transfer date-t final good into date-(t+1) intermediate good. Only the entrepreneurs know how to operate their projects. The projects are indivisible with random returns: Each project takes 1 unit of the final good as input, and produces 1 or 0 unit of the intermediate good with probability θ and $1 - \theta$, respectively. The success probability θ is a random draw from a cumulative distribution function $G(\theta)$ on a support $[0, 1]$

We assume that it is costly forbidden for a household to screen the type of a project (in terms of its success probability) ex ante or to monitor the outcome of the project (in terms of its realized return) ex post, whereas it is costless for a bank to do both. This gives rise to a role of banks in intermediating borrowing and lending between entrepreneurs and households.[18]

A bank exploits its traditional intermediation role by taking deposits from young households and making loans to entrepreneurs. This 'originate to hold' activity is subject to a capital requirement regulation in that at least k fraction of the bank's loans must be financed by its equity and thus at most $1 - k$ fraction of the loans can be financed by households' deposits. Both households and banks are interest-rate takers when making their deposit supply and demand decisions. We assume a full deposit insurance so there is no risk premium attached to the interest rate on deposits r, and that a bank has access to an outside market where capital can be raised at a cost $\rho > r$. This is a parsimonious way to capture the notion that a capital requirement regulation is costly for banks. Since debt is cheaper than equity, a bank will not raise more capital than needed for meeting the

[18] As in Diamond [36], what is essential here is that the screening and monitoring costs are smaller for a bank than for a household.

capital requirement regulation. This pins down the bank's capital structure: It will choose a debt-equity ratio of $(1-k)/k$.

At the heart of the model is an expansion of the bank's intermediation business to including the 'originate to distribute' approach for credit extension, under which the bank can sell some of its originated loans to young households instead of funding them with its deposit liabilities. The loan sale is subject to a 'skin-in-the-game' constraint that requires the bank to keep on its balance sheet at least λ fraction of the pool of loans that it originates. This helps address potential adverse selection and moral hazard problems associated with the off-balance-sheet activity.

The setup above provides a basic framework for analyzing the rudimentary role of bank competition for lending opportunities in motivating loan sales. As a useful benchmark, we first present a situation that abstracts from bank competition, that is, the case with a monopoly bank. In what follows, we omit the subscript t to help simplify presentation whenever the timing is clear.

3 The Case of No Bank Competition

In the absence of bank competition, loan sales may not be of a large scale as long as the households are reasonably risk averse. To help make this point, it is useful to examine first the decision of a monopoly bank. In each period, the bank makes decisions on its capital, deposit, loan contract, and loan sales sequentially. A period can be divided into four stages accordingly. In the first stage, the bank chooses the amount of capital, K, at the cost ρ. In the second stage, the bank raises deposit S from young households taking the market rate r as given, subject to the capital requirement constraint $k(S+K) \leq K$, which we recall is always binding. In the third stage, the bank posts a loan contract concerning the lending rate, γ, and the cutoff point for the quality of a project, θ_1: With perfect screening, only a project with a success probability greater than or equal to θ_1 will get funded, and the bank gets paid the rate γ if the project indeed succeeds but nothing if the project actually fails. In the fourth stage, the bank may raise additional funds by selling to young households loans originated in the third stage. These loans sold by the bank to the households have a risky return: With probability $\mathring{\theta} = \int_{\theta_1}^{1} \theta dG(\theta) / [1 - G(\theta_1)]$, which is the average success probability for the pool of loans originated in the third stage, they will receive an interest rate r^a, but, with probability $1 - \mathring{\theta}$ they will receive nothing. The expected interest rate on sold loans is then $\mathring{\theta} r^a$. Denote by θ_2 and γ^a respectively cutoff point for the quality of and lending rate on additional projects that get financed when the possibility of loan sales is considered.

The bank's expected profit is then given by

$$\pi_b = \max_{\gamma, \gamma^a, \theta_1, \theta_2} \left[N \int_{\theta_1}^{1} \theta dG(\theta) \gamma - (\rho K + rS) + N \int_{\theta_2}^{\theta_1} \theta dG(\theta) \gamma^a - \mathring{\theta} r^a S^a \right], \tag{1}$$

where the amount of loans originated in the third stage but sold by the bank to the households in the fourth stage, S^a, that is used to finance the $N [G(\theta_1) - G(\theta_2)]$ amount of additional projects, must be non-negative, i.e., $0 \leq S^a$, and respect the "skin-in-the-game" constraint,

$$S^a \leq (1 - \lambda) N [1 - G(\theta_1)]. \tag{2}$$

With its limited liability prescribed by the contract, any entrepreneur would be willing to take out a loan to invest in its project if the loan rate γ is not greater than the expected price of intermediate good q. However, in this current case of no bank competition, its monopoly power would allow the bank to extract the entire expected surplus while leaving an entrepreneur to earn zero profit from an invested project. Accordingly, the cutoff point is determined in a way so that the bank expects to break even on the lowest quality project that gets financed.[19] These imply that $\gamma = \gamma^a = q$. If the bank ever engages in loan sales, it must be the case that $\mathring{\theta} r^a \leq \theta_2 q$ and $\mathring{\theta} r^a \leq \eta$, where $\eta = (1 - k) r + k\rho$ is the marginal cost of obtaining on-balance-sheet fund. If the "skin-in-the-game" constraint is binding, we may have $\mathring{\theta} r^a < \eta$ and then θ_1 may be greater than, equal to, or lower than η / q, whereas the wedge, $\eta - \mathring{\theta} r^a$, represents a regulatory arbitrage opportunity that cannot be materialized (i.e., there is a limit to arbitrage) due to a binding "skin-in-the-game" constraint. If the "skin-in-the-game" constraint is not binding, we must have $\mathring{\theta} r^a = \eta$ if $S^a > 0$, and then we must also have $\theta_1 > \eta / q$. Of course, this choice of θ_1 must also be made compatible with the on-balance-sheet funds chosen at the first two stages, that is, it must be the case that $N [1 - G(\theta_1)] = K + S$. However, when choosing θ_1 and θ_2, the bank does not take into account how this decision would affect the expected price of intermediate good.

[19] With only a finite number of projects in the pool, however, the bank may realize a negative profit ex post, which may trigger a bank failure under a loose capital requirement regulation. The assumption of a full insurance in the banking sector that we have made above is meant to take care of this potential problem of bank failure.

A young household can save via deposit, loan-sales, or a storage technology, that can take s units of final good in one period to yield $z_s s^{\varsigma}$ units of final good in the next period, for some $\varsigma \in (0,1)$ and $z_s > 0$. It is worth noting that it is the availability of this storage technology to households that makes the bank behave competitively on the markets for deposits and loan sales, although it has a sole monopoly power over entrepreneurs on the loan market. The bank's profit is returned to the old household. Given that households have non-satiated preferences, the expected lifetime utility of a young household is

$$u(w - s - S - S^a) + \beta \left[\mathring{\theta} u\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right) + (1 - \mathring{\theta}) u\left(z_s s^{\varsigma} + rS + \pi_b\right) \right],$$

where both the consumption when young and that when old must be strictly positive given the property of the utility function that $\lim_{c \to 0^+} u(c) \to +\infty$. Since the marginal rate of return to the storage technology will approach positive infinity as $s \to 0^+$, it must be the case that s is strictly positive as well. The household's choice of s then must guarantee that

$$u'\left(w - s - S - S^a\right) = \beta \varsigma z_s s^{\varsigma - 1} \left[\mathring{\theta} u'\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right) + (1 - \mathring{\theta}) u'\left(z_s s^{\varsigma} + rS + \pi_b\right) \right].$$

Since in any given period entrepreneurs must rely on bank loans to finance their projects for generating intermediate inputs in the subsequent period, which must be combined with labor services for final good production, an active banking sector in period $t-1$ is necessary to ensure an active production sector in period t, which is essential in order for a young household of generation t to carry on, for all $t \geq 1$. Note that a positive level of household deposit is required for the banking sector to be active, since loan sales would not be possible without any household deposit to finance loans to be sold in the first place. Therefore, we must have $S > 0$. The household's choice of S then must guarantee that

$$u'\left(w - s - S - S^a\right) = \beta r \left[\mathring{\theta} u'\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right) + (1 - \mathring{\theta}) u'\left(z_s s^{\varsigma} + rS + \pi_b\right) \right].$$

From the above two optimality conditions it follows that $r = \varsigma z_s s^{\varsigma - 1}$. Let $\varphi_a \geq 0$ denote the multiplier associated with the constraint $S^a \geq 0$. The household's choice of S^a satisfies

$$u'\left(w - s - S - S^a\right) = \beta r^a \mathring{\theta} u'\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right) + \varphi_a, \text{ and } \varphi_a S^a = 0.$$

It follows from the last two optimality conditions that, if the household ever goes to purchase loans sold by the bank, it must be the case that

$$\left(\frac{r^a}{r} - 1\right) = \left(\frac{1}{\mathring{\theta}} - 1\right) \left[\frac{u'\left(z_s s^{\varsigma} + rS + \pi_b\right)}{u'\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right)} \right],$$

which implies $r < \mathring{\theta} r^a$, given that the household is risk averse. The difference, $\mathring{\theta} r^a - r$, represents a premium that the bank has to compensate the household for the risk on sold loans.

The analysis above taken together shows that, for any loan sale to appear in equilibrium, its expected rate of return, $\mathring{\theta} r^a$, must fall into $(r, \eta]$. It is then clear that, in our model framework, a capital requirement regulation is necessary for loan sales to be an equilibrium phenomenon: Without any capital requirement, the half-open interval would be empty and so there would never be any equilibrium loan sales. However, for S^a to increase, the household would require an increase in the relative risk premium, $\mathring{\theta} r^a / r$, to an extend depending on his degree of risk aversion. We can show that the scale of loan sales is not significant with only one bank if households are reasonably risk averse.

4 Bank Competition as a Motivation for Loan Sales

We turn now to the case with bank competition by considering the number of banks operating in the economy, denoted as B, to be greater than 1. The central theme of our analysis in this section is that, competition among banks for lending opportunities will drive interest rate on loans way below the price of intermediate good, and thus make a large room for loan sales.

To demonstrate in a transparent way how bank competition for lending can motivate loan sales, it is convenient to embed our model with the empirically plausible feature that, a bank's lending practice (say at the third stage descried in the previous section) may generate proprietary information about the qualities of projects owned by the entrepreneurs applying to its loans that can't be observed by or credibly communicated to its competing banks during the same period (e.g., Rajan, 1992; Lummer and McConnell, 1989; Dell'Ariccia, 2000; Parlour and Plantin, 2008). Thus, although competition for lending from other banks would drive down the profit margin of the bank's on-balance-sheet activity, the originating advantage developed in this third stage of lending practice would allow the bank to capture the information rent in the fourth stage when it engages in off-balance-sheet activity, loan sales in the current context. As we will show below, an equilibrium in this context will always feature a binding "skin-in-the-game" constraint and loan sales at the maximal scale possible.

