Interbank Trading, Collusion, and Financial Regulation

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Abstract

We show theoretically and empirically that interbank markets provide a channel for banks to collude in the market for business loans. By lending funds to a competitor, a bank commits not to compete. Interbank interest rates allow banks to split the benefits from such collusion. Using global syndicated loans data, we find that firms paid 31bps higher spread on $239 billion of loans provided by banks that took an interbank loan from a competitor. We compare the decentralized solution with interbank market to the planner's solution and to the decentralized equilibrium without interbank market. The results suggest that restricting interbank trading may increase aggregate welfare.

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1 Introduction

Interbank markets are an integral part of the financial system; banks provide loans to each other to allocate liquidity in the economy. Despite the potential benefits of the interbank market, we propose a novel cost. Our argument is based on a simple observation that banks compete with each other in the provision of loans to businesses in one market, but provide loans to each other in another (interbank) market. We build a stylized model to study how strategic spillovers between these two markets can generate an inefficient allocation of resources and provide a role for government regulation. The model provides a surprising result – in certain regions of the parameter space, an interbank market can facilitate collusion between banks and regulations limiting trade in the interbank market can implement the planner's solution.

Collusion happens when two competing banks have enough resources to provide business loans. To avoid competition in this state of the world, one bank (call it bank B) provides a loan to another bank (call it bank A) and as a result bank B does not have sufficient funds to compete with bank A. If these two banks are the only two banks in the region, bank A effectively becomes a monopolist making monopolistic profits by rationing the supply of loans. The interbank loan from bank B to bank A is a credible commitment device not to compete. Bank B benefits from this commitment by receiving a higher interest rate on the interbank loan, which represents a share of the monopolistic profits earned by bank A. Without an interbank market, both banks would compete and receive zero profits, an allocation which a social planner would choose.

If banks are allowed to trade in the interbank market, then the decentralized solution may be inefficient. The main result of the paper is to show that interbank trading allows banks to collude. Even when benefits from interbank trade exist due to liquidity sharing, the welfare loss from collusion can outweigh the benefit.

The interbank market provides a convenient way for banks to split the surplus from collusion. The interest rate on the interbank loan is equal to some part of the monopolistic profits received by the borrowing bank (specifically, the share of surplus that the bank lending in the interbank market receives depends on its bargaining power). Importantly, the inefficient level of business loans does not depend on the way the surplus is split, as the joint surplus is maximized when there is a monopolistic level of lending.

We extend the model to allow banks to enter the market for business loans endogenously. Banks make this strategic decision by taking into account expected profits from entry. These profits depend on the entry decision of the other bank, liquidity shocks, and the presence of the interbank market. We calibrate the model to match moments in the global syndicated loans market. The extended model allows us to make two empirical predictions. First, the spreads on business loans are higher when the lead arranger borrowed from a competitor relative if the lead bank borrowed from a non-competitor. We confirm this empirical prediction using \$34.5 trillion of syndicated loans. Banks that borrow from a competitor firm charge 31 basis points higher spread on average, controlling for borrowers' credit rating, borrowers characteristics, loan characteristics and a wide range of fixed effects, including lender fixed effects. Business loans provided by lead arrangers that borrowed from other banks, but not competitors, do not exhibit larger spreads. The economic magnitude of the increased spread is large. The additional spread is equivalent to pricing a loan to an A rated borrower as if it was a BBB rated borrower. Overall, these results are consistent with the collusion argument described in the model.

Second, we find that the presence of an interbank market can increase entry when profits are low relative to the cost of entry, but decrease entry when the profits are high. Overall, collusion in the interbank market increases incentives to enter, but liquidity sharing can reduce these incentives because banks that do not enter can still make profits by supplying liquidity to bankers that enter but lack liquidity.

The policy implications of our findings are important for financial regulation. If indeed some banks use interbank markets for collusion, the cost of restricting interbank trading is not as high as previously thought. While it is well understood that interbank loans increase fragility of the banking system due to contagion (Allen and Gale (2000); Rochet and Tirole (1996); Elliott et al. (2014); Acemoglu et al. (2015); Gofman (2017)), the cost of interbank linkages due to undersupply of loans and reduced competition has not been studied before. Our model shows that interbank trading can reduce competition. If interbank lending was not allowed, competition would be restored. However, a complete ban on interbank trading is not optimal either because not all interbank trades are for collusion. In particular, if one bank has a comparative advantage to monitor loans in a particular market, but does not have enough resources to provide loans, interbank lending is welfare improving. Given the mixed nature of interbank loans, it makes direct government intervention in the interbank market a significant challenge for regulators.

For instance, instead of banning the interbank market, regulators can utilize usury laws that limit interest on bank loans. If banks cannot charge interest above the level prescribed in the planner's solution, interbank loans would not be an effective mechanism for banks to collude. Even if a transfer of funds would limit bank's ability to compete, the borrowing bank cannot take advantage of its monopolistic power when the cap is set at the competitive rate level. The downside of this policy is that the planner's solution changes with the scarcity of funds available to banks. If banks do not have enough deposits to provide loans, the planner's solution implies higher interest rate on the loans to induce only entrepreneurs with low outside option to take the loans.[1] If loans are priced artificially low in times when the resource feasibility constraint is binding, funding can go to entrepreneurs who are not the most efficient borrowers.

Literature. The paper contributes to several strands of literature. First, we contribute to the banking literature by studying how interbank lending may affect competition between banks. Conditional on entry decisions, competition delivers the constrained optimum allocations when banks cannot trade with each other. We find that adding an interbank market

[1] In our model, outside options are private information of the borrowers and the interest rate on loans is used by the planner to attract the right borrowers.

can reduce aggregate welfare in the economy. This result is similar to the famous result by Hart (1975) that with incomplete markets opening a new market can decrease welfare. It also resembles a result in Gofman (2014) that with incomplete networks, adding a link between two banks can reduce allocational efficiency. While these different results appear similar, the logic is not the same. In our model, adding an interbank market changes banks' interaction in another market. In a one-shot game the two banks cannot commit to collude without an interbank market. The interbank market provides not only a commitment technology, it is also perfectly suited for sharing profits via the interest rate on the interbank loan.

Second, we contribute to the literature about oligopolistic competition and collusion. First, collusion between non-banks requires repeated interactions to enforce collusive behavior (see Green and Porter (1984); Sannikov and Skrzypacz (2007)). We show how banks can collude even without repeated interaction. Moreover, we show how interaction in one market affects collusion in another market. This effect is novel because these are not multiple product markets (as in Bernheim and Whinston (1990) and Bulow et al. (1985)). The main reason why our results are different from the previous studies in industrial organization is because non-financial firms that compete with each other cannot provide "loans" to one another, while banks can.

Third, the paper is also related to literature on how to incentivize behavior in one market by linking it to another market. That has been used in the sovereign debt literature by Cole and Kehoe (1998) and in the consumer finance literature by Chatterjee et al. (2008).

The forth strand of literature focuses on interbank networks. This literature models interbank trading decisions explicitly and studies how prices and allocations are determined (Gofman (2014); Babus and Hu (2017); Atkeson et al. (2015)). Interbank trading leads to interbank exposures that are important for studying financial contagion (Elliott et al. (2014); Acemoglu et al. (2015); Gofman (2017)). While we focus on a simple case with two banks, the result suggests that it is important to study interbank trading by accounting for interbank competition in the lending market.

On the empirical side, we contribute to the literature that studies borrowing costs faced by firms. We show that interbank loans can help banks to commit not to compete and allows them to charge higher spreads on the loans to firms. Sufi (2007) is among the first to utilize the syndicated loans data to study the structure of syndicates how it is affected by asymmetric information and moral hazard. Ivashina (2009) shows that asymmetric information also affects syndicated loans spreads. De Haas and Van Horen (2012) use cross-border syndicated loans to study transmission of shocks after the Lehman Brothers collapse to other countries. In a recent study, Schwert (2018) finds that syndicated loans are priced higher than corporate bonds with similar risk and maturity. This finding is consistent with an explanation that lenders overprice loans due to imperfect competition in the market for syndicated loans. Our paper provides a mechanism that would allow banks to collude in the syndicated loans market.[2]

The rest of the paper is organized as follows. In the next section, we present the model environment. In Section 3, we present the main insight of the paper on how the interbank market can facilitate collusion. In Section 4, we present empirical evidence consistent with collusion in the global syndicated loans market. In section 5, we derive policy implications by solving the planner's problem and studying welfare implications of restricting trading in the interbank market. Section 6 concludes.

2 Environment

There are three types of agents in the economy: a measure $M \geq 1$ of risk-neutral entrepreneurs, 2 risk-neutral bankers, and a measure $H \geq 1$ of risk-averse households. There are two dates: beginning-of-period (BOP) and end-of-period (EOP).

Entrepreneurs. An entrepreneur can invest 1 unit of consumption good in a risky project at the BOP. The project return $R^P_\eta(\sigma)$ at the EOP depends both on an idiosyncratic shock $\sigma \in \{s, f\}$ for success or failure and an aggregate shock $\eta \in \{H, L\}$ for High or Low.

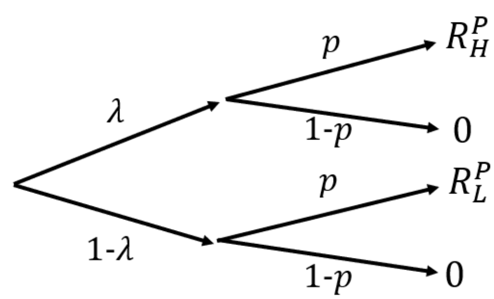
[2] Vives (2011) and Carletti (2008) provide a literature review about the role of competition in banking.

The aggregate state is known before entrepreneurs decide whether to invest in a risky project or not. The idiosyncratic state σ is unknown at the time of the investment decision and i.i.d. across entrepreneurs.

With probability λ, the aggregate state of the world is $\eta = H$. In state H, if the project succeeds $\sigma = s$, it generates a gross return $R_H^P(s) > 0$ with probability p and if it fails $\sigma = f$, it generates gross return $R_H^P(f) = 0$ with probability $1 - p$.

With probability $1 - \lambda$, the aggregate state of the world is $\eta = L$. In state L, if the project succeeds, it generates a gross return $R_L^P(s) > 0$ with probability p and $R_L^P(f) = 0$ with probability $1-p$ where $R_L^P(s) < R_H^P(s)$. For brevity, hereafter we drop the s dependence and simply write $R_L^P < R_H^P$. Figure 1 provides a graphic representation of the payoffs.

Figure 1: **Project's Payoffs**



Entrepreneurs have an outside option, denoted ω, of EOP goods drawn from a uniform distribution on $[0, M]$. For example, we can interpret this outside option as the utility from using an alternative means of financing their project. The outside option of each entrepreneur is his private information. The role of the outside option is to generate a downward sloping demand for bank loans, which we will introduce later. Entrepreneurs do not have own resources so if they want to invest, they need to get resources from either a household or a banker. We assume limited liability for entrepreneurs, meaning that their consumption cannot be negative.

Households. Households have log utility over consumption and are each endowed with one indivisible unit of goods. At the BOP, some households are randomly matched with bankers, such that each banker is matched with a mass $\overline{D}$ of households with probability γ or matched with no households with probability $1-\gamma$.[3] The probability of the match between households and bankers is i.i.d. across bankers. All household have access to a risk-free storage technology with a gross rate of return $\overline{R}=1$.