4.1 Model Setup

One way to make operational the empirically plausible notion described above, and discussed in length in the Introduction, is to cast our analysis of bank competition for lending using the framework of directed search. We locate the banks on separated islands, indexed by $i = 1, 2, ...B$. We assume that the households have access to all the banks and the banks raise deposit in a national competitive market as in the one bank case. What's different here is that every bank posts a loan contract to compete entrepreneurs in the fund lending stage.

In each period, a bank i makes decisions on its capital, deposit, loan contract, and loan sales sequentially. A period can be divided into four stages accordingly. In the first stage, the bank chooses an amount of capital, K_i, at a cost ρ. In the second stage, the bank i raises deposit S_i from the young households taking the market rate r as given, subject to the capital requirement constraint $k(S_i + K_i) \leq K_i$, which we recall is always binding. In the third stage, the bank i posts a loan contract $\{\gamma_i, \theta_{1,i}(n_i)\}$ concerning the lending rate, γ_i, and the cutoff point for the quality of a project, $\theta_{1,i}(n_i)$: With perfect screening, only a project with a success probability greater than or equal to $\theta_{1,i}(n_i)$ will get funded, and the bank gets paid the rate γ_i if the project indeed succeeds but nothing if the project actually fails. As in Peters [28], for simplicity, we let γ_i not contingent on the number of visitors. However, the selection criterion $\theta_{1,i}$ will depend on the number of visitors, n_i. The larger the number of visitors n_i, the higher the $\theta_{1,i}$, given the bank's fixed lending capacity. We also assume that the banks can commit their γ_i, so we do not consider the possible bargaining after the banks meet with the entrepreneurs as in Camera and Selcuk [35].

In the fourth stage, the bank i may raise additional funds by selling to young households loans originated in the third stage. These loans sold by the bank i have a risky return: With probability $\mathring{\theta} = \int_{\theta_{1,i}}^{1} \theta dG(\theta) / [1 - G(\theta_{1,i})]$, which is the average success probability for the pool of loans originated in the third stage, they will receive an interest rate r^a, but, with probability $1 - \mathring{\theta}$ they will receive nothing. The expected interest rate on sold loans is then $\mathring{\theta} r^a$. Denote by $\theta_{2,i}$ and γ_i^a respectively the cutoff point for the quality of and the lending rate on additional projects that get financed when the possibility of loan sales is considered.

Given the interest rate r, the expected interest rate r^a, the total funding $K_i + S_i$, the reaction of the entrepreneurs, and the strategy of other banks, the bank i chooses a pair of

$(\gamma_i,\, \theta_{1,i})$ to maximize the following combined profit from the third and the fourth stages:

$$\pi_{b,i} = \max_{\gamma_i, \gamma_i^a, \theta_{1,i}, \theta_{2,i}} \left[n_i \int_{\theta_{1,i}}^{1} \theta dG(\theta)\gamma_i - (\rho K_i + rS_i) + n_i \int_{\theta_{2,i}}^{\theta_{1,i}} \theta dG(\theta)\gamma_i^a - \mathring{\theta} r^a S_i^a \right],$$

where the amount of loans originated in the third stage but sold by the bank to the households in the fourth stage, S_i^a, that is used to finance the $n_i\left[G(\theta_{1,i}) - G\left(\theta_{2,i}\right)\right]$ amount of additional projects, must be nonnegative, i.e., $0 \leq S_i^a$, and subject to the "skin-in-the-game" constraint,

$$S_i^a \leq n_i\left[G(\theta_{1,i}) - G\left(\theta_{2,i}\right)\right]. \tag{3}$$

When a bank posts a contract, it faces a trade-off between the loan rate γ_i and the number of entrepreneurs attending its island n_i. A lower γ_i can attract a larger number of n_i, allowing the bank to increase $\theta_{1,i}$. Because the information about the quality of projects will be fully revealed and the entrepreneurs will not leave the first chosen island, allowing the bank in the first chosen island to extract the entire expected surplus while leaving an entrepreneur to earn zero profit.

After observing the loan contract conditions $\{\gamma_i, \theta_{1,i}(n_i)\}$, the entrepreneurs choose a strategy on which island to attend. After an entrepreneur has arrived at its chosen island i, it draws a success probability θ from the distribution $G(\theta)$. The information of θ is private. The bank needs to evaluate the project in order to discover the value of θ. After the bank's evaluation, θ is discovered to both the bank and the entrepreneur, but it is still a sealed information for other banks. Since banks can evaluate projects only once in a period, we shut down the incentive for entrepreneurs to move to other islands during the same period.[20] Staying in the first chosen island the entrepreneur has a second chance to get financed through loan sales if its quality is relatively high.

[20] This assumption of entrepreneurs being locked to an island during one period does not affect the general results, but it makes the model much simpler. This assumption leads to that banks cannot compete for clients in the loan sales stage. This lack of competition in the loan-sales stage affects only the magnitude of loan sales, but not the motive for selling loans.

In an extension, we can allow the entrepreneurs to signal other banks about their quality and assume they succeed with a positive probablitity that is less than 1. As a result, a bank may loss some entrepreneurs to other banks in the fourth stage. This assumption will lower the incentive of banks to attract entrepreneurs in the third stage and lower the incentive for selling loans. But the extent to which it will affect the incentive of banks for loan sales is limited. This is because the low quality entrepreneurs may pretend to be high quality ones to prevent successful movement of entrepreneurs across banks.

If an entrepreneur goes to island i, it faces a contract $\{\gamma_i,\ \theta_{1,i}(n_i)\}$. An entrepreneur can expect to be financed in the first round with probability $1 - G(\theta_{1,i})$. The expected profit of an entrepreneur that chooses island i is

$$\pi_{e,i} = \int_{\theta_{1,i}(n_i)}^{1} \theta dG(\theta) (q - \gamma_i), \tag{4}$$

where q is the expected price of the intermediate good in the next period. In loan sales stage, although the entrepreneur has a chance to get financed, it earns zero profit given that $\gamma_i^a = q$.

An entrepreneur chooses an island according to $\max_i \{\pi_{e,i}\}$ across all i. Given $\pi_{e,i}$ determined in (4), an entrepreneur faces a trade-off between γ_i and $\theta_{1,i}$: In an island with a lower γ_i, the probability of being invested is lower, and vice verse. This is because the island i with a lower γ_i may attract a larger number of entrepreneurs (higher n_i) competing for the limited funding. Given this trade-off, the entrepreneurs' expected profits in all islands should be equal in an equilibrium and the marginal entrepreneur should be indifferent between staying in one island and moving to another one. Otherwise, if an island offers lower expected profit than other islands, the entrepreneurs would choose not to come to this island.

The household's problem is the same as in the case with only one bank. The only difference here is that the profit of entrepreneurs, π_e, is positive and it is returned to the households. The expected lifetime utility of a young household is

$$u(w - s - S - S^a) + \beta \left[\mathring{\theta} u (z_s s^\varsigma + rS + r^a S^a + \pi) + (1 - \mathring{\theta}) u (z_s s^\varsigma + rS + \pi) \right],$$

where $S = BS_i$, $S^a = BS_i^a$, $\pi = \pi_b + \pi_e$, $\pi_b = B\pi_{b,i}$, and $\pi_e = N\pi_{e,i}$.

The household's choice of $s > 0$, $S_i > 0$, and $S_i^a \geq 0$ then satisfy $r = \varsigma z_s s^{\varsigma - 1}$,

$$u'(w - s - S - S^a) = \beta r \left[\mathring{\theta} u' (z_s s^\varsigma + rS + r^a S^a + \pi) + (1 - \mathring{\theta}) u' (z_s s^\varsigma + rS + \pi) \right],$$

and

$$u'(w - s - S - S^a) = \beta r^a \mathring{\theta} u' (z_s s^\varsigma + rS + r^a S^a + \pi) + \varphi_a, \text{ and } \varphi_a S^a = 0.$$

4.2 Symmetric equilibrium

We restrict our attention to a stationary symmetric strong Nash equilibrium where K_i, S_i, γ_i, n_i, $\theta_{1,i}$, $\theta_{2,i}$, S_i^a, and γ_i^a are identical for all $i = 1, 2, ...B$, and all the entrepreneurs choose an identical mixed strategy on which banks to attend. As shown in Peters [28] and BSW [32], such a capacity-constrained Bertrand equilibrium always exists and it is unique.

If there are more than one bank competing in the same market, then banks cannot maintain a symmetric equilibrium with $\gamma_i = q$, for all $i = 1, 2, ..., B$. Suppose all the banks post $\gamma_i = q$, the equilibrium outcome is equivalent to that with only a single bank. However, if all the banks post $\gamma_i = q$, then a bank has an incentive to deviate from it. If a bank i decreases its γ_i a little bit, so that $\gamma_i < q$ and all other banks still post $\gamma_{-i} = q$, then an entrepreneur's expected profit from visiting bank i is positive. As a consequence, all the entrepreneurs would be attracted to the deviating bank i. If all the entrepreneurs come to island i, the bank i can select better projects than before the deviation.

Let $\theta^d_{1,i}$ be the project selection criterion by the bank i corresponding to γ^d_i ($\gamma^d_i < q$), let $\theta^*_{1,i}$ be the project selection criterion if all the banks post $\gamma = q$, then $\theta^d_{1,i} > \theta^*_{1,i}$. The bank faces all N potential projects when it deviates from $\gamma_i = q$, while it faces N/B if it posts $\gamma_i = q$. The total funding $(K_i + S_i)$ can now be used to support $\left[1 - G(\theta^d_{1,i})\right] N$ number of projects, that is, $\left[1 - G(\theta^d_{1,i})\right] N = K_i + S_i$, while before the deviation $K_i + S_i$ can be used to support $\left[1 - G(\theta^*_{1,i})\right] N/B$ number of projects, that is, $\left[1 - G(\theta^*_{1,i})\right] N/B = K_i + S_i$. Since $B \geq 2$, we have $\theta^d_{1,i} > \theta^*_{1,i}$. Therefore, the average success probability of the invested projects is higher when $\gamma^d_i < q$. Using the same funding $K_i + S_i$, now the bank i can invest in the same number of projects with a much higher average probability of success, which may motivate the bank i to deviate from posting $\gamma_i = q$. As a result, it is not an equilibrium if all the banks post $\gamma = q$. If there is a symmetric equilibrium with bank competition, then $\gamma_i < q$.

The market-clearing conditions are apparent in the labor market, the intermediate good market, and the credit market. In the consumption good market, it should be $c^y_1 + c^o_1 + s_1 + S_1 + S^a_1 = y_1$, where $y_1 = z_1 f(m_0)$, and $c^y_t + c^o_t + s_t + S_t + S^a_t = y^s_t + y_t$, for $t = 2$, 3, ... The total profit of entrepreneurs is $\pi_e = N \int^1_{\theta_{1,i}(n_i)} \theta dG(\theta) \left(q - \gamma_i\right)$.