A household can also match with one entrepreneur directly and offer to lend one unit at BOP in return for an EOP transfer conditional on the outcome of the project. However, given that with $1-p$ probability a project fails in which case the household's EOP utility is $log(0)=-\infty$, direct lending will not happen in the model.[4]

Bankers. Bankers are endowed with I units of the consumption good. They must decide whether to invest their endowment in the monitoring/verification technology that allows them to verify the outcome of an entrepreneur's project at cost c. Without making this investment, the cost of monitoring is ∞, effectively making it impossible to provide loans to entrepreneurs directly. Both bankers must make a simultaneous decision after they observe the aggregate state of the world and before they know the realization of their match with households. If a banker decides not to invest in the monitoring technology (not to enter the market for business loans), she needs to consume her endowment at the BOP.[5] A banker who has not invested in the monitoring technology, can still take funds (we will call them deposits) from households and provide interbank loans or invest in the risk-free storage technology.[6]

After the realization of the liquidity shock (i.e. matching $D\in\{0,\overline{D}\}$), banker i offers a gross deposit rate R_i^D to be paid at the EOP and households decide whether they want to exchange their unit endowment of consumption good at the BOP or simply use their risk free technology yielding $\overline{R}$ at the EOP. Let $D_i\leq\overline{D}$ be the mass of households matched to banker

[3]We abstract from competition for deposits between bankers. Drechsler et al. (2017) provide strong evidence that banks have high bargaining power against depositors.

[4]Even if households could match many-to-many with entrepreneurs, bankers would still exist in equilibrium because of the economies of scale in monitoring.

[5]This assumption is not essential.

[6]For example, many credit unions do not lend directly to businesses, but they do collect deposits and provide loans to other banks or have correspondence accounts with these banks.

i who accept banker i's offer. If households are indifferent, we assume that they accept the offer. Under this assumption, a banker will always set the deposit rate to be equal to the outside option of the household: $R_i^D = \overline{R} = 1$. All households, matched to banker i, agree to the offer, resulting in $D_i = \overline{D}$ funds available to the banker at the BOP, conditional on the match. As we explain below, additional BOP funds are available to a banker if she borrows from another banker. These interbank loans are junior to a bank's liabilities to households.

Each banker can use available funds in three ways.

Storage. Banker i can store S_i out of the D_i available funds using the risk-free storage technology with a gross return $\overline{R} = 1$.

Interbank trading. She can agree to transfer $f_{i,j}$ of her funds to banker j at the BOP for a promise to receive $F_{j,i}$ at the EOP. Bankers engage in bilateral bargaining to determine the interest rate on the interbank loan (R^I). We assume Kalai bargaining with $\theta \in [0, 1]$ as the bargaining power of the lender.

Lending. The third investment option is to provide funding to entrepreneurs. In particular, banker i can offer to an entrepreneur one unit of goods at the BOP in exchange to an EOP payment that depends on the outcome of his project. We will describe the optimal contract between a banker and an entrepreneur after we describe the informational frictions that constrain the contract.

Informational Frictions. The contract cannot discriminate between different entrepreneurs because the outside option of each entrepreneur is private information and non-verifiable. If a banker would provide better terms to entrepreneurs with a higher outside option relative to entrepreneurs with a low outside option, the latter would have an incentive to pretend to be the former. Given that a project requires one unit of investment and cannot be scaled up or down, a banker cannot offer loans of different sizes in an attempt to separate entrepreneurs with different outside options.

Project outcomes are privately observed by entrepreneurs, but verifiable if the banker invests in the monitoring technology. Because of the limited liability, an entrepreneur cannot pay back anything if the project fails. Therefore, a payoff potentially needs to take place if the projects succeeds. However, an entrepreneur can report that the project has failed even if it succeeded. As a result, bankers need to monitor projects that they fund. Bankers use costly state verification (Townsend, 1979) to monitor entrepreneurs. We provide the details of the monitoring technology next.

Monitoring. If a banker invests in the monitoring technology, she can commit at the BOP to verify the outcome of a project at a cost c, which is paid at the EOP.[7] If a banker decides not to invest in the monitoring technology, she effectively cannot provide loans to entrepreneurs because none of the loans will be repaid as all entrepreneurs will claim that their project failed. We interpret this assumption to mean that a banker does not have a geographical presence in the market or that it does not have an expertise or a license to provide loans to a businesses.

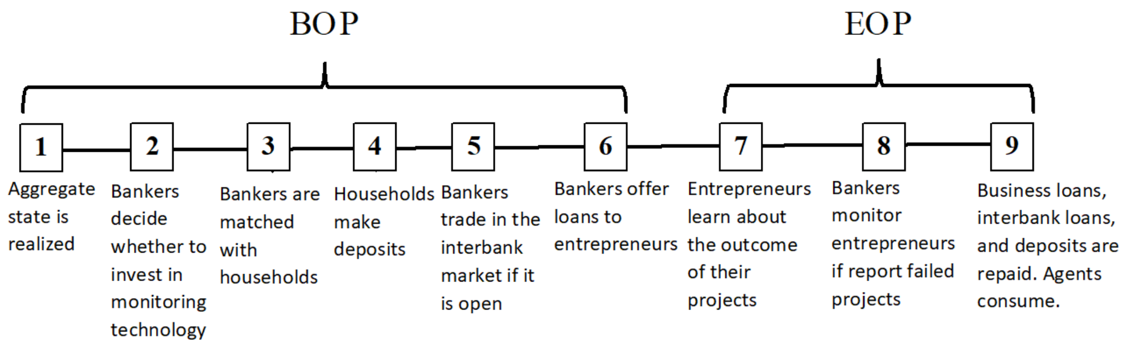
A verified entrepreneur who is found to lie that his project failed needs to pay all the proceeds from the project to the banker. When only one banker invests in monitoring, she is effectively a monopolist. When both invest, there is the potential to compete in the business loan market. We write *potential* because we are going to show that banks can use interbank lending to commit not to compete while there can be perfect competition without interbank trading.

Given the monitoring cost and the report of an entrepreneur about the outcome of his project, a banker needs to decide when to pay the verification cost and to check whether the entrepreneur is telling the truth. Formally, let $h_{i,\widehat{\sigma}} \in \{0, 1\}$ be banker i's strategy to verify an entrepreneur's report of state $\widehat{\sigma}$ at the EOP. If two bankers are able to monitor, each can choose a different monitoring strategy. We denote no monitoring by $h_{i,\widehat{\sigma}} = 0$ and monitoring by $h_{i,\widehat{\sigma}} = 1$.

Timing. The events that take place at the BOP are: (1) the aggregate state is realized,

[7] We follow Townsend (1979) by assuming commitment in monitoring and a deterministic monitoring technology. Koreli and Trigilia (2018) study a case of monitoring without commitment. The commitment in monitoring or the deterministic monitoring are not crucial for the main result that banks may use the interbank market to collude.

Figure 2: **Timeline**



(2) bankers decide whether to invest in the monitoring technology, (3) households match exogenously with bankers, (4) bankers offer households an interest rate on deposits (i.e. an EOP transfer for their BOP deposit of goods), households decide whether to deposit their funds with the bankers or store in the risk free technology, (5) bankers decide whether to make transfers in the interbank market, (6) bankers offer loans to entrepreneurs (i.e. a BOP transfer of resources to start a project in return in return for an EOP transfer from the random proceeds of the project) and entrepreneurs decide whether to borrow and invest in risky projects or choose their outside option, and bankers invest remaining resources in the risk-free storage technology.

The events that take place at the EOP are: (7) project returns are realized for each entrepreneur, entrepreneurs report the outcome of the project, (8) bankers decide whether to monitor or not, (9) entrepreneurs repay the loans subject to limited liability, interbank loans are repaid, and deposits are returned to households. All agents consume their available resources. Figure 2 depicts the timeline of the events.

States. Besides the idiosyncratic realizations of entrepreneurs' outside options and project payoffs, the state space of the model is characterized by the realization of the aggregate state, the banker's entry decisions, and the realization of liquidity/matching shocks. Specifically, there are four possible outcomes of the entry/investment decisions: {both bankers enter, only banker A enters, only banker B enters, no entry}. For each of these outcomes, there are four possible realizations of matches between bankers and households:

both bankers are matched ($\{\overline{D},\overline{D}\}$), only banker A is matched ($\{\overline{D},0\}$), only banker B is matched ($\{0,\overline{D}\}$), no banker is matched ($\{0,0\}$). Therefore, for each possible aggregate state, there are 16 possible states post-entry.

3 Decentralized Equilibrium

We analyze a decentralized equilibrium using backwards induction. In the next subsection, we study the equilibrium that will emerge after the entry/investment decisions are made (i.e. after stage 2 in the timing). It allows us to solve for bankers' payoffs in all possible states of the world. Then in subsection 3.2, we study the entry/investment decisions by banks (i.e. at stage 2 in the timing). The endogenous entry decisions allow us to derive empirical predictions about the interest rates bankers charge entrepreneurs.

3.1 Post-Entry Analysis

If no banker decides to enter the market, then no loans can be extended as bankers lack ability to verify entrepreneurs' reports about the outcome of their projects. Similarly, if bankers are not matched with households, they lack liquidity needed to finance projects. These two cases cover seven out of the 16 outcomes and we study them in more detail when we analyze entry.

Out of the remaining nine states, there are six states in which only one banker is able to provide loans and has liquidity to do it. The interbank market plays no role in these cases as the banker is a classic monopolist associated with that loan.

The most interesting results emerge in the remaining three cases. First we show that when both bankers enter the loan market (i.e. invest in the monitoring technology) and both bankers receive liquidity from households (i.e. $\{\overline{D},\overline{D}\}$), the interbank market allows bankers to collude, resulting in a monopolistic level of lending and pricing. In subsection 3.1.2, we analyze the remaining two states in which one banker has liquidity but cannot monitor and another banker can monitor, but lacks liquidity. The interbank market is used for liquidity sharing in these two states of the world.

3.1.1 Interbank Trading for Collusion Purposes

Assume that both bankers have the monitoring technology and are matched with households.[8] Both bankers are matched with households and each banker has enough liquidity to provide the socially optimal level of loans even if the aggregate state is high.

Interbank trading changes bankers' lending capacities as they move funds between them. Let f be a loan from banker B to banker A at the BOP, and F is the EOP repayment from banker A to banker B. Interbank loans are junior relative to deposits. If $f > 0$ and $F > 0$, it means banker B is the lender and banker A is the borrower in the interbank market. If $f < 0$ and $F < 0$ it means banker A is the lender and banker B is the borrower.

The definition of equilibrium with interbank trading is:

Definition 1. *Equilibrium with Interbank market*

- *Bankers maximize their profits by choosing deposits rate (R^D), lending rate (R_i), BOP interbank loan amount f, EOP interbank loan repayment F, allocation to the risk-free storage technology S_i, and monitoring strategy $h_{i,\widehat{\sigma}}$. Bankers choose optimally interbank loan (f) that maximizes their profits. The repayment of interbank loan (F) is an outcome of Kalai bargaining between the bankers.*
- *Depositors choose optimally between depositing money with a banker or keeping it at the risk-free rate ($\overline{R}$).*
- *At the BOP, entrepreneurs choose optimally between borrowing at rate lowest rate offered or pursuing their outside options. At the EOP, entrepreneurs choose whether to report truthfully the outcome of their project or not.*
- *The market for loans to entrepreneurs clears*
- *Interbank loans market clears*

Bank i's problem is to choose R_i^D, R_i, f, and F to maximize expected EOP profits subject to limited liability and bargaining to solve

$$\max\left\{[pR_i - (1-p)c]\,\ell_i + \overline{R}S_i + \iota_i f - \iota_j F - \overline{R}D_i, 0\right\}.$$

[8] The project returns are high enough to incentivize investment in the monitoring technology regardless of the aggregate state. Later, we will provide conditions on the profitability of loans that assures entry. With this assumption, the analysis does not depend on the aggregate state. To avoid extra notation, we drop subscripts that refer to the aggregate state for the relevant variables.

where

$$\iota_i = \begin{cases} -1 & \text{if } i = 1 \\ 1 & \text{if } i = 2 \end{cases}$$

The BOP balance sheet identity for bank i is

$$\ell_i + S_i + \iota_i f - D_i = 0$$

Market clearing requires

$$\ell_i = L_i^d$$

where L_i^d denotes the demand for loans offered by bank i.

Proposition 1. *Interbank trading between two bankers results in the monopolistic level of business loans and entrepreneurs pay the monopolistic interest rate on these loans.*

As part of the proof we show that the equilibrium (monopolistic) level of loans is

$$\ell^* = \frac{pR^P - (1-p)c - \overline{R}}{2} \tag{1}$$

The business loans rate is

$$R^* = \frac{R^P + ((1-p)c + \overline{R})/p}{2} \tag{2}$$

The monopolistic profit from lending is:

$$\pi^M = \frac{\left(pR^P - (1-p)c - \overline{R}\right)^2}{4} \tag{3}$$

The intuition for proposition 1 is that the interbank market allows one banker to commit not to compete in the market for business loans. This banker (call him B), provides an interbank loan to another banker (banker A) at the BOP. The size of this loan equals to the size of the deposits banker B receives from households ($f = \overline{D}$). Importantly, banker A does not need these funds, because she also got matched with households and has $D = \overline{D}$ resources to lend. When banker B does not have funds to lend to businesses, banker A becomes a monopolist.

Remark 1. *The interest rate on the interbank loan reflects part of the monopolistic profits generated by collusion between the bankers.*

We can easily see this result by looking on the equilibrium repayment of the interbank loan is:

$$F = f + \theta\pi^M = D + \theta\frac{\left(pR^P - (1-p)c - \overline{R}\right)^2}{4} \tag{4}$$

where θ is the bargaining power of banker B. The interbank interest rate is given by

$$R^I = \frac{F-f}{f} = \frac{\theta\pi^M}{f} = \theta\frac{\left(pR^P - (1-p)c - \overline{R}\right)^2}{4D} \tag{5}$$

If the bargaining power of the lender in the interbank market is higher, the interbank rate is higher.

To summarize, in this subsection, we show that interbank market can facilitate collusion and that it allows to split the benefits from collusion via the interest rate on the interbank loans.

3.1.2 Interbank Trading for Liquidity Purposes

Now we study the two remaining states of the world in which interbank trading takes place for liquidity purposes. In particular, assume that $D_A = 0$, $D_B = \overline{D} = pR_H^P - (1-p)c - \overline{R}$, with only banker (banker A) who can monitor the loans at cost c. Banker A is able to monitor loans but does not have liquidity to lend, and banker B has liquidity but cannot monitor.

The decentralized solution with interbank market results in the same level of investments as in subsection 3.1.1. Banker A borrows from banker B and provides monopolistic level of investment at monopolistic loan rates. Therefore, the interbank transfer at the BOP needs to be equal to monopolistic level of investment ($f = \frac{pR^P-(1-p)c-\overline{R}}{2}$). The repayment ($F$) will reflect the bargaining outcome.

The result is symmetric if banker A has liquidity, while banker B can monitor the loans, but lacks liquidity.

3.2 Endogenous Entry

In this section, we turn to analyze bankers' endogenous choice of monitoring costs. The main empirical prediction that arises in this section is that bankers are more likely to enter to business lending when the aggregate state is high (corresponds to high profits) than when the aggregate state is low (low profits).[9]

We denote $\pi_\eta^M(R_\eta^P)$ to be the profitability of a monopolistic banker in the market in which idiosyncratic project return is R_η^P and the aggregate state is η. The expression for $\pi_\eta^M(R_\eta^P)$ is given in equation (3).[10]

To solve for the optimal entry strategy, we need to compute an expected payoff for each possible entry decision of banker A and banker B.

3.2.1 Both bankers acquire a monitoring technology

First, we analyze a case when both bankers decide to invest in the monitoring technology. In this case, there are four possible realizations of the liquidity shocks to the bankers, which we model via random matching with the households. The realizations are: $\{\overline{D}, \overline{D}\}$, $\{\overline{D}, 0\}$, $\{0, \overline{D}\}$, and $\{0,0\}$. The respective probability of each of the above states is γ^2, $\gamma(1-\gamma)$, $(1-\gamma)\gamma$ and $(1-\gamma)^2$.

If both bankers are matched with households, then we have the case of collusion described in section 3.1.1. In this case, one banker (without loss of generality, call her banker B) provides an interbank loan to another banker (banker A) equal to her amount of deposits ($\overline{D}$). It makes the banker A a monopolist in the market for business loans. Assuming banker B's bargaining power is $\theta \in [0,1]$, she will get $\theta\pi_\eta^M$ share of the monopolistic profit and banker A will receive $(1-\theta)\pi_\eta^M$. The split of the surplus from collusion is done via the interest rate on the interbank loan. For simplicity, we assume that $\theta = 0.5$. This assumption results in symmetric payoffs to the bakers and allows us to focus on a symmetric equilibrium. The results can be easily extended to any θ.

If only one banker is matched with households, then this banker becomes a monopolist in the market for loans and gets all the profits. Her payoff is π_η^M in this case. The other banker receives a payoff of zero. There is no need for interbank market in this scenario because both

[9]A high aggregate state corresponds to a market with high project returns.

[10]The profit function does not change depending on the entry decision of bankers because investment in the monitoring technology is a sunk cost by the time bankers make lending decisions.

bankers have the ability to lend and do ex-post monitoring, but only one has the resources to provide loans.

The last scenario is when neither bankers is matched with the households. In this scenario, both bankers receive a payoff of zero. They are able to lend, but there is not enough aggregate liquidity to provide loans.

Then, the expected payoff from entry is given by $\underbrace{\gamma^2\theta\pi_\eta^M}_{\text{collusion}} + \underbrace{\gamma(1-\gamma)\pi_\eta^M}_{\text{direct lending}} - I$, which can be simplified to

$$\frac{\gamma\pi_\eta^M}{2}(2-\gamma) - I. \tag{6}$$

3.2.2 One banker acquires a monitoring technology

In this subsection, we study payoffs when only one banker enters the market for loans. If the banker who can monitor the loans matches with the households, she receives monopolistic level of profits from lending to firms: π_η^M. The other banker receives a payoff of zero. There is no need for interbank market in this scenario because the bank that has the resources can also monitor loans.

If the banker who can monitor the loans does not get any deposits, but the other banker does, then they will trade in the interbank market as in section 3.1.2. This is the case when there is no collusion because the trading is not between bankers who are competitors in the market for loans. In this realization of liquidity shocks, assuming equal bargaining power ($\theta = 0.5$), each banker receives half of monopolistic profits ($\frac{\pi_\eta^M}{2}$). Despite the equal split of profits ex-post, the banker who invested in monitoring technology paid cost I, while the second banker did not pay this cost.

If none of the bankers are matched to households, lending is not possible, and profits of both bankers are zero.

Considering all possible realizations of liquidity shocks, the expected payoff from investment in the monitoring technology to the banker who makes the investment is given by

$$\underbrace{\gamma^2\pi_\eta^M}_{\text{direct lending}} + \underbrace{\gamma(1-\gamma)\pi_\eta^M}_{\text{direct lending}} + \underbrace{(1-\gamma)\gamma\theta\pi_\eta^M}_{\text{liquidity sharing}} - I.$$ After simplification we get

$$\frac{\gamma\pi_\eta^M}{2}(3-\gamma) - I. \tag{7}$$

It is easy to see that each banker would strongly prefer to be the only one who invests in the monitoring technology as the expected payoff in (7) is larger than the expected payoff when both bankers invest in the technology given in (6) by $\frac{\gamma\pi_\eta^M}{2}$. This additional benefit can be decomposed into two parts. With probability γ^2 both bankers are matched with households, but the banker who can monitor loans will take the full monopolistic profit, while if both bankers can monitor they will collude using the interbank market and split the monopolistic surplus. The second part of the benefit comes when one banker matches with households, but another one does not. It happens with probability $\gamma(1-\gamma)$. If both bankers can monitor, then the banker without liquidity gets zero surplus. However, if only one banker can monitor, but does not have the resources to lend, she will borrow from the second banker. In this case, each banker receives half of the monopolistic profit. The expected profit of the banker who did not invest is $\frac{\gamma\pi_\eta^M}{2}(1-\gamma)$.

If both bankers do not invest in the monitoring technology, the payoffs are zero regardless of the liquidity shocks because bankers cannot provide loans without being able to do costly state verification.

3.2.3 Equilibrium of the entry game with interbank market

We summarize the expected payoffs from the entry decisions of bankers in the following table:

		Banker 2: c	Banker 2: ∞
Banker 1	c	$\left(\frac{\gamma\pi_\eta^M}{2}(2-\gamma) - I, \frac{\gamma\pi_\eta^M}{2}(2-\gamma) - I\right)$	$\left(\frac{\gamma\pi_\eta^M}{2}(3-\gamma) - I, \frac{\gamma\pi_\eta^M}{2}(1-\gamma)\right)$
	∞	$\left(\frac{\gamma\pi_\eta^M}{2}(1-\gamma), \frac{\gamma\pi_\eta^M}{2}(3-\gamma) - I\right)$	$(0,0)$

First, we solve for the conditions such that entry of both bankers is a unique Nash equilibrium in pure strategies. Because of the symmetry in the payoffs, it is sufficient to analyze conditions on the profitability such that banker B's best response to any action of banker A is to invest in the monitoring technology. If banker A invests, banker B's best response is to invest if the following condition holds

$$\frac{\gamma\pi_{\eta}^{M}}{2}(2-\gamma) - I > \frac{\gamma\pi_{\eta}^{M}}{2}(1-\gamma) \tag{8}$$

The left-hand side is the payoff from investing in monitoring and the right-hand side is the payoff from not investing in monitoring, conditional that the other banker invests in monitoring. After simplifying we get

$$\frac{\gamma\pi_{\eta}^{M}}{2} > I \tag{9}$$

The second condition assures that if banker A does not invest, banker B's best response is to invest. It rules out an equilibrium without entry by either of the bankers. The second condition is

$$\frac{\gamma\pi_{\eta}^{M}}{2}(3-\gamma) - I > 0 \tag{10}$$

Therefore, the condition on the profitability to investment ratio is

$$\frac{\gamma(3-\gamma)\pi_{\eta}^{M}}{2} > I \tag{11}$$

Given that $3-\gamma > 0$, condition (11) is always satisfied if condition (9) is satisfied. Therefore, condition (9) is necessary and sufficient for investment by both bankers to be a unique Nash equilibrium.

If profits are too low to satisfy condition (9), but are high enough to satisfy condition (11), then there are two pure strategy Nash equilibria in which one of the bankers enters the market for business loans and another one does not ((c, ∞) or (∞, c)). If profits are so low that even condition (11) cannot be satisfied, then it is a dominant strategy for both bankers not to enter. In this case, even if bankers had liquidity they cannot provide loans.

Next, we solve for unique symmetric Nash equilibrium in mixed strategies. Let q be the probability of investment in the monitoring technology of banker A and $1-q$ the probability of no investment. For banker B to play a mixed strategy, she needs to be indifferent between investing and not investing in the monitoring technology. This indifference condition requires:

$$q\left[\gamma\pi_\eta^M(1-\frac{\gamma}{2})-I\right]+(1-q)\left[\gamma\pi_\eta^M(\frac{3}{2}-\frac{\gamma}{2})-I\right]=q\left[(1-\gamma)\gamma\frac{\pi_\eta^M}{2}\right] \quad (12)$$

From this equation we can compute the probability of investment in monitoring technology by banker A that makes banker B indifferent:

$$q^*=\frac{\gamma\pi_\eta^M(\frac{3}{2}-\frac{\gamma}{2})-I}{\gamma\pi_\eta^M(1-\frac{\gamma}{2})} \quad (13)$$

Because of the symmetry in payoffs, equation (13) is the mixed strategy equilibrium of the entry game.