Definition 1 *A symmetric equilibrium with bank competition is defined by sequences of prices* $\left\{ \left\{ \gamma_{i,t},\, \gamma^a_{i,t} \right\}^B_{i=1},\, r_t,\, r^a_t,\, q_t,\, w_t \right\}^\infty_{t=1}$*, selection rules* $\left\{ \left\{ \theta_{1,i,t},\, \theta^a_{2,i,t} \right\}^B_{i=1} \right\}^\infty_{t=1}$*, quantities* $\left\{ \left\{ K_{i,t},\, S_{i,t},\, S^a_{i,t},\, n_{i,t},\, \right\}^B_{i=1},\, m_t,\, y_t,\, y^s_t,\, s_t,\, c^y_t,\, c^o_t \right\}^\infty_{t=1}$*, an initial value of intermediate good* m_0*, and a policy parameter* k *such that: (i) the representative young household maximizes its expected life-time utility subject to its budget constraint, taking as given the wage rate, the interest rates, and the expected profit from entrepreneurs; (ii) the representative old* *household consumes everything it gets from its income; (iii) taking as given the market deposit rate, the strategy of entrepreneurs and the strategy of other banks, the capital requirement rate k, and the expected price of the intermediate good q_{t+1}, the banks choose their capital $K_{i,t}$, raise deposit $S_{i,t}$ from the young households, post a committed contract $\left(\gamma_{i,t},\ \theta_{1,i,t}\right)$ and choose loan sales $\left(\gamma_{i,t}^{a},\ \theta_{2,i,t},\ S_{i,t}^{a}\right)$ to maximize it's profit; (iv) an entrepreneur chooses a strategy on which islands to attend to maximize its expected profit; (v) the consumption good is produced according to $y_t = z_t f(m_{t-1})$ and $y_t^s = z_s s_{t-1}^{\varsigma}$; (vi) all the markets clear; (vii) all the prices and quantities are identical across islands; and (viii) no banks deviate from the equilibrium.*

In a symmetric equilibrium, we have $n_i = N/B$ and $n_i \left[1 - G\left(\theta_{1,i}\right)\right] = K_i + S_i$. If a symmetric equilibrium with $\gamma_i \in [0,\ q]$ exists, we have to ensure that no banks deviate from it. We prove that such a symmetric equilibrium exists and it is unique.

Note that it is possible that $\gamma_i \theta_{1,i} < \eta$, i.e., the bank may invest in some projects with negative expected return in the third stage. If a bank invests in these "non-profitable" projects, then the purpose is either to attract more clients or to relax a binding "skin-in-the-game" constraint by originating more loans. In both cases, the bank expects to get more profit in the loan sales stage.

The possibility of investing in "non-profitable" projects highlights the banks' motive for reselling their loans: they have good originating opportunity. This originating opportunity is caused by excess competition across banks: a low γ_i increases the lending standard and cuts off funding for some good projects. The banks put themselves in a difficult situation by competing to each other: if a bank increases its γ_i, it loses a pool of potential projects to its competitors; if the bank keeps a low γ_i, then only some very good projects can give the bank enough return to cover the cost of funding and many good projects cannot be financed. The banks may choose to post a relatively low γ_i to attract the potential projects to them, and then get additional funding from selling their loans to finance the projects that could not get financed in the first run.

Whether or not we have some "non-profitable" projects being invested in the third stage may depend on whether or not the "skin-in-the-game" constraint (3) is binding and on the intensity of bank competition. If the constraint is binding, then the bank may invest in some projects that have negative expected return, i.e., $\gamma_i \theta_{1,i} < \eta$, in order to raise more funding in the fourth stage. If the bank competition is intense, then banks may try to attract entrepreneurs using a very attractive contract, which may give themselves negative profit in the third stage.

Depending on whether or not the constraint (3) is binding, we have two possible cases. In the first case, if the constraint (3) is binding, then not all projects with $\theta \geq \mathring{\theta}_i r^a/q$ are invested, so $\theta_{2,i} q \geq \mathring{\theta}_i r^a$, where $\theta_{2,i}$ is determined by $n_i \left[G(\theta_{1,i}) - G\left(\theta_{2,i}\right)\right] = (1-\lambda) n_i \left[1 - G\left(\theta_{1,i}\right)\right]$. In the second case, if the constraint (3) is not binding, then $\theta_{2,i} q = \mathring{\theta}_i r^a$.

We first consider the case in which the constraint (3) is binding. In this case, the binding "skin-in-the-game" constraint gives

$$G(\theta_{1,i}) - G\left(\theta_{2,i}\right) = (1-\lambda)\left[1 - G(\theta_{1,i})\right]. \tag{5}$$

We differentiate completely the equation (5) to get

$$\frac{d\theta_{2,i}}{d\theta_{1,i}} = \frac{(2-\lambda)\, g(\theta_{1,i})}{g(\theta_{2,i})}. \tag{6}$$

The term $d\theta_{2,i}/d\theta_{1,i} > 0$ in (6), indicating that if $\theta_{1,i}$ increases, then $\theta_{2,i}$ increases. It means that a higher quality of assets (a smaller volume of assets) in the third stage would cause a lower amount of loan sales in the fourth stage, due to the binding "skin-in-the-game" constraint.

Proposition 2 *In the case where the "skin-in-the-game" constraint (3) is binding, there exists a unique pair of $(\gamma_i,\ \theta_{1,i})$ that maximizes the profit of bank i if the distribution of θ satisfies the following condition: Given any $\theta_{1,i} \in [0,1]$ and $G\left(\theta_{2,i}\right) = (2-\lambda) G(\theta_{1,i}) - (1-\lambda)$, we have $\theta_{2,i}\left[1 - G(\theta_{2,i})\right] > \int_{\theta_{2,i}}^{\theta_{1,i}} \theta dG(\theta)$.*

Proof. We will focus on a symmetric strong Nash equilibrium in which all the banks get the same K in the first stage and the same S in the second stage, post $\{\gamma, \theta_1\}$ in the third stage, and choose $\{\gamma^a,\ \theta_2,\ S^a\}$ in the fourth stage for every period. Here, $\gamma \in [0, q]$ and $\gamma^a \in [0, q]$. In order to prove the existence of such an equilibrium, we need to prove that given K and S there exists a pair of $\{\gamma, \theta_1\}$ from which no banks will deviate. In order to find this equilibrium with γ, we need to show that $\pi\left(\gamma_i^d\right) \leq \pi\left(\gamma\right)$ for any $\gamma_i^d \in [0, q]$.

First we show that, in the third stage after K_i and S_i are determined, there is an equilibrium pair of $\{\gamma, \theta_1\}$ such that if a bank i posts a contract $(\gamma_i^d,\ \theta_{1,i}^d)$ with $\gamma_i^d \leq \gamma$, then $\pi\left(\gamma_i^d\right) \leq \pi\left(\gamma\right)$. If a bank posts γ_i^d, the corresponding selection rule of the threshold value of project quality $\theta^d_{1,i}$ should satisfy $\theta^d_{1,i} \geq \theta_1$. This is because a larger number of projects, n^d_i, will be attracted by the new contract, i.e., $n^d_i \geq n^c_i$, such that the bank can select better projects given a larger pool available. As a consequence, the average quality of projects becomes higher. The bank's profit becomes

$$\pi^d_{b,i} = n^d_i \int_{\theta^d_{1,i}}^{1} \theta dG(\theta)\gamma^d_i - \eta\left(K_i + S_i\right) + n^d_i \int_{\theta^d_{2,i}}^{\theta^d_{1,i}} \theta dG(\theta) q - n^d_i \left[G(\theta^d_{1,i}) - G\left(\theta^d_{2,i}\right)\right] \mathring{\theta} r^a_i.$$

For an entrepreneur, the probability of being financed by bank i, $1 - G(\theta^d_{1,i})$, becomes lower. Since the bank faces a better pool of projects, it uses up all of its funding to finance the projects, i.e., $n^d_i \left[1 - G(\theta^d_{1,i})\right] = K_i + S_i$.

When a bank varies its contract, it faces a trade-off between the lending rate γ^d_i, and the number of potential projects attracted, n^d_i. It is crucial to figure out how n^d_i moves in response to γ^d_i. Observing $(\gamma^d_i,\ \theta^d_{1,i})$, an entrepreneur will visit island i if its expected profit from borrowing at island i is higher than or equal to what it could get from other islands. If we consider an economy with a large number of entrepreneurs, the last visitor (marginal visitor) will have the same profit as if it visited any other islands, that is

$$\int_{\theta^d_{1,i}}^{1} \theta dG(\theta)(q - \gamma^d_i) = \pi_e. \tag{7}$$

Equation (7) gives an indifference curve over the choices of $\left(\gamma^d_i,\ \theta^d_{1,i}\right)$ for an entrepreneur. Differentiating equation (7) completely, we get

$$\frac{d\theta^d_{1,i}}{d\gamma^d_i} = -\frac{\int_{\theta^d_{1,i}}^{1} \theta dG(\theta)}{(q - \gamma^d_i)\theta^d_{1,i} g(\theta^d_{1,i})}. \tag{8}$$

Given the indifference curve of the entrepreneurs, the expected profit of the deviating bank is

$$\pi^d_{b,i} = \frac{K_i + S_i}{1 - G(\theta^d_{1,i})} \left[\frac{\gamma^d_i \pi_e}{(q - \gamma^d_i)} + q \int_{\theta^d_{2,i}}^{\theta^d_{1,i}} \theta dG(\theta) - \mathring{\theta} r^a \int_{\theta^d_{2,i}}^{\theta^d_{1,i}} dG(\theta)\right] - \eta\left(K_i + S_i\right).$$

Here we have used $n^d_i = (K_i + S_i) / \left[1 - G(\theta^d_{1,i})\right]$. Define $\psi(\gamma^d_i) \equiv \frac{\partial \pi^d_{b,i}(\gamma^d_i)}{\partial \gamma^d_i}$, then

$$\psi(\gamma^d_i) = \frac{q\pi_e\left(K_i + S_i\right)}{\left[1 - G(\theta^d_{1,i})\right](q - \gamma^d_i)^2 \theta^d_{1,i}} \left[\theta^d_{2,i}\left[1 - G\left(\theta^d_{2,i}\right)\right] - \frac{\gamma^d_i}{q} \int_{\theta^d_{1,i}}^{1} \theta dG(\theta) - \int_{\theta^d_{2,i}}^{\theta^d_{1,i}} \theta dG(\theta)\right]. \tag{9}$$

To derive (9), we have used $d\theta_{2,i}^d/d\theta_{1,i}^d$ from (6), the entrepreneur's trade-off between γ_i and $\theta_{1,i}$ given by (8), π_e from (7), and the binding "skin-in-the-game" constraint $G(\theta_{1,i}^d) - G\left(\theta_{2,i}^d\right) = (1-\lambda)\left[1 - G(\theta_{1,i}^d)\right]$.

Now we will show that the solution to $\psi(\gamma_i) = 0$ exists, i.e., the equilibrium exists. We define

$$\phi(\gamma_i) = \left[\theta_{2,i}^d\left[1 - G\left(\theta_{2,i}^d\right)\right] - \frac{\gamma_i}{q}\int_{\theta_{1,i}^d}^{1}\theta dG(\theta) - \int_{\theta_{2,i}^d}^{\theta_{1,i}^d}\theta dG(\theta)\right]. \tag{10}$$

The sign of $\phi(\gamma_i)$ determines the sign of $\psi(\gamma_i)$. We first look at the sign of $\phi(\gamma_i)$ when $\gamma_i \to q$,

$$\lim_{\gamma_i \to q}\phi(\gamma_i) = -\int_{\theta_{2,i}^d}^{1}\left(\theta - \theta_{2,i}^d\right)dG(\theta) < 0.$$

Second, we look at the value of $\phi(\gamma_i)$ as $\gamma_i \to 0$. We have

$$\lim_{\gamma_i \to 0}\phi(\gamma_i) > 0, \tag{11}$$

given the condition that given any $\theta_{1,i} \in [0,1]$ and $G\left(\theta_{2,i}^d\right) = (2-\lambda)\,G(\theta_{1,i}) - (1-\lambda)$, we have $\theta_{2,i}^d\left[1 - G(\theta_{2,i}^d)\right] > \int_{\theta_{2,i}^d}^{\theta_{1,i}}\theta dG(\theta)$. Since $\phi(\gamma_i)$ is continuous, there exists a γ_i such that $\phi(\gamma_i) = 0$, i.e., there exists a γ_i such that $\psi(\gamma_i) = 0$. We have proved the existence of a symmetric equilibrium.

Next we will prove the uniqueness of the equilibrium. A sufficient condition is that the function $\phi(\gamma_i)$ is monotonically decreasing in γ_i. From (10) we can get

$$\phi'(\gamma_i) = -\frac{(2-\lambda)^2\left[1 - G(\theta_{1,i})\right]\int_{\theta_{1,i}}^{1}\theta dG(\theta)}{(q-\gamma_i)\theta_{1,i}g(\theta_{2,i})} < 0.$$

As a result, the solution to $\phi(\gamma_i^{d*}) = 0$ is unique. We have a unique stationary symmetric equilibrium.

Now we show that no banks post γ_i^d such that $\gamma_i^d > \gamma_i^{d*}$. The proof is relatively simpler. If a bank i can post a contract $(\gamma_i^d,\, \theta_{1,i}^d)$ and $\gamma_i^d > \gamma_i^{d*}$ to earn a higher expected profit, then other banks would do the same. However, all the banks posting $(\gamma_i^d,\, \theta_{1,i}^d)$ with $\gamma_i^d > \gamma_i^{d*}$ is not an equilibrium; as shown above, banks will deviate from it until $\gamma_i^d = \gamma_i^{d*}$. This γ_i^{d*} defines the unique stationary symmetric equilibrium, i.e., $\gamma = \gamma_i^{d*}$. ■

Next, we need to figure out the optimal decision of S_i in the second stage and the optimal decision of K_i in the first stage. Both $\theta_{1,i}$ and $\theta_{2,i}$ are a function of K_i through $K_i/k = N/B\left[1 - G(\theta_{1,i})\right]$ and $G(\theta_{1,i}) - G\left(\theta_{2,i}\right) = (1-\lambda)\left[1 - G(\theta_{1,i})\right]$. It is easy to show that the bank's profit is concave in K_i. The optimal amount of K_i is obtained from maximizing the bank's total profit, i.e.,

$$\max_{K_i} \frac{N}{B}\gamma_i \int_{\theta_{1,i}}^{1} \theta dG(\theta) - \eta K_i/k + \frac{N}{B} q \int_{\theta_{2,i}}^{\theta_{1,i}} \theta dG(\theta) - \mathring{\theta} r^a (1-\lambda) K_i/k.$$

Since this decision of K_i is made before γ_i, the optimal pair $(\gamma_i, \theta_{1,i})$ is a function of K_i. Applying the envelop theorem, we have the first order condition for K_i,

$$\gamma_i \theta_{1,i} = \eta - \left[(\theta_{2,i} - \theta_{1,i}) q + (1-\lambda) \left(\theta_{2,i} q - \mathring{\theta} r^a \right) \right]. \tag{12}$$

To get (12), we have used $K_i/k = N/B\left[1 - G(\theta_{1,i})\right]$ and so $d\theta_{1,i}/dK_i = -B/N/g(\theta_{1,i})/k$, and $d\theta_{2,i}/d\theta_{1,i} = (2-\lambda)\, g(\theta_{1,i})/g(\theta_{2,i})$.

In the right hand side of the equation (12), the sign of the term $(\theta_{2,i} - \theta_{1,i})\, q + (1-\lambda) \left(\theta_{2,i} q - \mathring{\theta} r^a \right)$ determines whether $\gamma_i \theta_{1,i}$ is larger or smaller than η. Since $S_i^a > 0$, the first part $(\theta_{2,i} - \theta_{1,i})\, q < 0$; since the "skin-in-the-game" constraint is binding, the second part $\theta_{2,i} q - \mathring{\theta} r^a \geq 0$. If the "skin-in-the-game" constraint is not strictly binding, $\theta_{2,i} q - \mathring{\theta} r^a = 0$, then $\gamma_i \theta_{1,i} > \eta$, meaning the bank only invest in projects that make them positive profits in the third stage. Only if the "skin-in-the-game" constraint is strictly binding, $\theta_{2,i} q - \mathring{\theta} r^a > 0$, it is possible that the bank may invest in projects that make them negative profits in the third stage but help them to relax the "skin-in-the-game" constraint.

In the case where the "skin-in-the-game" constraint (3) is not binding, there is no stationary symmetric equilibrium. We will show that in lemma 3.

Lemma 3 *If the constraint (3) is not binding, there is no stationary symmetric equilibrium.*

Proof. If the constraint (3) is not binding, in the fourth stage, all the profitable projects will be financed, then the marginal project satisfies $\mathring{\theta} r^a = \theta_{2,i} q$. As a result, $d\theta_{2,i}/d\gamma_i = 0$. The relationship between S_i and S_i^a are determined by $\eta = \mathring{\theta} r^a$, instead of the "skin-in-the-game" constraint.

The bank's maximization problem in the third stage becomes:

$$\pi_{b,i} = \max_{\gamma_i, \theta_{1,i}} n_i \frac{\gamma_i \pi_e}{(q - \gamma_i)} - \eta K_i/k + n_i q \int_{\theta_{2,i}}^{\theta_{1,i}} \theta dG(\theta) - n_i \mathring{\theta} r^a \int_{\theta_{2,i}}^{\theta_{1,i}} dG(\theta), \tag{13}$$

where $n_i = (K_i + S_i)/\left[1 - G(\theta_{1,i})\right]$. The first order derivative of $\pi_{b,i}$ with respect to γ_i is

$$\psi(\gamma_i) = \frac{(K_i + S_i) q \pi_e}{\left[1 - G(\theta_{1,i})\right]^2 (q - \gamma_i)\theta_{1,i}} \left[-\frac{\gamma_i}{q} \int_{\theta_{1,i}}^{1} \theta dG(\theta) - \int_{\theta_{2,i}}^{\theta_{1,i}} \theta dG(\theta) + \theta_{2,i} \left[1 - G(\theta_{2,i})\right] \right].$$

We define

$$\phi(\gamma_i) = -\frac{\gamma_i}{q}\int_{\theta_{1,i}}^{1}\theta dG(\theta) - \int_{\theta_{2,i}}^{\theta_{1,i}}\theta dG(\theta) + \theta_{2,i}\left[1 - G\left(\theta_{2,i}\right)\right]. \tag{14}$$

Then,

$$\phi(\gamma_i) = \pi_e/q - \int_{\theta_{2,i}}^{1}\theta dG(\theta) + \theta_{2,i}\left[1 - G\left(\theta_{2,i}\right)\right],$$

and $\phi'(\gamma_i) = 0$. As a result, $\psi(\gamma_i) \neq 0$ and so we have no interior solution of γ_i. In the case where the "skin-in-the-game" constraint is not binding, we have no stationary symmetric equilibrium. ■

Combining the results from proposition 2 and lemma 3, we can expect a unique equilibrium with a binding "skin-in-the-game" constraint. As a result, the banks explore, to the maximum, "out of balance sheet" activities, loan-sales in the current circumstance, in the equilibrium with bank competition.

Let us add some remarks on the bank capital. In an environment of bank competition, capital requirement reduces the potential benefit from deviating the symmetric equilibrium. This is because the deposit at a bank is restricted by the capital requirement rate. With restricted size of deposit, the benefit from attracting additional projects is limited. So capital requirement has the effect of preventing excess bank competition, which is also the reason that banks can earn positive profit in the equilibrium. Without capital requirement, the equilibrium will be a Bertrand equilibrium with all the banks earning zero profit.

5 Example

We solve an example with an isoelastic utility function $c^{1-\sigma}/(1-\sigma)$, a Cobb–Douglas production function $y = zm^{\alpha}$, and a uniform distribution of θ with CDF $G(\theta) = \theta$.

5.1 Monopoly Bank

Taking the interest rates and the expected price of the intermediate goods, r, r^a, and q, as given, the bank maximizes its profit,

$$\pi_b = \max_{\theta_1,\theta_2} N\int_{\theta_1}^{1}\theta dG(\theta)q - \eta(S+K) + N\int_{\theta_2}^{\theta_1}\theta dG(\theta)q - \mathring{\theta}r^a S^a.$$

To solve the profit of the bank, we do backward induction. The bank takes $\mathring{\theta}$ and r^a, as well as r and q, as given when it issues loan sales. In the fourth stage, if $\theta_1 > \mathring{\theta}r^a/q$, the bank would like to raise funds from the household until $\theta_2 = \mathring{\theta} r^a / q$, as long as the "skin-in-the-game" constraint is not binding, that is $N\left[G\left(\theta_1\right) - G\left(\theta_2\right)\right] < (1-\lambda)(S+K)$. If the "skin-in-the-game constraint" becomes binding, then $S^a = N\left[G\left(\theta_1\right) - G\left(\theta_2\right)\right] = (1-\lambda)(S+K)$ and $\theta_2 q > \mathring{\theta} r^a$.

In the third stage, since both γ and γ^a equal to q, the bank only compares η and $\mathring{\theta} r^a$. If $\eta > \mathring{\theta} r^a$, then the bank would like to issue loan sales as much as possible, until the "skin-in-the-game" constraint becomes binding. If $\eta < \mathring{\theta} r^a$, then the bank does not expect to issue any loan sales. If $\eta = \mathring{\theta} r^a$, then the bank may issue an amount of loan sales belong to the set $[0, (1-\lambda)(S+K)]$.