A simple comparative statics shows that $\frac{\partial q^*}{\partial\gamma}=\frac{\gamma^2(\pi_\eta^M)^2+4I(1-\gamma)}{(\gamma-2)^2\gamma^2\pi}>0$ suggesting that bankers are more likely to enter the market for business loans when the probability of a positive liquidity shock is higher.

3.2.4 Spread on business loans and collusion

In the previous subsection, we solved for two equilibria of the entry game. The first equilibrium is a pure strategy Nash equilibrium in which both bankers invest in the monitoring technology. This equilibrium exists in markets for which business loan profitability is high (condition (9) is satisfied). We refer to these markets as high profit markets that have high gross return on entrepreneurs' projects.[11] We assume that project returns in the high aggregate state always satisfy this condition. Therefore, R_H^P is a project return in this market. Using equation (2), the interest rate on a business loan charged by a monopolistic banker is given by

$$R_H^*=\frac{R_H^P+((1-p)c+\overline{R})/p}{2} \quad (14)$$

We further assume that when the aggregate state is low, condition (9) is not satisfied because the returns on the projects (R_L^P) are too low. Therefore, when the aggregate state is low, each banker enters with probability q^*. When the aggregate state is low, the spread on the interest rate loan is given by

$$R_L^*=\frac{R_L^P+((1-p)c+\overline{R})/p}{2} \quad (15)$$

[11] Alternatively, we could have assumed that these markets have high success rate (p) of the projects.

Given that the probability of the high aggregate state is λ, the ex-ante fraction λ of loans has high project returns and $1-\lambda$ has low returns.

Given the optimal entry decisions by bankers, we can use Bayes rule to derive a prediction about the relationship between the interest rate on the loans and collusion. This probability is given by

$$Prob(R_H^*|\mathfrak{C}) = \frac{Prob(\mathfrak{C}|R_H^*)Prob(R_H^*)}{Prob(\mathfrak{C}|R_H^*)Prob(R_H^*) + Prob(\mathfrak{C}|R_L^*)Prob(R_L^*)} \tag{16}$$

where where $\mathfrak{C}$ denotes collusion. We can simplify this formula by substituting probability of collusion in each state and the probability of each type of state

$$Prob(R_H^*|\mathfrak{C}) = \frac{\gamma^2\lambda}{\gamma^2\lambda + \gamma^2(q^*)^2(1-\lambda)} \tag{17}$$

Further simplification yields

$$Prob(R_H^*|\mathfrak{C}) = \frac{\lambda}{\lambda + (q^*)^2(1-\lambda)} > 0 \tag{18}$$

Similarly, we can use the Bayes rule to derive a probability of observing a high spread on a loan that is intermediated by bankers who are not competitors but liquidity providers.

$$Prob(R_H^*|\mathfrak{L}) = \frac{Prob(\mathfrak{L}|R_H^*)Prob(R_H^*)}{Prob(\mathfrak{L}|R_H^*)Prob(R_H^*) + Prob(\mathfrak{L}|R_L^*)Prob(R_L^*)} = 0 \tag{19}$$

where $\mathfrak{L}$ denotes liquidity. However, this probability is zero because $Prob(\mathfrak{L}|R_H^*) = 0$. The intuition for this result is as follows. In the state with high project returns, both bankers enter with probability one (pure strategy equilibrium). If both bankers enter, the only usage of the interbank market is for collusion. If only one banker received liquidity shock, this banker is able to lend directly to entrepreneurs. Interbank market is used for liquidity provision only in the market with low project returns because in this market with probability $q^*(1-q^*)(1-\gamma)\gamma$ banker A invests in the monitoring technology, banker B does not invest, but banker B has liquidity and banker A does not. This is the classic case of intermediation in the provision of business loans (see section 3.1.2). A similar need for liquidity sharing between bankers takes place when banker A and banker B switch roles.

To summarize, the main empirical prediction that arises from the above analysis is that business loans that are colluded have higher spread than business loans that are intermediated. The intuition is that the entry decision of bankers is endogenous. They are more likely to enter a market that has high profit margins for bankers. But when both bankers enter the market they are more likely to collude. Next, we test this prediction in the market for syndicated loans.

4 Empirical Analysis

In this section, we provide empirical predictions and results of the empirical analysis using data about global syndicated loans. We also provide additional empirical predictions that can further be used to test our theory.

4.1 Interbank lending and spreads on loans to corporations

We use syndicated loans to test empirical predictions derived from the model.[12] We utilize DealScan data that includes a panel data about identities of the lender(s), the borrower, and the terms of the loan for a global cross section of firms and banks. Most importantly, the database includes not only loans to corporations, but also loans to banks.[13] That is an ideal setting for testing our main hypotheses:

Hypothesis I: *The spread on the syndicated loans to firms is higher when a lead arranger borrows from a competing bank relative the spread on the syndicated loans to firms when the lead arranger either does not have a loan from another bank or has a loan from non-competing banks.*

Hypothesis II: *The spread on the syndicated loans to firms provided by a lead arranger that has an outstanding loan from a competing bank is proportional to the spread on the interbank loan.* This prediction comes from the bargaining problem between banks. The interbank market is used to share monopolistic profits that arise from collusion.

Hypothesis III: *The higher spread on the syndicated loans to firms provided by a lead arranger that has an outstanding loan from a competing bank does not require repeated interactions between the two banks.* As opposed to the standard collusion in the IO literature, our

[12] Sufi (2007) provides excellent explanation of the institutional details of the syndicated loans market.

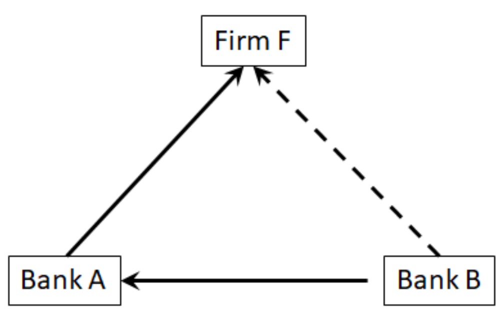
[13] Banks are defined as financial institutions that belong to industries with SIC code between 6000 and 6800.

collusion mechanism does not require banks to have repeated interactions. Once the competitor provided a loan to the lead arranger, it has limited resources to lend to firms. This type of commitment not to compete is effective even with a one-time interaction between the two banks.

To test these hypotheses, we define a collusion dummy for each loan. The dummy is equal to one if exists a triplet of two banks (call them A and B) and a borrowing firm (F) that satisfies the following conditions: (1) bank A is a lead lender to firm F in this syndicated loan, (2) bank B has provided a loan to bank A in the past and this loan has not been repaid yet, (3) firm F had borrowed from bank B in the past and this loan's maturity is within the five years from origination of the current loan by bank A. The third condition is necessary because it tells us that bank B could provide the loan to firm F because it has the technology to monitor this firm, but there is no active loan extended by bank B to firm F at the time when the new loan is originated by bank A.[14]

Figure 3 provides graphical relationships between the three entities. The dashed arrow indicates that this loan could be given, solid lines represent connections based on the actual loans outstanding. The key dependent variable is the spread on the loan from bank A to firm F. The model predicts that this spread is higher if the loan is part of the triplet. Bank B's loan to bank A reduces resources available to lend to firm F.

Figure 3: **Illustration when a collusion dummy = 1**



[14]The collusion dummy is computed at the bank's ultimate parent level to avoid designating different branches/subsidiaries of the same bank as competitors.

4.1.1 Data

We combine data from DealScan, Global Compustat database, and Standard & Poor's issue credit rating data. We have 172,034 unique facilities (loans) from June 29th, 1982 to April 4th, 2018. We run regressions at the facility level and focus on the syndicated loans.[15] To identify lead bank for each syndicated loan that has more than one lead arranger credit status, we follow Ivashina (2009) and define the administrative agent to be the lead bank. Otherwise, the lead arranger is the bank that has the Lead Arranger League Table credit based on Reuters LPC's League Table guidelines. We drop any facility having more than one administrative agent or no administrative agent. That leaves us with a sample of 138,515 facilities. The sample includes both US and non-US firms and banks.

We use standard controls variables, such as credit rating of the borrower, whether the firm is public, maturity of the loan, collateral, whether the lender had a previous relationship with the borrower, etc. All the variables and the descriptions appear in Table 1.

4.1.2 Summary statistics

Table 2 provides the summary statistics for all the sample and the restricted sample used in our benchmark specification. The whole sample has $34.5 trillions of loans to 26,583 non-financial firms by 2,419 lenders.[16]. Out of these loans, there are 1,285 loans for which the collusion dummy is one. These loans total $239 billion.

In the whole sample (Panel A), the average (median) maturity of the loans is 55 (60) months. The average (median) spread is 259 (225) basis points over Libor. The average (median) loan size is $257 ($80) million.[17]

After we condition on the availability of the control variables, the sample becomes 13,560 loans. In this sample (Panel B), the average (median) maturity of the loans is 54 (60) months. The average (median) spread is 220 (200) basis points over Libor. The average

[15] Variable `distributionmethod` equal to 'Syndication' in DealScan.
[16] We adjust the aggregates for inflation and report values in 2018 USD
[17] We adjust for inflation only aggregate amounts, the rest of the variables are not adjusted.

(median) loan size is $557 ($270) million.

4.1.3 Main results

Table 3 reports the main empirical results. We start with regressing the All-in-drawn spread in the 103,582 loans on the Collusion dummy and a constant (Specification 1). This result of with simple specification tells us that on average, when a lead arranger has an outstanding loan from a competitor bank, the borrower firm pays 32 basis points higher spread. The t-stat on the collusion dummy in this regression is 4.04.[18]

In specification (2), we add firm level controls, loan characteristics and fixed effects for S&P long term ratings of the borrower firm.[19] Firm level characteristics, loan characteristics and the credit ratings are important determinants of the credit risk which consequently affects the spread. The adjusted R^2 increases by 45.6% relative to specification (1). The coefficient on the collusion dummy is 40 basis points, significant at the 1% level.

From the results in specification (2), we see that publicly traded firms pay lower spreads, as well as firms that borrowed from the same lender within the last five years. Firms with more revenues pay lower spreads, but the coefficient on the log of total assets is positive. Profitability (ROA) reduces the spreads. Loans that are larger benefit from better pricing, possibly because the borrowers have higher bargaining power and can shop around for better pricing. The collateral dummy has a positive and statistically significant coefficient. Schwert (2018) also finds that the spreads are higher for collateralized loans. His interpretation is that firms are required to put collateral as their conditions deteriorate as suggested by Roberts and Sufi (2009) and Rauh and Sufi (2010). This explanation could hold in our sample as well if credit rating fixed effects are not able to control for this deterioration in the credit quality.

In specifications (3)-(7), we add a wide range of fixed effects to control for unobservables.

[18] We report robust standard errors in the brackets below the coefficient. Standard errors are clustered by bank.

[19] We take ratings that are available within one year prior to the loan origination. The results are robust if we take a rating available within two years from the date of origination or the first rating available after the origination.

The results are robust and the coefficient on the collusion dummy is economically and statistically significant at 1% level in all these specifications that we consider. The adjusted R^2 increases from 46.5% in specification (2) to 65% in specification (7), suggesting the five fixed effect help to explain the variation in the loan pricing. Next, we discuss of each one of these specifications in more detail.