To compute the equilibrium, we guess the initial values of r, r^a, and q. If the "skin-in-the-game" constraint is not binding, then $\theta_2 = \mathring{\theta} r^a / q$, and the bank's maximization problem implies that $\mathring{\theta} r^a = \eta$. Accordingly, can solve for θ_1 and θ_2, and get π_b, $m = N \int_{\theta_2}^{1} \theta dG(\theta)$, $q^{new} = z f'(m)$, and $w = z f(m) - qm$. Given r, we get $s = \left[r / \left(\varsigma z_s\right)\right]^{1/(\varsigma - 1)}$. From the household's problem, we solve for the supply of funding S and S^a,

$$u'\left(w - s - S - S^a\right) = \beta r \left[\mathring{\theta} u'\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right) + (1-\mathring{\theta}) u'\left(z_s s^{\varsigma} + rS + \pi_b\right)\right]$$

and

$$u'\left(w - s - S - S^a\right) = \beta r^a \mathring{\theta} u'\left(z_s s^{\varsigma} + rS + r^a S^a + \pi_b\right) + \varphi_a, \text{ and } \varphi_a S^a = 0.$$

In the equilibrium the equalization of the demand of funding and the supply of funding imply θ_1^{new} and θ_2^{new}. Then we check whether we have $\theta_1^{new} = \theta_1$, $\theta_2^{new} = \theta_2$, and $q^{new} = q$ or not. If not, we change the initial guess until we get a convergence. If the "skin-in-the-game" constraint is binding, then $\left[G\left(\theta_1\right) - G\left(\theta_2\right)\right] = (1-\lambda)\left[1 - G\left(\theta_1\right)\right]$. The bank's maximization problem implies that

$$\eta - (2-\lambda)\,\theta_2 q + (1-\lambda)\mathring{\theta} r^a = 0.$$

Other steps will be similar as in the case of binding "skin-in-the-game" constraint. However, there may be no convergence with a binding "skin-in-the-game" constraint.

5.2 Competitive Banks

To compute the equilibrium, we guess the initial market values of q, r, and r^a. To compute $\theta_{1,i}$ and $\theta_{2,i}$, we first compute K_i and establish the relationship between them and K_i. Since the funding markets clear in both the third stage and the fourth stage, we have $S_i/(1-k) = n_i\left[1-G\left(\theta_{1,i}\right)\right]$, and $S_i^a = n_i\left[G(\theta_{1,i}) - G(\theta_{2,i})\right]$. Since the "skin-in-the-game" constraint is binding, we have $n_i\left[G(\theta_{1,i}) - G(\theta_{2,i})\right] = (1-\lambda) K_i/k$. According to the funding market clearing condition and the binding "skin-in-the-game" constraint, we establish the link between S_i^a and K_i, $S_i^a = (1-\lambda) K_i/k$ and the link between $\theta_{2,i}$ and $\theta_{1,i}$, $\theta_{2,i} = (2-\lambda)\theta_{1,i} - (1-\lambda)$. Accordingly, $d\theta_{2,i}/d\theta_{1,i} = (2-\lambda)$. Applying equilibrium symmetry, we have $N/B = K_i/\left\{k\left[1-G\left(\theta_{1,i}\right)\right]\right\}$. Thus, we can write $\theta_{1,i}$ and $\theta_{2,i}$ as a function of K_i,

$$\theta_{1,i} = 1 - BK_i/\left(kN\right), \text{ and } \theta_{2,i} = 1 - (2-\lambda) BK_i/\left(kN\right). \tag{15}$$

The first order derivative of the bank's profit has the same sign as $\phi(\gamma_i)$ defined in (10). Substituting (15) into $\phi(\gamma_i)$, we have

$$\begin{aligned}\phi(\gamma_i) &= (1-\gamma_i/q)\left[BK_i/\left(kN\right) - \left[BK_i/\left(kN\right)\right]^2/2\right] \\ &\quad - (2-\lambda)^2\left[BK_i/\left(kN\right)\right]^2/2.\end{aligned}$$

So the first order condition is equivalent to $\phi(\gamma_i) = 0$, which gives

$$\gamma_i = q - q\frac{(2-\lambda)^2 BK_i/\left(kN\right)}{2 - BK_i/\left(kN\right)}. \tag{16}$$

Substituting γ_i, $\theta_{1,i}$, and $\theta_{2,i}$ into (12),

$$d^2 - \left[\frac{7-3\lambda}{2(2-\lambda)} - \frac{\vartheta}{2(2-\lambda)^2}\right] d + \frac{1}{2-\lambda} - \frac{\vartheta}{(2-\lambda)^2} = 0, \tag{17}$$

where $d = BK_i/\left(kN\right)$ and $\vartheta = \left[\eta + (1-\lambda)\mathring{\theta} r^a\right]/q$. We can solve for the optimal K_i. Thus, we can compute $\theta_{1,i}$, $\theta_{2,i}$, and γ_i.

According to $\theta_{1,i}$ and $\theta_{2,i}$, we get $\pi_b = B\pi_{b,i}$, $\pi_e = N\int_{\theta_{2,i}}^1 \theta dG(\theta)\left(q-\gamma_i\right)$, $m = N\int_{\theta_{2,i}}^1 \theta dG(\theta)$, $q^{new} = zf'\left(m\right)$, and $w = zf\left(m\right) - qm$. Given r, we get $s = \left[r/\left(\varsigma z_s\right)\right]^{1/(\varsigma-1)}$. Next, we compute the supply of S_i and S_i^a from the household's problem,

$$\begin{aligned}&u'\left(w - s - BS_i - BS_i^a\right) \\ &= \beta r\left\{\begin{array}{c}\mathring{\theta} u'\left(z_s s^\varsigma + rBS_i + r^a BS_i^a + \pi\right) \\ +\left(1-\mathring{\theta}\right) u'(z_s s^\varsigma + rBS_i + \pi)\end{array}\right\},\end{aligned} \tag{18}$$

and

$$u'\left(w - s - BS_i - BS_i^a\right) = \beta r^a \mathring{\theta} u'\left(z_s s^\varsigma + rBS_i + r^a BS_i^a + \pi\right). \tag{19}$$

In the equilibrium the equalization of the demand of funding and the supply of funding imply θ_1^{new} and θ_2^{new}. Then we check whether we have $\theta_1^{new} = \theta_1$, $\theta_2^{new} = \theta_2$, and $q^{new} = q$ or not. If not, we change the initial guess until we get a convergence.

5.3 Numerical results

In the numerical exercise, we use the following values of parameters: $\alpha = 0.4$, $z = 100$, $z_s = 10$, $\varsigma = 0.5$, $N = 500$, $\lambda = 0.5$, $\beta = 0.9$ and $\rho = 0.3$. Let the value of risk aversion parameter σ vary from 1 to 10, and the value of k vary from 0.01 to 0.08.

In the case of no bank competition the loan sales won't be very significant under moderate capital requirement, if households are reasonably risk averse (so the required premium for compensating the risk on sold loans, $\mathring{\theta} r^a/r - 1$, is non-negligible). Figures 1 and 2 give the ratio of loan sales to the total bank credits in the case of no bank competition

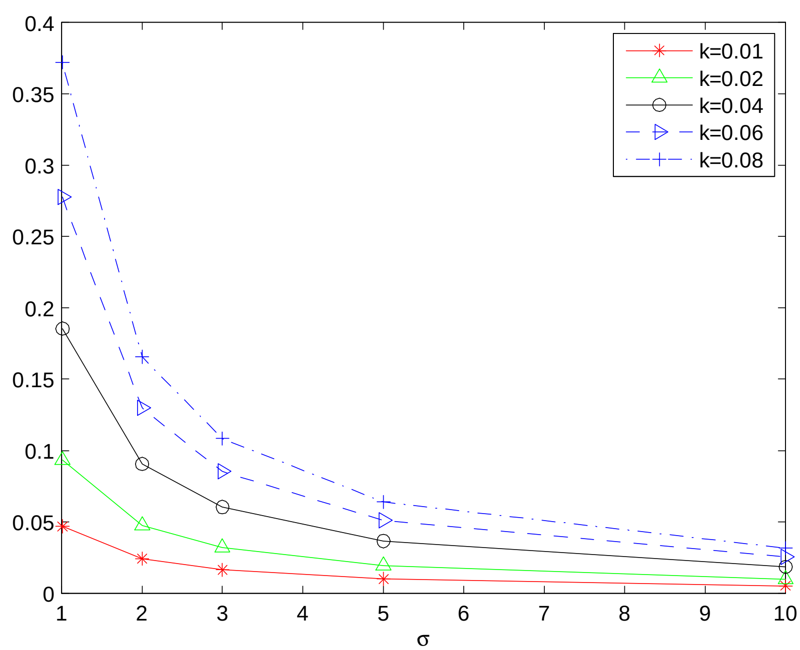

Figure 1. Loan sales as a fraction of total bank credits: no bank competition

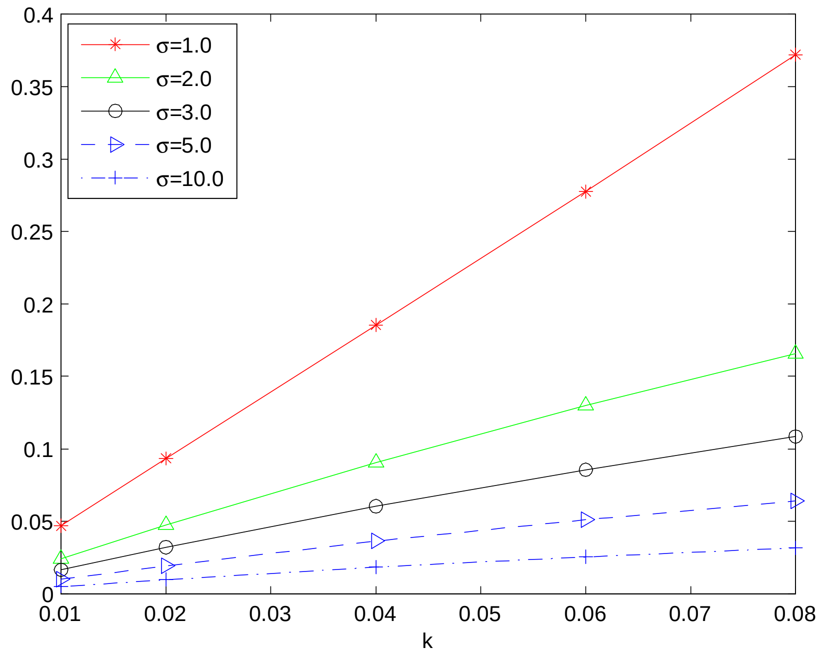

Figure 2. Loan sales as a fraction of total bank credits: no bank competition

In the case of bank competition, on-balance-sheet funds are lower and loan sales are greater than in the case with no bank competition. Figure 3 and Figure 4 give the increase in the share of loan sales in total bank credits due to bank competition.