In specification (3) we add year fixed effects. Not surprisingly, the (unreported) coefficient on the 2009 fixed effect is positive and statistically significant, which is an indication that borrowers needed to pay an extra spread in the middle of the financial crisis. In specification (4) we add loan purpose fixed effect. Syndicated loans can be used for different purposes (corporate needs, repurchase debt, investments, LBO, acquisition, debtor in possession financing, working capital, etc). It could be that loans for some purposes are priced higher than others and the credit ratings are not capturing it. We add borrower country fixed effects in specification (5) to address a possibility that loans to borrowers in some countries are priced higher potentially accounting for the country-specific credit risk that is not captured by the credit ratings (e.g., expropriation risk). We add fixed effects for loans types in specification (6). These fixed effects accounts for the possibility that bridge loans are priced differently than revolving credit lines or term loans.

The benchmark specification in the paper is specification (7). In this specification, we include lender fixed effects to absorb heterogeneity across banks and to account for banks' unobservable characteristics. It addresses a valid concern that banks probably differ in the costs of capital which could affect pricing of loans that they provide. We find that a loan provided by the same bank to a firm that borrowed from the lender's competitor in the past is priced on average 31 basis points higher than a loan provided by the same bank to another firm that did not borrow from the competitor. This specification controls for firm characteristics, loan characteristics, firm credit rating, year fixed effects, loan type, loan purpose, and borrow firm country. This result is consistent with our model that suggests that competition is reduced when competing banks lend to each other because it reduces the lending capacity of the bank that lends in the interbank market.

Overall, the coefficient on the collusion dummy does not change much across the specifications in Table 3. It ranges between 31bps and 40bps. In terms of economic significance, the effect of collusion is larger than the spread between BBB and A rated syndicated loans (24bps), but smaller than the spread between BBB- and A rated loans (41bps) based on the fixed effects coefficients in specification (7). It means that an A rated firm that borrows from a bank that has an outstanding loan from a competitor pays the same interest as a firm rated between three to four notches lower, but that does not borrow from a bank that colludes using interbank loans. We conclude that interbank market can facilitate collusion that has an economically significant effect on the pricing of corporate loans.

4.1.4 Collusion vs. Intermediation

In the way the collusion dummy is defined, one can wonder whether the increase in the loan pricing comes from the fact that the lender borrows from another bank (intermediation channel) or from the fact that the lender borrows from its competitor (the collusion channel). We address this question in this subsection.

We define a chain dummy that is equal to one if the lead lender borrowed form another bank, but the other bank had not provided a loan to the borrowing firm within the last five years. This corresponds to the case of interbank market being used for liquidity allocation purposes (see discussion in subsection 3.1.2). The chain dummy captures cases when the lead lender borrowers from a bank that is unlikely to be a potential lender to the firm.

In Table 4 specification (1) we add the chain dummy to the benchmark specification with the collusion dummy, firm characteristics, loan characteristics and six sets of fixed effects. The coefficient on the chain dummy is indistinguishable from zero. The coefficient on the collusion dummy is 32bps, statistically significant at 1%. This is consistent with the predictions of the model (equations (19) and (16)).

The difference between the coefficient on the collusion dummy and the chain dummy is 29bps, statistically significant at 1%. This result is consistent with the prediction of the model that colluded loans are more likely to have a higher spread than intermediated loans because banks are more likely to enter markets with high spreads (see equation 18). We conclude that the increased cost of capital to firms is caused by collusion and not by intermediation.

Next, we study the relationship between the pricing of the interbank loan and the pricing of the bank to firm loan. In the model, banks bargain over the monopolistic profit that is generated by collusion. The spread on the interbank loan is proportional to the spread on the loan. If the spread on the colluded loan is zero, the spread on the interbank loan is zero as well. In specification (2), we add the interbank spread on the outstanding loan(s) owned by lead arranger(s) to competitor banks as an explanatory variable. We find that the interbank spread has a positive and statistically significant coefficient. This result is consistent with Hypothesis II. Moreover, the coefficient on the collusion dummy is indistinguishable from zero, meaning that the interbank spread is a sufficient statistic to capture the additional spread on the business loans. If the interbank spread is zero, the spread on the loans is zero as well.

In the last two specifications in Table 4, we test whether the collusion result requires repeated interactions between banks. In specification (4), we add "Interbank two-way link collusion" variable, which measures how many times two competing banks provided loans to each other (regardless of the direction) prior to the time when a business loan is originated. We also add a similar variable ("Interbank two-way link chain") for the loans between non-competing banks. In specification (5), we add the same variables, but this time defined only as the number of previous loans from bank's counterparties to the bank. The collusion dummy is still significant in both specifications, but none of the interbank link variables is significant. That confirms the predictions of our model that collusion using interbank market does not require repeated interactions (Hypothesis III), which distinguishes our collusion mechanism from the standard collusion among non-financial firms. The latter is not sustainable without repeated interactions.

4.1.5 Robustness

In Table 5, we assess the robustness of the empirical results by focusing on subsamples of loans. In all regressions we adopt the benchmark specification (specification 4 in Table 3) and report how the results change when we condition on loans extended pre-financial crisis (specification 1), post-financial crisis (specification 2), loans by US borrowers only (specification 3) and loans provided by US lenders (specification 4), loans to private firms (specification 5), and specification (6) in which the collusion dummy equals one when a competitor bank had a loan repaid to it by the firm within three years (instead of five years) prior to the date of the firm's loan origination.

In specification (1), the coefficient on the collusion dummy is 23bps for loans originated before 2007, statistically significant at 5% level. The spread on colluded loans increases to 67bps for the post-crisis period of 2010-2018 (specification 2) and is significant at 1% level. The post-crisis effect is economically large. It is of the same magnitude as the difference between spread on loans to A rated borrowers and BBB- rated borrowers (71bps) in this specification.[20]

In specifications (3) and (4), we focus on the US-based borrowers and lenders respectively. The coefficient on the collusion dummy variable in these regressions is around 30bps which is effectively the same as in the full sample.

In specification (5), we restrict the sample to include only private borrowers. We find that loans to private firms by colluding banks are priced at 66bps compared to 32bps for the whole sample. It suggests that collusion concerns are more relevant for private firms, whose ability to raise money from outside the banking system are lower than that of public firms.

In specification (6), we redefine the collusion variable and the chain variable by using only a three years window. The coefficient on the collusion dummy is 35 basis points and

[20]The realized one-year default probability of BBB- rated firms is 31.10bps, which is almost four times higher than that of A rated firms (7.9bps) according to "The Credit Research Initiative of the National University of Singapore (2018), Probability of Default implied Rating (PDiR) White Paper", Accessible via the following link: https://www.rmicri.org/en/white_paper.

significant at 5% level. We conclude that our results are robust to the alternative definition of the collusion dummy.

In addition to the above robustness tests, we also verified in untabulated results that the collusion dummy is economically large and statistically significant when we add lender year fixed effects, industry fixed effects, lender borrower fixed effects. These additional robustness tests tell us that (1) the identification comes from the same bank facing two borrowers at the same year but for one borrower the collusion dummy is one while for another borrower it is zero, (2) the collusion is not driven by a given industry, (3) the results are not coming from some unobservable market power of a given lender to a given firm, which is not related to the collusion. We also tried to double cluster by lender and year and the collusion dummy is still statistically significant at either 5% or 1% levels.

4.2 Alternative explanations

In this subsection, we explore some possible alternative explanations for our findings. One possibility is that firms that have more relationships with banks are more likely to have collusion dummy equal to one because for any given loan it is more likely for them to have a previous relationship with the lending bank's counterparty. There are several reasons why this alternative explanation is not plausible. First, we control for firm size which should be positively correlated with the number of bank relationships. Second, if the borrowing firm has many relationships with banks, it would be less likely to pay a higher spread on the loan because it becomes more difficult to collude as more banks compete in providing a loan to the firm. Third, this explanation does not explain why the interbank spread is positively correlated with the spread on the loan.

Another concern is that the competitor bank that provided a loan to the same firm in the past knows some negative information about the firm and thus is not willing to lend to it. The firm needs to pay a higher spread because this negative information is also known to the lending bank, at least partially. While it is not clear in this explanation how the negative information was transferred from the competitor to the lender, there are several ways to alleviate this concern. First, we control for the credit rating of the firm which was given to it within one year from the origination.[21] We also control for collateral and for other firm level characteristics that could be affecting its rating. Second, in Table 5 specification (7), we find that if the loan was repaid to the competitor more recently (within three years) the collusion spread is smaller than in the benchmark case (within five years). One would assume that more recent interaction with the firm will provide more accurate actionable information to the competitor, while loans that were repaid four or five years ago would carry less informational content. Lastly, in untabulated results we find that the collusion dummy coefficient is 35bps (significant at 1%) in the subsample of firms that borrowed from the same lead arranger in the past. For firms that did not borrow from the same lead arranger in the past five years, the coefficient is 34bps (significant at 1%). The fact that lender's previous relationship with the borrower does not affect the spread for colluded loans tells us that it is unlikely that the collusion spread is a compensation for some hidden information about the riskiness of the borrower.

4.3 Additional empirical evidence for collusion

The model predicts that banks that have similar monitoring costs are more likely to use interbank market to collude. Geographical proximity is one proxy for similarity in monitoring. If two banks are located in the same geographical area, they are more likely to be competitors in the market for local business loans and they are more likely to trade in the interbank loans market for collusion purposes. Similarly, banks that provide loans to the same companies are competitors because they have similar monitoring technology. Therefore, banks with a higher overlap in the business loan portfolios would be more likely to lend to each other to facilitate collusion.

Several papers have found a strong correlation between the probability of trade in the

[21] In unreported results we also used the first available rating after the loan was originated and the results are robust, suggesting that if this negative information exists, it is not revealed for many years after it has been collected.

interbank market and the geographical proximity between the banks. For the Fed funds market, Bech and Atalay (2010) find that the trade flows between banks in the same district are 165% higher than between banks in two non-neighboring districts. Similarly, Afonso et al. (2014) find that banks are 20 times more likely to trade in the Fed funds market with banks in the same state. Moreover, they find that banks of similar size are more likely to trade. In a recent paper, Elliott et al. (2019) report that German banks lend more to each other in the interbank loans market if they have similar business loans portfolios. The economic magnitude of their finding is particularly large, a change from 25th to 75th percentile in their measure of an overlap in business loans between two banks, increases the net lending between these banks by 31%.

Overall, these findings from US and Germany are consistent with our main insight that interbank markets can be used by banks to reduce competition in the market for business loans.

5 Regulation

In this section, we first solve the planner's problem so that we know the constrained efficient post-entry allocation and the socially optional entry decision. Then we solve the decentralized equilibrium without an interbank market. Contrasting the decentralized equilibrium that we observe (i.e. with an interbank market as in Section 3)with a counterfactual equilibrium without an interbank market allows us to study the effect of the interbank market on banks' lending and entry decisions. This analysis allows us to evaluate the difference in aggregate welfare between an economy with and without interbank markets and to derive policy implications. These implications are important in the light of the Basel III regulation of large interbank exposures.

5.1 Planner's post-entry problem

First, we focus on the the social planner's problem post-entry. The planner maximizes expected utility of entrepreneurs, depositors, and bankers subject to resource feasibility, participation and incentive compatibility constraints.

If both bankers do not enter or neither of the bankers is matched with households (which happens in 7 out of the 16 possible states), the planner's solution is the same as the decentralized solution (i.e. it is just autarky). The difference between the planner's solution and the decentralized solution is in the remaining 9 out of 16 states.