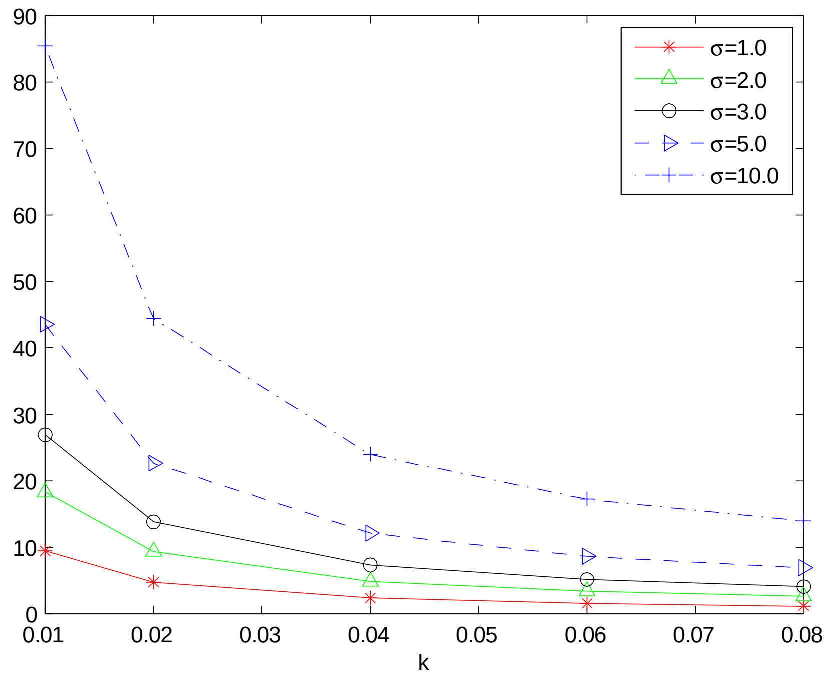

Figure 3. Increase in the share of loan sales in total bank credits due to bank competition

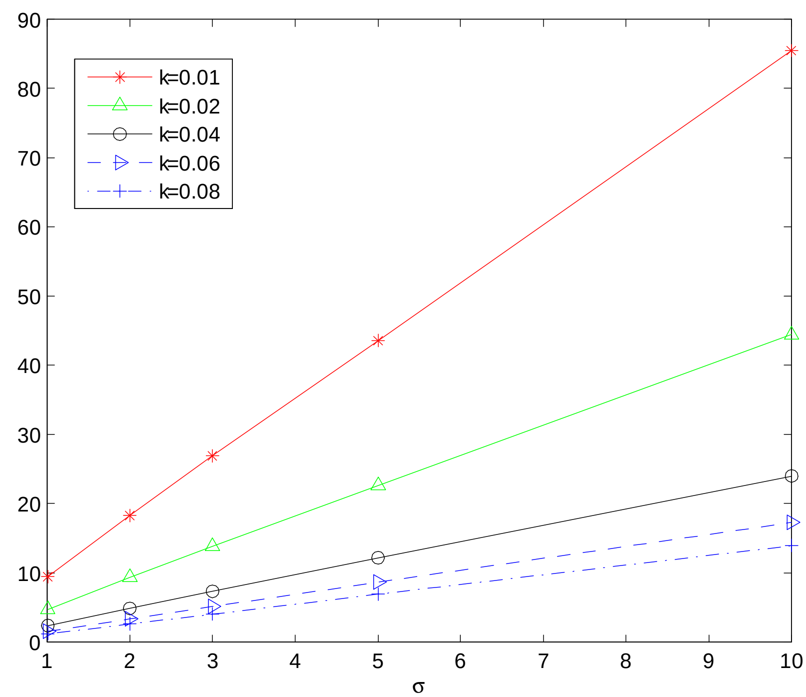

Figure 4. Increase in the share of loan sales in total bank credits due to bank competition

6 Extension

In this section we introduce a mutual fund to deal with loan sales. The mutual fund takes fundings from the young households and buys loan sales from banks. The profit of the mutual fund is returned to the households when they become old. This setup mitigates the effect of risk aversion since households can share risk through the mutual fund. This setup also helps to understand the determination of prices on different Tranches of loan sales and the influence of the pricing mechanism on loan sales. The mutual fund and the bank determine the price of the loan sales through Nash bargaining. In addition to the price of loan sales, the bank also charges a fixed margin $\xi_b \geq 0$ on each unit of loan sales. We shall also assume (by choice of parameters) that undertaking all evaluated projects yields a negative expected project return, net of funding costs. This serves to guarantee that the optimal reservation success probability for accepting projects is always positive.

6.1 The Case of No Bank Competition

We first examine the decision of a monopoly bank. In each period, the bank makes decisions on its capital, deposit, loan contract, and loan sales sequentially. In the fourth stage, the bank may raise additional funds by selling to the mutual fund loans originated in the third and fourth stages. The marginal quality of projects financed by loan sales, θ_2, is unobservable by the mutual fund. The bank is asked to hold λ proportion of its newly issued projects financed by loan sales to avoid moral hazard and adverse selection problems.[21] As a result, the bank needs to sell not only some loans originated in the fourth stage, but also some loans that are originated in the third stage in order to obtain enough funding. We call the loan sales originated in the fourth stage the Junior Tranche, and the loan sales originated in the third stage the Senior Tranche. We also assume that every share of the loan sales in the same Tranche has the same quality, denoted by $\mathring{\theta}_1$ and $\mathring{\theta}_2$ for the Senior

[21] The regulator can monitor and verify that the bank indeed hold at least λ proportion of its loan sales and punish the banks that do not satisfy this rule. However, the regulator cannot verify the accurate amount of loan sales held by the banks and cannot reveal this inforamtion. Although we allow that the bank to hold a higher than λ proportion of its loan sales, but the mutual fund does not know exactly how much the bank holds and therefore the mutual fund chooses to believe that the bank holds λ proportion of its loan sales. The bank, therefore, has no incentive to hold more than λ proportion of its loan sales.

and Junior Tranche, respectively, and

$$\mathring{\theta}_1 = \frac{\int_{\theta_1}^{1} \theta dG(\theta)}{\int_{\theta_1}^{1} dG(\theta)}, \mathring{\theta}_2 = \frac{\int_{\theta_2}^{\theta_1} \theta dG(\theta)}{\int_{\theta_2}^{\theta_1} dG(\theta)}.$$

Without bank competition, we have $\gamma = \gamma^a = q$ as in the banchmark model. If loan sales do not exist in the equilibrium, then the solution is $\theta_1 = \eta/q$. If loan sales exist, to solve the equilibrium, we do backward induction. First, in the loan sales stage, given λ, θ_1, r, q, and $\gamma = \gamma^a = q$, the bank chooses θ_2 to maximize its profit. Although the mutual fund does not observe θ_2, it can derive the value of θ_2 according to the regulation λ and its rational expectation on bank's maximization problem. Let P_1 and P_2 be the prices of the loan sales in the Senior Tranche and the Junior Tranche, respectively. Given this information structure, the bank and the mutual fund bargain on the asset prices P_1 and P_2 through Nash bargaining. Let the bargaining powers of the bank and the mutual fund be ϕ and $1 - \phi$, respectively, then $P_1 = \phi \left(\mathring{\theta}_1 q - r - \xi_b \right)$ and $P_2 = \phi \left(\mathring{\theta}_2 q - r - \xi_b \right)$, i.e., the bank gets ϕ proportion of the total excess return. Here, we have assumed myopic bargaining: that is the bank and the mutual fund only bargain on the direct profit, but ignore that the bank may gain or loss due to the associated transactions.

Taken θ_1 and the price functions $P_1(\theta_1)$ and $P_2(\theta_1, \theta_2)$ as given, the bank chooses θ_2 to maximize its profit in the loan sales stage:

$$\pi_b^a = \max_{\theta_2} (1-\lambda) P_2(\theta_1, \theta_2) S^a + \left[\lambda \mathring{\theta}_2 q + \lambda \left(P_1(\theta_1) - \mathring{\theta}_1 q \right) \right] S^a + \xi_b S^a, \; S^a \geq 0. \tag{20}$$

The first term in (20) is the benefit from selling $1 - \lambda$ proportion of Junior Tranches loans, and the second term is the benefit from holding λ proportion of Junior Tranches loans but selling a same amount of Senior Tranches loans. Substituting in the prices P_1 and P_2, the objective function becomes

$$\pi_b^a = \max_{\theta_2} \left[-\varepsilon \mathring{\theta}_1 q + (\varepsilon + \phi) \mathring{\theta}_2 q - \zeta \right] S^a,$$

where $\varepsilon = \lambda (1 - \phi)$, and $\zeta = \phi r - (1 - \phi) \xi_b$. The first order condition with respect to θ_2 gives that

$$\theta_2 = \frac{\varepsilon \mathring{\theta}_1 q + \zeta}{(\varepsilon + \phi) q}. \tag{21}$$

From (21), it is obvious that θ_2 weakly increases in θ_1. To show it mathematically, we can differentiate the above equation to get

$$\frac{d\theta_2}{d\theta_1} = \frac{\varepsilon}{\varepsilon+\phi}\frac{d\mathring{\theta}_1}{d\theta_1} = \frac{\varepsilon}{\varepsilon+\phi}\frac{g(\theta_1)\left(\mathring{\theta}_1-\theta_1\right)}{\int_{\theta_1}^{1} dG(\theta)}.$$

For loan sales to exist, i.e., for the bank to sell loans, we also need to have $\theta_2 < \theta_1$. According to the solution (21), this condition becomes

$$\varepsilon\mathring{\theta}_1 q - (\varepsilon+\phi)\,\theta_1 q + \zeta < 0. \tag{22}$$

If λ is very small, the bank may have incentive to finance some projects that earn negative profits, the mutual fund may not participate in the loan sales. Let $\pi_{m,1}$ and $\pi_{m,2}$ be the mutual fund's marginal profits from the Senior Tranche and the Junior Tranche of loan sales, respectively, then $\pi_{m,1} \geq \pi_{m,2}$ and the participation constraint of the mutual fund satisfies

$$\pi_{m,2} = (1-\phi)\left(\mathring{\theta}_2 q - r - \xi_b\right) \geq 0. \tag{23}$$

The total profit of the mutual fund is

$$\pi_m = \pi_{m,1}\lambda S^a + \pi_{m,2}(1-\lambda)S^a.$$

If λ is large, the bank may face a capacity constraint. That is, the bank's holding of off-balance-sheet financing, λS^a, cannot exceed the amount of on-balance-sheet loans that can be sold, i.e.,

$$\lambda S^a \leq S + K. \tag{24}$$

Now back to stage three, the bank's profit with loan sales is

$$\pi_b = \max_{\theta_1} Nq\int_{\theta_1}^{1}\theta dG(\theta) - N\eta\int_{\theta_1}^{1} dG(\theta) + \pi_b^a. \tag{25}$$

Substituting π_b^a into (25), the objective becomes

$$\pi_b = \max_{\theta_1}\left\{N\left(\mathring{\theta}_1 q - \eta\right)\int_{\theta_1}^{1} dG(\theta) + \left[-\varepsilon\mathring{\theta}_1 q + (\varepsilon+\phi)\,\mathring{\theta}_2 q - \zeta\right]S_a\right\}.$$

The first order condition with respect to θ_1 gives

$$\theta_1 = \frac{\eta - \zeta - \varepsilon(1+\varphi)\,\mathring{\theta}_1 q}{(1-\varepsilon\varphi-\varepsilon-\phi)\,q}, \text{ where } \varphi = \frac{\int_{\theta_2}^{\theta_1} dG(\theta)}{\int_{\theta_1}^{1} dG(\theta)}. \tag{26}$$

Here we have used

$$\frac{d\mathring{\theta}_1}{d\theta_1} = \frac{g(\theta_1)\left(\mathring{\theta}_1 - \theta_1\right)}{\int_{\theta_1}^{1} dG(\theta)}, \text{ and } \frac{d\mathring{\theta}_2}{d\theta_1} = -\frac{g(\theta_1)\left(\mathring{\theta}_2 - \theta_1\right)}{\int_{\theta_2}^{\theta_1} dG(\theta)} + \frac{g(\theta_2)\left(\mathring{\theta}_2 - \theta_2\right)}{\int_{\theta_2}^{\theta_1} dG(\theta)} \frac{d\theta_2}{d\theta_1}.$$

Given the parameter values of k, ρ, λ, ϕ, and ξ_b, and the prices r and q, equations (21) and (26) together determine the optimal value of θ_1 and θ_2. The equation (21) shows that θ_2 increases in θ_1. The equation (26) shows that when θ_1 increases, the value of φ has to decreases, leading to an increase in θ_2. Since both two equations show monotone relationship between θ_2 and θ_1, there is a unique loan sales equilibrium if the equilibrium exists.

To complete the model here, we solve the household's problem. A young household can save via deposit, mutual fund, or the storage technology. Given that households have non-satiated preferences, the expected lifetime utility of a young household is

$$u(w - s - S - S^a) + \beta u\left(z_s s^{\varsigma} + rS + rS^a + \pi_m + \pi_b\right),$$

where both the consumption when young and that when old must be strictly positive given the property of the utility function that $\lim_{c\to 0^+} u(c) \to +\infty$. Since the marginal rate of return to the storage technology will approach positive infinity as $s \to 0^+$, it must be the case that s is strictly positive as well. The household's choice of s then must guarantee that

$$u'\left(w - s - S - S^a\right) = \beta\varsigma z_s s^{\varsigma-1} u'\left(z_s s^{\varsigma} + rS + rS^a + \pi_m + \pi_b\right).$$

Since in any given period entrepreneurs must rely on bank loans to finance their projects for generating intermediate inputs in the subsequent period, which must be combined with labor services for final good production, an active banking sector in period $t-1$ is necessary to ensure an active production sector in period t, which is essential in order for a young household of generation t to carry on, for all $t \geq 1$. Note that a positive level of household deposit is required for the banking sector to be active, since loan sales would not be possible without any household deposit to finance loans to be sold in the first place. Therefore, we must have $S > 0$. The household's choice of $S + S^a$ then must guarantee that

$$u'\left(w - s - S - S^a\right) = \beta r u'\left(z_s s^{\varsigma} + rS + rS^a + \pi_m + \pi_b\right).$$

The equilibrium $S > 0$ and $S^a \geq 0$ will be determined by the demand of funding by the bank and the mutual fund. From the above two optimality conditions it follows that $r = \varsigma z_s s^{\varsigma-1}$.

The value of q and w are determined in $q = zf'(m)$ and $w = zf(m) - qm$, respectively, and the total intermediate goods produced is $m = N\int_{\theta_2}^{1} \theta dG(\theta)$.

6.2 Bank Competition as a Motivation for Loan Sales

We turn now to the case with bank competition. If loan sales exist, to solve the equilibrium, we do backward induction. We first consider the decision of the bank in the loan sales stage. Given λ, $\theta_{i,1}$, r, and q, the bank chooses $\theta_{i,2}$ to maximize its profit. Although the mutual fund does not observe $\theta_{i,2}$, it can derive the value of $\theta_{i,2}$ according to the regulation λ and its rational expectation on bank's maximization problem. Let S_i^a denote the amount of loan sales by bank i, then $S_i^a = n_i \int_{\theta_{i,2}}^{\theta_{i,1}} dG(\theta)$, while the total on-the-balance-sheet loans is $S_i + K_i = n_i \int_{\theta_{i,1}}^{1} dG(\theta)$. Let $P_{i,1}$ and $P_{i,2}$ be the prices of the loan sales in the higher branch and lower branch respectively. Given these information, the bank and the mutual fund bargain on the asset prices $P_{i,1}$ and $P_{i,2}$ through Nash bargaining. Let the bargaining power of the bank be ϕ, then $P_{i,1} = \phi\left(\mathring{\theta}_{i,1}\gamma_i - r - \xi_b\right)$ and $P_{i,2} = \phi\left(\mathring{\theta}_{i,2}q - r - \xi_b\right)$, where

$$\mathring{\theta}_{i,1} = \frac{\int_{\theta_{i,1}}^{1} \theta dG(\theta)}{\int_{\theta_{i,1}}^{1} dG(\theta)},\ \mathring{\theta}_{i,2} = \frac{\int_{\theta_{i,2}}^{\theta_{i,1}} \theta dG(\theta)}{\int_{\theta_{i,2}}^{\theta_{i,1}} dG(\theta)}.$$

Taken K_i, S_i, r, γ_i, $\theta_{i,1}$, n_i and the price functions $P_{i,1}(\theta_{i,1})$ and $P_{i,2}(\theta_{i,1}, \theta_{i,2})$ as given, the bank chooses $\theta_{i,2}$ to maximize its profit in the loan sales stage:

$$\pi_{i,b}^a = \max_{\theta_{i,2}} \left[\lambda\left(P_{i,1}(\theta_{i,1}) - \mathring{\theta}_{i,1}\gamma_i\right) + \lambda\mathring{\theta}_{i,2}q + (1-\lambda)P_{i,2}(\theta_{i,1}, \theta_{i,2}) + \xi_b\right] S_{i,a}.$$

Substituting the prices $P_{i,1}$ and $P_{i,2}$ into the objective function, we get

$$\pi_{i,b}^a = \max_{\theta_{i,2}} \left[-\varepsilon\mathring{\theta}_{i,1}\gamma_i + (\varepsilon + \phi)\,\mathring{\theta}_{i,2}q - \zeta\right] n_i \int_{\theta_{i,2}}^{\theta_{i,1}} dG(\theta).$$

If λ is large, the bank may face a capacity constraint. That is, the bank's holding of off-balance-sheet loans, λS_i^a, cannot exceed the amount of on-balance-sheet loans that can be sold, i.e.,

$$\lambda S_i^a \leq S_i + K_i. \tag{27}$$

In this case, we have $\theta_{i,2}$ being determined by

$$\lambda \int_{\theta_{i,2}}^{\theta_{i,1}} dG(\theta) = \int_{\theta_{i,1}}^{1} dG(\theta). \tag{28}$$

If (27) is not binding, then the first order condition with respect to $\theta_{i,2}$ gives that

$$\theta_{i,2} = \frac{\varepsilon \mathring{\theta}_{i,1}\gamma_i + \zeta}{(\varepsilon + \phi)\, q}. \tag{29}$$

This result is similar to what we get in the one bank case, except that $\gamma_i < q$ here while it is $\gamma = q$ in the one bank case.

Given that some projects that may earn negative profits could be financed by loan sales, the mutual fund may not participate in the loan sales if λ is very small. Let $\pi_{m,i,1}$ and $\pi_{m,i,2}$ be the mutual fund's marginal profits from higher branch and lower branch loan sales from bank i respectively, then the participation constraints of the mutual fund satisfy

$$\pi_{m,i,1} = (1-\phi)\left(\mathring{\theta}_{i,1}\gamma_i - r - \xi_b\right) \geq 0 \tag{30}$$

and

$$\pi_{m,i,2} = (1-\phi)\left(\mathring{\theta}_{i,2} q - r - \xi_b\right) \geq 0. \tag{31}$$

The total profit of the mutual fund is

$$\pi_{i,m} = \pi_{m,i,1}\lambda S_{i,a} + \pi_{m,i,2}(1-\lambda)S_{i,a}.$$

If there will be loan sales, in the third stage, the bank chooses γ_i to maximize its profit by taking $S_i + K_i$ as given

$$\pi_{i,b} = \max_{\gamma_i}\left(\mathring{\theta}_{i,1}\gamma_i - \eta\right)(S_i + K_i) + \pi^a_{i,b},$$

subject to the entrepreneurs' indifference curve (8).

In the case where (27) is binding,

$$\frac{\partial \theta_{i,2}}{\partial \theta_{i,1}} = \left(1 + \frac{1}{\lambda}\right)\frac{g(\theta_{i,1})}{g(\theta_{i,2})}, \text{ and } \frac{\partial \theta_{i,2}}{\partial \gamma_i} = 0.$$

The first order condition with respect to γ_i gives

$$\phi\mathring{\theta}_{i,1}\gamma_i = -\varepsilon\theta_{i,1}q + (1+\varphi)(\varepsilon+\phi)\,\theta_{i,2}q - \varphi(\varepsilon+\phi)\,\mathring{\theta}_{i,2}q, \tag{32}$$

in which $\varphi = 1/\lambda$.