When both bankers are matched with households and can monitor, no interbank transfers between bankers are needed. Under the assumption that resources available to one banker are sufficient for optimal lending, the planner's solution when both bankers are able to monitor loans is the same as when one banker is able to monitor loans. Therefore, we can reduce the problem to having one banker. The utility of the households matched to the second banker is zero because their funds are not needed for investment, so they are stored at the risk-free rate $\overline{R} = 1$, such that their utility is $log(1) = 0$. Allocating higher consumption to households is not optimal because of the decreasing marginal utility from consumption. The utility of the second banker is also zero because her monitoring technology is not needed for the optimal investment and she does not have any remaining resources to consume. Given that both bankers are risk neutral, social welfare does not depend on which one of the two bankers intermediates between the households and the entrepreneurs.

The planner's problem is to choose τ_s, τ_f, h_s and h_f to maximize the following objective:

$$\begin{aligned}&\int_0^M [1 - \mathbf{1}_\omega]\, \omega d\omega \\ &+ \int_0^M \mathbf{1}_\omega \left[p \cdot \left(R_\eta^P - \tau_s\right) + (1-p)\cdot(-\tau_f)\right] d\omega \\ &+ \int_0^M \mathbf{1}_\omega \left[p(\tau_s - h_s \cdot c) + (1-p)(\tau_f - h_f \cdot c)\right] d\omega + \left[D - \int_0^M \mathbf{1}_\omega d\omega\right]\overline{R} - DR^D \\ &+ Dlog(R^D) + (\overline{D} - D)log(\overline{R}) \end{aligned} \tag{20}$$

where $\mathbf{1}_\omega$ is an indicator function which denotes whether an entrepreneur with outside option ω chooses to participate. The first line in the planner's objective represents the utility of entrepreneurs who take their outside option. $\mathbf{1}_\omega$ is an indicator function that is equal 1 if a planner decides to fund a project of an entrepreneur whose outside option is ω.

The second line captures the utility of entrepreneurs who receive funding and invest in the project. The expected gross return on the project is pR^P, the τ_s is the transfer from an entrepreneur to the banker when the project succeeds. The τ_f is the transfer from an entrepreneur to the banker when the project fails. Notice that with the limited liability assumption, this transfer cannot be positive because the project returns zero in this state of the world.

The third line represents the utility of the banker who is chosen by a planner to provide intermediation services. The first term represents the expected payoff from the entrepreneurs. Notice that the payoff depends on the monitoring strategy of the banker. To keep notation simple, we assume truthful reporting, which is, as we discuss later, the optimal strategy. h_s is one if banker monitors entrepreneurs who report that their project succeeded. h_f is one if banker monitors entrepreneurs who report that their project failed.

The second term in the third line is the payoff on the risk-free assets (A), which equal to deposits minus funds used for financing the projects. The last term is the transfer from the banker to the households according to the deposit rate R^D, where D represents the measure of households who transferred funds to the banker at the BOP.

The last line computes the utility of the households. The first term captures the utility of the households who deposited funds at the BOP and the second term captures the utility of the households who decided to store their funds at the risk-free storage technology.

Importantly, the planner's problem does not specify transfers conditional on the outside option of the entrepreneurs because entrepreneurs will not report truthfully their outside option. They will all report $\hat{\omega}$ that maximizes their surplus. We use the direct mechanism to solve the planner's problem subject to the resource feasibility, the participation constraints and the incentive compatibility constraints that we define next.

5.1.1 Resource Feasibility

Let $\tau_\sigma(\omega)$ be a transfer of an entrepreneur with an outside option ω to a banker when the state of project is σ. For all ω, σ contingent transfers must satisfy:

$$R_\eta^P - \tau_s(\omega) \geq 0 \tag{RF Success}$$

$$-\tau_f(\omega) \geq 0 \tag{RF Failure}$$

It means that in case of success, the transfer to a banker cannot exceed the proceeds from the project, and in case of failure, the transfer cannot be positive because there are no resources to transfer. For the banker, resource feasibility requires:

$$A + \int_0^M \mathbf{1}_\omega d\omega \leq D \leq \overline{D} \tag{RF BOP}$$

$$\int_0^M \mathbf{1}_\omega \left\{p(\tau_s(\omega) - h_s c) + (1-p)(-\tau_f(\omega) - h_f c)\right\} d\omega + \left[D - \int_0^M \mathbf{1}_\omega d\omega\right] \overline{R} \geq DR^D \tag{RF EOP}$$

The resource feasibility constraints include the constraint that the banker has enough resources to make the transfers to the entrepreneurs at the BOP and enough resources to repay fully to depositors at the EOP. The EOP constraint assures that the banker has enough resources at the EOP to transfer to the household the amount promised by the planner. The calculation relies on the fact that the project risk is idiosyncratic, and the banker invests in a pool of projects achieving a perfect diversification of the idiosyncratic risk.

5.1.2 Participation Constraints

The planner faces three participation constraints: one for entrepreneurs who receive the funding, one for the banker who provides the funding, and one for households who provide deposits. The participation constraint for an entrepreneur with an outside option ω is given by

$$p \cdot \left(R_\eta^P - \tau_s(\omega)\right) + (1-p)(-\tau_f(\omega)) \geq \omega \tag{PC ENT}$$

This constraint states that the expected payoff for an entrepreneur who invests in the project is higher than his outside option. The participation constraint for the banker is:

$$\int_0^M \mathbf{1}_\omega \left\{p(\tau_s(\omega) - h_s c) + (1-p)(\tau_f(\omega) - h_f c)\right\} d\omega + \left[D - \int_0^M \mathbf{1}_\omega d\omega\right] \overline{R} - DR^D \geq 0 \tag{PC BK}$$

The banker needs to have expected revenues higher than liabilities, otherwise her consumption would be negative. The outside option of the banker is not to intermediate the transaction and to receive a payoff of zero.[22] The participation constraint for households is:

$$log(R^D) \geq log(\overline{R}) \tag{PC HH}$$

The household needs to receive a deposit rate that is at least as high as the return on the risk-free storage technology.

5.1.3 Incentive Compatibility Constraints

. The incentives arise in our setting because of the informational frictions. An entrepreneur with a low outside option can pretend that he has a high outside option if that would reduce the required transfer to the banker. An entrepreneur has incentives to report that the project failed and to keep all the proceeds to himself. Therefore, the truthtelling needs to be incentivized either via payoffs or punishment.

Let $\tau_{\widehat{\sigma}}(\widehat{\omega})$ denote the transfer from an entrepreneur who follows reporting strategy $(\widehat{\omega}, \widehat{\sigma})$ to a banker. Entrepreneur's truthtelling about ω requires:

$$\begin{aligned} &p \cdot \left(R^P_\eta - \tau_s(\omega)\right) + (1-p) \cdot (-\tau_f(\omega)) \geq \\ &p \cdot \left(R^P_\eta - \tau_s(\widetilde{\omega})\right) + (1-p) \cdot (-\tau_f(\widetilde{\omega})), \widetilde{\omega} \neq \omega \end{aligned} \tag{IC Type}$$

Entrepreneur's truthtelling about σ requires:

$$R^P_\eta - \tau_s(\omega) \geq \quad (1-h_f)R^P_\eta + h_f(0) \tag{IC Success}$$

$$-\tau_f(\omega) \geq \quad (1-h_s)(-\tau_s(\omega)) + h_s(0) \tag{IC Failure}$$

The first constraint states that an entrepreneur whose project succeeded is better off to

[22] Both bankers are equally suited to be an intermediary in this environment so banker's participation constraint needs to provide her at least zero, but not more than zero, even after she received deposits from the households.

report the truth than to report that his project failed. The second constraint states that an entrepreneur whose project failed is better off to report the truth than to report that his project succeeded.

5.1.4 Planner's Solution vs. Decentralized Solution

In this section we compare the planner's solution to the decentralized solution. The planner's solution suggests that the decentralized solution results in underprovision of loans. It is formalized in the following proposition.

Proposition 2. *The social planner's solution is to provide double the amount of loans provided in the decentralized solution.*

The intuition of for this result is straightforward. The planner's level of lending ($\omega^{SP} = pR^P - (1-p)c - \overline{R}$) results in zero profits for bankers. Therefore, a monopolist wants to increase interest rate on the loans, even at a cost that it results in less loans. In particular, Banker A has enough deposits to provide planner's level of investment in the projects, but that level results in zero profits to the banker. So banker A provides ℓ^* loans and the remaining deposits ($D - \ell^*$) she stores in the risk-free storage.

The transfers from entrepreneurs to bankers, conditional on project's success, in the planner's solution are $\tau_s^* = R^P - \frac{\omega^{SP}}{p} < R^*$. The expected return on a loan in the planner's solution is just the risk-free return. The expected return on a loan provided by a monopolist is $\frac{pR^p-(1-p)c+\overline{R}}{2} > \overline{R}$.

The total consumption (TC) achieved by the planner's allocation is:

$$\int_{\omega^{SP}}^{M} \omega d\omega + \int_0^{\omega^{SP}} \left[p \cdot R_\eta^P - (1-p)c - \overline{R}\right] d\omega$$
$$+D\left(\overline{R} - R^D\right) + Dlog(R^D)$$

Substituting $\omega^{SP} = pR^P - (1-p)c - \overline{R}$, $R^D = \overline{R} = 1$ we get:

$$\frac{M^2}{2} + \frac{(pR_\eta^P - (1-p)c - \overline{R})^2}{2} \qquad \text{(TC Social Planner)}$$

Relative to an autarky, the total utility increases by $\frac{(pR^P-(1-p)c-\overline{R})^2}{2}$. The aggregate utility in autarky is $= \int_0^M \omega d\omega = \frac{M^2}{2}$.

The distribution of surplus in the planner's solution is such that entrepreneurs receive all the surplus from investment. The banker does not receive any transfer under planner's solution. Households receive transfers that only compensate them for their outside option.

Proposition 3. *The welfare loss post-entry in the decentralized solution with liquidity is* $\frac{(pR_\eta^P-(1-p)c-\overline{R})^2}{8}$.

The welfare loss is larger if projects have higher expected return and lower opportunity cost. The intuition for this result is as follows. When banks collude using the interbank market, they ration out the provision of loans. Therefore, the welfare loss from this rationing depends on the surplus created by the loans. When the surplus is high, the welfare loss is high as well.

Despite the fact that interbank market reduces aggregate welfare, the decentralized equilibrium with interbank market is still higher than in autarky. In the autarky, the aggregate utility is $\frac{M^2}{2}$. The decentralized economy with interbank trading increases it by $\frac{3(pR_\eta^P-\overline{R})^2}{8}$.

5.2 Socially optimal entry decisions

In this subsection, we study the planner's solution in the economy with entry decisions by banks. First, the planner's choice is different from the decentralized solution because the social planner chooses only between two options: an entry by one of the bankers or no entry by both banker. From the social perceptive, entry by both bankers is a waste of resources because in the presence of an interbank market, it is sufficient that one of the bankers is able to monitor entrepreneurs.

Second, the interbank market is not needed if the banker who enters the market also matches with households. It happens with probability $\gamma^2+\gamma(1-\gamma)$. The first term is when both bankers match with households and the second term is that only the banker with the monitoring technology matches with the households and the second banker does not. The planner is going to use the interbank market if banker who is able to monitor (call him banker A) does not have liquidity, and the banker who cannot monitor (call him banker B) does get a positive liquidity shock. This scenario happens with probability $\gamma(1-\gamma)$. The interbank market in this case is such that banker B provides funds to banker A (f) at the BOP and banker A transfers this funds back to banker B at the EOP (F).

Banker B does not receive any profit from the interbank transfer because any profit to the bankers reduces the aggregate welfare as this profit would need to come from increased interest on the business loans. Therefore, the planner chooses an allocation that generates as little profit to the bankers as possible without violating their participation constraints. That means that banker A does receive some profit as a compensation for the investment of I in the monitoring technology. The participation constraint of banker A is binding when investment in the monitoring technology (I) is equal to the expected profit.

The expected profit of banker A is generated from the resources it provides to entrepreneurs. The profit function for a monopolistic banker is given in equation 39. Even if a planner would want to provide a banker with higher profit than the monopolistic profit, it would not be possible. Therefore, we can use this profit to solve for the ratio of monopolistic profit to the entry cost, such that there is entry in the planner's solution. For that we need to compute the highest expected profit that a banker can receive accounting for the fact that with probability $(1-\gamma)^2$ both bankers do not have liquidity what results in zero profits despite the investment in monitoring. With probability $1-(1-\gamma)^2$, the banker can receive the monopolistic level of profits. Therefore, the condition for entry is

$$(1-(1-\gamma)^2)\pi_\eta^M \geq I \tag{21}$$

where $\pi_\eta^M = \frac{\left(pR^P-(1-p)c-\overline{R}\right)^2}{4}$. After rearrangement and simplification of equation 21, we derive the following condition on the profit to entry cost ratio

$$\frac{\pi_\eta^M}{I} \geq \frac{1}{\gamma(2-\gamma)} \tag{22}$$

If this condition is not satisfied, the planners solution is an autarky, such that both bankers consume I, households keep their resources and entrepreneurs take their outside option. The expected total surplus in autarky is $2I+\frac{M^2}{2}$.

Proposition 4.

i. When the aggregate state is low, the lack of entry by any banker is higher in the decentralized solution than in the planner's solution.

ii. When the aggregate state is high, there is too much entry in the decentralized solution relative to the planner's solution.

The intuition for this result is simple. When the state is low, bankers either do not enter at all or enter with probability less than one, while in the planner's solution one banker always enters. The planner's solution has a lower cost of monitoring because only one bank enters relative to the decentralized solution in which both banks enter with positive probability. The lower cost of entry result in more entry in the planner's solution.

If constraint (22) is not binding, then the planner chooses the highest amount of lending without violating banker's participation constraint. Let ω_0^{SP} be the threshold for the case with entry. All entrepreneurs with outside option higher than ω_0^{SP} do not invest in the project and below this threshold do invest in the project. We solve for ω_0^{SP} that generates expected profit to the banker equal to the cost of entry, where the profit is given by equation (39).

$$q(2-q)\left((pR_P-(1-p)c-\omega_0^{SP})\omega_0^{SP}-\overline{R}\omega_0^{SP}\right)=I \tag{23}$$

The solution to this quadratic equation yields

$$\omega_0^{SP}=\frac{(\omega^{SP})^2+\sqrt{(\omega^{SP})^2-4\frac{I}{\gamma(2-\gamma)}}}{2} \tag{24}$$

where $\omega^{SP}=pR_P-(1-p)c-\overline{R}$ is the optimal threshold on lending in the case without entry costs (equation 50). It is easy to verify that $\omega_0^{SP}=\omega^{SP}$ when $I=0$. The level of lending with entry costs is smaller than without entry costs because bankers need to be compensated for the cost of entry and this is achieved by rationing out entrepreneurs and providing the banker who invests in the monitoring technology with some level of profits.

The social planner's solution with the cost of entry results in lower total surplus because of the profits generated by the banker who provides loans. By substituting equation (24) in equation (21) we get

$$I+\frac{M^2}{2}+\frac{(\omega^{SP})^2}{4}+\frac{\omega^{SP}\sqrt{(\omega^{SP})^2-\frac{4I}{\gamma(2-\gamma)}}}{4}+\frac{I}{2\gamma(2-\gamma)} \quad \text{(TS Social Planner with entry)}$$

If the cost of entry was zero, then equation (TS Social Planner with entry) simplifies to be the same as the social planner's solution for the total surplus without taking entry decisions into account (equation TC Social Planner). When the entry cost is positive, the surplus from provision of loans is smaller because the amount of lending is smaller when there is the cost of entry.

5.3 Decentralized Economy without Interbank Trading

In the decentralized economy, bankers compete in prices for providing loans to entrepreneurs. Bank i makes loans at the BOP by choosing rate R_i to be repaid if the project succeeds. If the project fails, the entrepreneur needs to pay 0 due to limited liability. A negative payment (insurance) in the state of project failure would provide more incentives to misreport but would not provide any benefit because entrepreneurs are risk neutral.

The interest rate on the loans does not depend on the outside option (ω) because outside options are private information. If a banker would provide a menu of repayment options as a function of ω, entrepreneurs would pick the cheapest option and misreport their type. Therefore, as is in the planner's solution, optimal contracts in the decentralized solution are not contingent on the unobservable type.

Definition 2. *Equilibrium without Interbank Trading*

- *Bankers choose R_i^D, then R_i, S_i and $h_{i,\widehat{\sigma}}$ at the BOP to maximize their consumption (profits).*
- *Households matched with a banker i choose optimally between depositing resources with the banker for R_i^D or investing in a risk-free storage technology with a return $\overline{R}$.*
- *At the BOP, entrepreneurs choose optimally between borrowing from the banker who offers the lowest rate or pursuing their outside options. At the EOP, entrepreneurs who borrowed decide on their report to the banker about the outcome of their project.*
- *Market for loans clears.*

In the market for deposits, we assume that bankers post deposit rates and households decide whether to accept them or not. Effectively, bankers have full bargaining power and are able to extract full surplus by offering a rate $R_1^D = R_2^D = \overline{D} = 1$. Households are indifferent, so they deposit their funds with the banker, such that $D_1 = \overline{D_1}$ and $D_2 = \overline{D_2}$.

We maintain the assumption that $\overline{D_1} = \overline{D_2} \geq \omega^{SP}$ for both banks. It means that each banker matches with enough households to be able to provide planner's level of investment in the project. This assumption is important because it results in a classic case of Bertrand competition without capacity constraints.

Proposition 5. *Decentralized equilibrium without interbank market implements the planner's solution.*

The above proposition states that perfect competition results zero profits for the bankers. Planner's solution also allocates all the surplus from lending to entrepreneurs and zero to bankers. Therefore, it has to be that the interest rate on loans in the decentralized solution is the same as transfers from entrepreneurs to bankers in the planner's solution. If the interest rate is the same, it attracts the same amount of borrowers, so the decentralized solution coincides with the planner's solution both on the intensive and an extensive margins.

5.4 The importance of the interbank market for entry

In this subsection, we solve the same entry decision problem, but we assume that an interbank market is closed. This assumption allows us to study the effect of the interbank market on the entry decision.

As before, there are 16 possible states of the world after the entry decisions are made. There are four states of the world for the realization of the liquidity shocks ($\{\overline{D}, \overline{D}\}$, $\{\overline{D}, 0\}$, $\{0, \overline{D}\}$, and $\{0,0\}$) and four monitoring costs outcomes of the entry game ({c,c},{c,∞},{∞,c}, and {∞,∞}). The presence of the interbank market affects payoffs only in three states of the world out of 16. First, if both bankers enter the market for business loans and also match to households, then instead of collusion they will need to compete because collusion requires interbank market. As we show in subsection 5.3, Bertrand competition between the bankers results in zero profits for both bankers.

The second case when interbank market matters is when only one banker enters, but this banker does not match with the households, while the second banker does match. Because of the symmetry, there are two possible states like that. With interbank market, each banker receives half of the monopolistic profits in this case. Without interbank market, both bankers will have zero profits in these two states of the world.

We summarize the expected payoffs of the entry game in the following table

		Banker 2	
		c	∞
Banker 1	c	$\big(\gamma(1-\gamma)\pi_\eta^M - I, \gamma(1-\gamma)\pi_\eta^M - I\big)$	$\big(\gamma\pi_\eta^M - I, 0\big)$
	∞	$\big(0, \gamma\pi_\eta^M - I\big)$	$(0,0)$

The solution approach is similar to the case with interbank market. There are two thresholds that define three regions for the $\frac{\pi_\eta^M}{I}$ ratio. The first threshold is $t_1 = \frac{1}{\gamma}$ and the second threshold is $t_2 = \frac{1}{\gamma(1-\gamma)}$. Notice that $t_1 < t_2$ for all $0 < \gamma < 1$. If $\frac{\pi_\eta^M}{I} > t_2$ then it is a dominant strategy for both bankers to enter. The monitoring costs in this unique pure strategy Nash equilibrium are $\{c, c\}$. If $t_1 < \frac{\pi_\eta^M}{I} < t_2$ then there is mixed strategy Nash equilibrium in which bankers enter the market with probability

$$q_{wo}^* = \frac{\gamma\pi_\eta^M - I}{\gamma^2\pi_\eta^M} \tag{25}$$

Lastly, if $\frac{\pi_\eta^M}{I} < t_1$ then there is a unique Nash equilibrium in which neither of the bankers enters the market.

Remark 2. *The effect of the interbank market on the entry decisions is not trivial. On one side, bankers who decide to spend the cost I and enter the market are getting less expected profits if interbank market is closed because they cannot collude. This drop in ex-post profits will result in less desire to enter the market and spend the entry cost. On the other side, when there is no interbank market, the benefit of not entering also decreases because in this case a banker who does not enter, but gets liquidity, is not getting half of the monopolistic* *profits from providing liquidity to the banker who enters but does not have liquidity to provide business loans.*

Because of the above opposing forces, whether there is more entry or less entry with interbank market depends on the regions of the parameter space.

5.5 Welfare effect of interbank market

In this section we provide a closed-form solution for the difference in total consumption with and without interbank market in the high state, in the low state, and before the aggregate state is realized.

5.5.1 The effect of the interbank market on welfare in the high state

Based on the analysis in sections (3.2.3) and (5.4) we know that the probability of entry is endogenous and depends on the region for the ratio of profits from lending (π_{η}^{M}) and cost of acquiring monitoring technology (I). The threshold for the probability of entry also depends on whether bankers are allowed to trade in the interbank market or not.

First, we compute the expected welfare loss of having an interbank market when the aggregate state is high. The expected welfare loss is defined as the expected difference in total consumption in the high state (TC_H) with and without an interbank market. If $\Delta TC_H = TC_H^{with} - TC_H^{without}$ is negative, the welfare loss is positive.