In the case where (27) is not binding,

$$\frac{\partial \theta_{i,2}}{\partial \theta_{i,1}} = \frac{\varepsilon\gamma_i}{(\varepsilon+\phi)\,q}\frac{d\mathring{\theta}_{i,1}}{d\theta_{i,1}} = \frac{\varepsilon\gamma_i}{(\varepsilon+\phi)\,q}\frac{g(\theta_{i,1})\left(\mathring{\theta}_{i,1} - \theta_{i,1}\right)}{\int_{\theta_{i,1}}^{1} dG(\theta)},$$

and

$$\begin{aligned}\frac{d\theta_{i,2}}{d\gamma_i} &= \frac{\partial\theta_{i,2}}{\partial\theta_{i,1}}\frac{d\theta_{i,1}}{d\gamma_i}+\frac{\partial\theta_{i,2}}{\partial\gamma_i}=\frac{\varepsilon\gamma_i}{(\varepsilon+\phi)\,q}\frac{d\mathring{\theta}_{i,1}}{d\theta_{i,1}}\frac{d\theta_{i,1}}{d\gamma_i}+\frac{\varepsilon\mathring{\theta}_{i,1}}{(\varepsilon+\phi)\,q}\\ &= -\frac{\varepsilon\gamma_i}{(\varepsilon+\phi)\,q}\frac{\mathring{\theta}_{i,1}\left(\mathring{\theta}_{i,1}-\theta_{i,1}\right)}{(q-\gamma_i)\theta_{i,1}}+\frac{\varepsilon\mathring{\theta}_{i,1}}{(\varepsilon+\phi)\,q}.\end{aligned}$$

The first order condition with respect to γ_i gives

$$(1-\varepsilon\varphi)\,\mathring{\theta}_{i,1}\gamma_i=(1-\varepsilon-\phi-\varepsilon\varphi)\,\theta_{i,1}q+(1+\varphi)\,(\varepsilon+\phi)\,\theta_{i,2}q-\varphi\,(\varepsilon+\phi)\,\mathring{\theta}_{i,2}q. \tag{33}$$

Here we have used

$$\frac{d\theta_{i,1}}{d\gamma_i}=-\frac{\int_{\theta_{i,1}}^{1}\theta dG(\theta)}{(q-\gamma_i)\theta_{i,1}g(\theta_{i,1})},$$

$$\frac{d\mathring{\theta}_{i,1}}{d\gamma_i}=\frac{d\mathring{\theta}_{i,1}}{d\theta_{i,1}}\frac{d\theta_{i,1}}{d\gamma_i}=-\frac{\mathring{\theta}_{i,1}\left(\mathring{\theta}_{i,1}-\theta_{i,1}\right)}{(q-\gamma_i)\theta_{i,1}},$$

$$\frac{d\mathring{\theta}_{i,1}}{d\theta_{i,1}}=\frac{g(\theta_{i,1})\left(\mathring{\theta}_{i,1}-\theta_{i,1}\right)}{\int_{\theta_{i,1}}^{1}dG(\theta)},$$

$$\frac{d\varphi}{d\gamma_i}=\frac{(1+\varphi)\,g(\theta_{i,1})\frac{d\theta_{i,1}}{d\gamma_i}-g(\theta_{i,2})\frac{d\theta_{i,2}}{d\gamma_i}}{\int_{\theta_{i,1}}^{1}dG(\theta)},$$

$$\frac{d\mathring{\theta}_{i,2}}{d\theta_{i,1}}=\frac{\left(\theta_{i,1}-\mathring{\theta}_{i,2}\right)g(\theta_{i,1})+\left(\mathring{\theta}_{i,2}-\theta_{i,2}\right)g(\theta_{i,2})\frac{d\theta_{i,2}}{d\theta_{i,1}}}{\int_{\theta_{i,2}}^{\theta_{i,1}}dG(\theta)},$$

$$\frac{d\mathring{\theta}_{i,2}}{d\theta_{i,2}}=\frac{\left(\mathring{\theta}_{i,2}-\theta_{i,2}\right)g(\theta_{i,2})}{\int_{\theta_{i,2}}^{\theta_{i,1}}dG(\theta)},$$

and

$$\begin{aligned}\frac{d\mathring{\theta}_{i,2}}{d\gamma_i} &= \frac{\partial\mathring{\theta}_{i,2}}{\partial\theta_{i,1}}\frac{d\theta_{i,1}}{d\gamma_i}+\frac{\partial\mathring{\theta}_{i,2}}{\partial\theta_{i,2}}\frac{d\theta_{i,2}}{d\gamma_i}\\ &= \left\{\begin{array}{c}\left(\mathring{\theta}_{i,2}-\theta_{i,1}\right)\int_{\theta_{i,1}}^{1}dG(\theta)\\ +\frac{\varepsilon}{(\varepsilon+\phi)q}\left(\mathring{\theta}_{i,2}-\theta_{i,2}\right)g(\theta_{i,2})\left(\theta_{i,1}q-\mathring{\theta}_{i,1}\gamma_i\right)\end{array}\right\}\frac{\mathring{\theta}_{i,1}}{(q-\gamma_i)\theta_{i,1}\int_{\theta_{i,2}}^{\theta_{i,1}}dG(\theta)}.\end{aligned}$$

The equation (33) gives bank's choices of different pairs of $\{\gamma_i,\theta_{i,1}\}$. Now back to the first two stages, the bank chooses S_i+K_i (or $\theta_{i,1}$) to maximize its profit. We assume that there is no deviation in the second stage and all the banks try to maximize their profits, assuming every bank gets the same market share, i.e., n_i will not be affected by their choices of $\theta_{i,1}$ (γ_i will also be fixed given n_i). The maximization problem is

$$\pi_{i,b} = \max_{\theta_{i,1}} n_i \int_{\theta_{i,1}}^{1} dG(\theta) \left(\mathring{\theta}_{i,1}\gamma_i - \eta\right) + n_i \int_{\theta_{i,2}}^{\theta_{i,1}} dG(\theta) \left[-\varepsilon\mathring{\theta}_{i,1}\gamma_i + (\varepsilon + \phi)\,\mathring{\theta}_{i,2}q - \zeta\right].$$

In the case where (27) is binding, the first order condition gives

$$0 = \eta + \zeta/\lambda - \phi\theta_{i,1}\gamma_i + (\varepsilon + \phi)\,\theta_{i,1}q - (1 + \varphi)\,(\varepsilon + \phi)\,\theta_{i,2}q. \tag{34}$$

In the case where (27) is not binding, the first order condition gives

$$\theta_{i,1} = \frac{\eta - \zeta - \varepsilon\,(1 + \varphi)\,\mathring{\theta}_{i,1}\gamma}{(1 - \varepsilon\varphi)\,\gamma_i - (\varepsilon + \phi)\,q}. \tag{35}$$

Given r and q, the three equations (29), (33), and (35) (or (28), (32), and (34)) determine the values of γ_i, $\theta_{i,1}$, and $\theta_{i,2}$.

The household's problem is the same as in the case with only one bank. The only difference here is that the profit of entrepreneurs, π_e, is positive and it is returned to the households. The expected lifetime utility of a young household is

$$u(w - s - S - S^a) + \beta u\left(z_s s^\varsigma + rS + rS^a + \pi_e + \pi_b + \pi_m\right),$$

where $S = BS_i$, $S^a = BS_i^a$, $\pi_b = B\pi_{b,i}$, and $\pi_e = N\pi_{e,i}$.

Since the marginal rate of return to the storage technology will approach positive infinity as $s \to 0^+$, it must be the case that s is strictly positive as well. The household's choice of s then must guarantee that

$$u'\left(w - s - S - S^a\right) = \beta\varsigma z_s s^{\varsigma-1} u'\left(z_s s^\varsigma + rS + rS^a + \pi_e + \pi_b + \pi_m\right).$$

Since in any given period entrepreneurs must rely on bank loans to finance their projects for generating intermediate inputs in the subsequent period, which must be combined with labor services for final good production, an active banking sector in period $t-1$ is necessary to ensure an active production sector in period t, which is essential in order for a young household of generation t to carry on, for all $t \geq 1$. Note that a positive level of household deposit is required for the banking sector to be active, since loan sales would not be possible without any household deposit to finance loans to be sold in the first place. Therefore, we must have $S > 0$. The household's choice of $S + S^a$ then must guarantee that

$$u'\left(w - s - S - S^a\right) = \beta r u'\left(z_s s^\varsigma + rS + rS^a + \pi_e + \pi_m\right).$$

The equilibrium $S > 0$ and $S^a \geq 0$ will be determined by the demand of funding by the bank and the mutual fund. From the above two optimality conditions it follows that $r = \varsigma z_s s^{\varsigma-1}$. The value of q and w are determined in $q = zf'(m)$ and $w = zf(m) - qm$, respectively, and $m = N\int_{\theta_{i,2}}^{1} \theta dG(\theta)$

6.3 Loan sales ratio with bank competition

With bank competition, the equilibrium lending rate γ is lower than q, causing the profit margin of on-ballance-sheet loans to decline. As a result, the credit provided by on-ballance-sheet loans shrinks, leading to a shift from the on-ballance-sheet to the off-ballance-sheet activities.

It is intuitive that bank's off-balance-sheet loans over on-ballance-sheet loans ratio, φ, is decreasing in γ. As a result, bank competition drives up the loan sales. It is easy to show that the direct effect of γ on φ is negative. The solution of θ_1 in the one bank case and $\theta_{i,1}$ in the case with bank competition are given by (26) and (35). The formula of θ_1 and $\theta_{i,1}$ are similar except that $\gamma = q$ in the one bank case. Rearrange equation (35) we get

$$\varphi = \frac{\eta - \zeta - \varepsilon\mathring{\theta}_{i,1}q - \theta_{i,1}\gamma_i + (\varepsilon + \phi)\,\theta_{i,1}q}{\varepsilon\left(\mathring{\theta}_{i,1}q - \theta_{i,1}\gamma_i\right)}.$$

We define a function

$$\Psi(\theta_1, \gamma) = \frac{\eta - \zeta - \varepsilon\mathring{\theta}_1 q - \theta_1\gamma + (\varepsilon + \phi)\,\theta_1 q}{\varepsilon\left(\mathring{\theta}_1 q - \theta_1\gamma\right)}.$$

The magnitude of $\Psi(\theta_1, \gamma)$ decreases in γ, i.e.,

$$\frac{\partial\Psi(\theta_1, \gamma)}{\partial\gamma} = -\frac{(1 - \varepsilon\varphi)\,\theta_1}{\varepsilon\left(\mathring{\theta}_1 q - \theta_1\gamma\right)} < 0.$$

The partial derivative $\frac{\partial\Psi(\theta_1,\gamma)}{\partial\gamma}$ measures the direct effect of γ on φ. The reason that a smaller lending rate γ makes a larger volume of loan sales is intuitive. When $\gamma < q$, selling senior Tranche loans transfers less profit to the mutual fund. As a result, holding a λ proportion of junior Tranche loans, which requires selling the same amount of senior Tranche loans, is less costly. Consequently, the volume of loan sales can expand more.

The direct negative effect of γ on φ is, however, mitigated by the indirect effect through the change of $\theta_{i,1}$ caused by the change in γ. The general equilibrium effect of bank competition on loan sales will be shown in a numerical example.

7 Conclusion

We have built a dynamic general equilibrium model with bank competition. The framework is a directed search model. Capital requirement imposes a short-run capacity constraint on banks' lending. Given the capacity constraint, the banks compete for projects using lending rate. The model is a Bertrand competition with capacity-constraint as in Peters [28] and BSW [32]. We focus on a stationary symmetric mixed strategy equilibrium. We find that bank competition can cause a low equilibrium lending rate and excess demand for funding. As a consequence, banks may seek funds through the sale of their loans. We show that loan sales could be motivated by a purpose other than risk sharing.

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