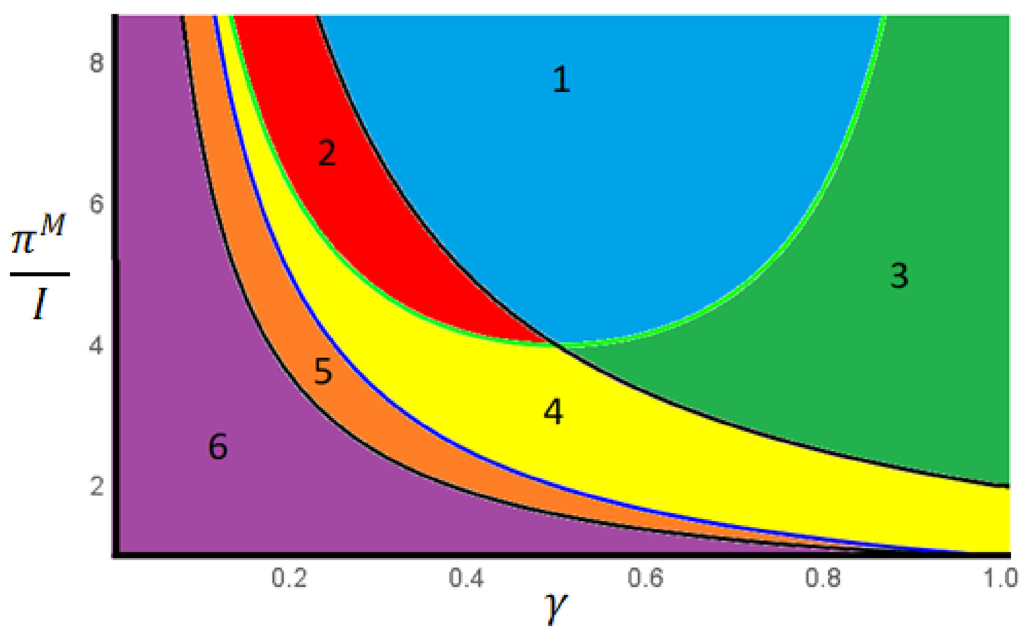
We assume that when the aggregate state is high, the monopolistic profit to investment ratio is high enough to incentivize entry by both bankers regardless of whether there is an interbank market or not ($\frac{\pi_H^M}{I} > \max\{\frac{1}{\gamma(1-\gamma)}, \frac{2}{\gamma}\}$). There are four possible realizations of the liquidity shocks. In all, but one state, the aggregate welfare does not change with bankers' ability to trade with each other. The interbank market matters when both bankers enter the market for business loans and both receive a positive liquidity shock. With interbank market they collude. Without interbank market they compete. Competition results in the first-best allocations with the total consumption given in equation (TC Social Planner). The total consumption in case of collusion is given by equation (55). When interbank market facilitates collusion, the welfare loss relative to the perfect competition case is given by equation (56). Taking into account the probability that both bankers are matched with the households (γ^2) and the welfare loss in this state of the world, we can compute the expected change in total consumption from opening an interbank market when the aggregate state is high

$$\Delta TC_H = TC_H^w - TC_H^{wo} = -\gamma^2 \frac{(pR_H^P - (1-p)c - \overline{R})^2}{8} = -\gamma^2 \frac{(\omega_H^{SP})^2}{8} < 0 \tag{26}$$

where TC_H^w is the expected total consumption with itnerbank market and TC_H^{wo} is the expected total consumption without interbank market. We conclude, that conditional on the high state interbank market reduces welfare because of collusion.

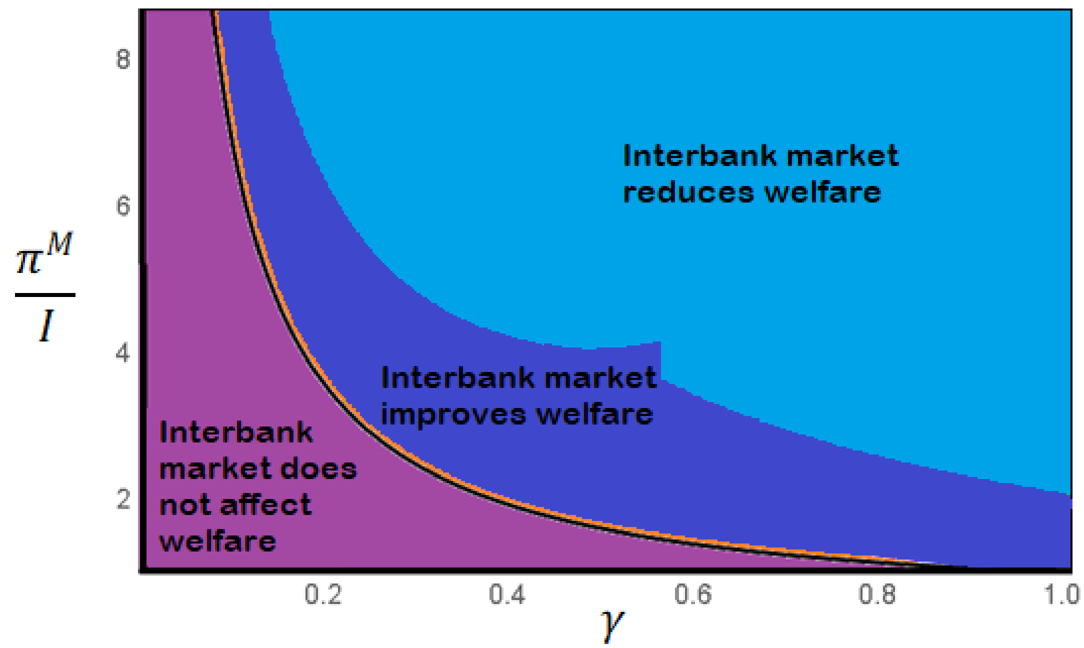
5.5.2 The effect of the interbank market on welfare in the low state

Figure 4: **Six regions describing bankers' entry decisions**



We compute the expected welfare effect of having an interbank market when the aggregate state is low. In this state, depending on the $\frac{\pi_L^M}{I}$ ratio, the endogenous entry decisions can be as follows: (1) $q = 1$, $q_{wo} = 1$, (2) $0 < q < 1$, $q_{wo} = 1$, (3) $q = 1, 0 < q_{wo} < 1$, (4) $0 < q < 1$, $0 < q_{wo} < 1$, (5) $0 < q < 1$, $q_{wo} = 0$ (6) $q = 0$, $q_{wo} = 0$, where q is the probability of entry if bankers can trade with each other (equation 13) and q_{wo} is the probability of entry if bankers cannot trade with each other (equation 25).[23] Figure 4 provides a visualization of the six regions.

Figure 5: **Effect of Interbank Market on Welfare**



Theorem 1.

i. There is a threshold function $T_1(\gamma)$, such that if $\frac{\pi_L^M}{I} > T_1(\gamma)$ then interbank market reduces welfare in the low state.

ii. There is a threshold function $T_2(\gamma)$, such that if $\frac{\pi_L^M}{I} < T_2(\gamma)$ then interbank market does not affect welfare in the low state.

iii. If $T_2(\gamma) < \frac{\pi_L^M}{I} < T_1(\gamma)$ then interbank market improves welfare in the low state.

where $T_1(\gamma) = \frac{1}{\gamma(1-\gamma)}$ when $0 \le \gamma < -1 + \frac{\sqrt{10}}{2} \approx 0.58$, $T_1(\gamma) = \frac{2}{\gamma}$ when $-1 + \frac{\sqrt{10}}{2} < \gamma \le 1$, and $T_2(\gamma) = \frac{2}{\gamma(3-\gamma)}$.

The results of the theorem are presented in Figure 5. The intuition is that when bankers enter with probability one (Case 1), collusion reduces welfare. The total surplus in case 2

[23] If $\gamma < 0.5$ then case (2) is feasible and case (3) is not. If $\gamma > 0.5$ then case (3) is feasible and case (2) is not.

with interbank market is lower than in case 1. Therefore, if interbank market reduces welfare in case 1, then it also reduces welfare in case 2. In the case 3, if γ above 0.58, interbank market reduces welfare, but if it is between 0.5 and 0.58 it increases welfare. That explains the kink in Figure 5 because case 3 effectively divided into two regions. In cases 4 and 5, interbank market improves welfare because there is more entry with interbank market. In case 6, the profits are too low to justify entry regardless of the interbank market. That is why in this region interbank market does not affect welfare in the low state. To sum up, the bottom region on the figure corresponds to case 6. The middle region combines part of case 3, and cases 4 and 5. The top region includes cases 1, 2 and part of case 3.

5.5.3 The ex-ante effect of interbank market on welfare

In this section we combine the results from the two previous subsections to study the effect of the interbank market on welfare prior to realization of the aggregate state.

Case 1. $\frac{\pi_L^M}{I} > \max\{\frac{1}{\gamma(1-\gamma)}, \frac{2}{\gamma}\}$. The change in consumption when interbank market is open in the low aggregate state (ΔTC_L) is computed similar to that in the high aggregate state (equation 26). The expected welfare loss prior to realization of the aggregate state is

$$E(\Delta TC) = \lambda \Delta TC_H + (1-\lambda)\Delta TC_L = -\lambda\gamma^2 \frac{(\omega_H^{SP})^2}{8} - (1-\lambda)\gamma^2 \frac{(\omega_L^{SP})^2}{8} < 0 \tag{27}$$

where $\Delta TC_L = TC_L^w - TC_L^{wo}$ is the difference in the total consumption with and without interbank market in the low aggregate state.

We conclude that the interbank market reduces expected welfare prior to the realization of the state because it reduces welfare in each of the two aggregate states.

Case 2. $\frac{1}{\gamma(1-\gamma)} < \frac{\pi_L^M}{I} < \frac{2}{\gamma}$ and $\gamma < \frac{1}{2}$. We combine results for each one of the states (equations 26 and 69) to get a formula for the ex-ante effect of interbank market on total consumpion

$$E(TC_L) = -\lambda\gamma^2 \frac{(\omega_H^{SP})^2}{8} + (1-\lambda)\left(\gamma(2-\gamma)(2+q^*(2-q^*)) - 4\gamma^2 - 6\gamma(1-\gamma)\right)\frac{(\omega_L^{SP})^2}{8} < 0 \tag{28}$$

Case 3. $\frac{2}{\gamma} < \frac{\pi_L^M}{I} < \frac{1}{\gamma(1-\gamma)}$ and $\gamma > \frac{1}{2}$. In this case, bankers enter with probability 1 when there interbank market and with probability $0 \le q_{wo} \le 1$ when there is no interbank market, where q_{wo} is given in equation (25). The expected difference in total consumption in the high state is given in equation 26. The difference in the low state is given in equation (72). We integrate out the aggregate state to compute the expected difference in consumption with and without interbank market:

$$E(\Delta TC) = -\lambda\gamma^2\frac{(\omega_H^{SP})^2}{8} + (1-\lambda)\left(-4+\gamma(2+\gamma)+\frac{6}{\gamma\frac{\pi_L^M}{I}}-\frac{2}{\gamma^2(\frac{\pi_L^M}{I})^2}\right)\frac{(\omega_L^{SP})^2}{8} \qquad (29)$$

If $-1+\frac{\sqrt{10}}{2} < \gamma \le 1$ restricting interbank trading will improve aggregate welfare because the total consumption without interbank market is higher both in the high and in the low states. If $0.5 < \gamma < -1+\frac{\sqrt{10}}{2}$, interbank market improves welfare in the low state, but reduces in the hgih state. Therefore, the effect of an interbank market on welfare depends on the probability of high aggregate state, probability of the liquidity shock and the difference between the project return in the high and low aggregate states.

Case 4. $\frac{1}{\gamma} < \frac{\pi_L^M}{I} < \min\{\frac{1}{\gamma(1-\gamma)}, \frac{2}{\gamma}\}$. To compute expected difference in total consumption, we combine the results from the high state (equation 26) and low state (equation 74)

$$E(\Delta TC) = -\lambda\gamma^2\frac{(\omega_H^{SP})^2}{8} + (1-\lambda)(q_w(2-q_w)\gamma(2-\gamma) - 2\gamma q_{wo}(2\gamma q_{wo}+1))\frac{(\omega_L^{SP})^2}{8} \qquad (30)$$

Given that we find that interbank market reduces welfare in the high state and improves welfare in the low state, the ex-ante effect on welfare depends on the probability of the high state, the probability of a liquidity shock, and the difference in project returns across the states.

Case 5. $\frac{2}{\gamma(3-\gamma)} < \frac{\pi_L^M}{I} < \frac{1}{\gamma}$. Combining the expected welfare loss from the presence of an interbank market in the high aggregate state due to collusion (equation 26) and the low state (equation 76) we can derive the expected difference in consumption before the realization of the aggregate state

$$E(\Delta TC) = -\lambda\gamma^2\frac{(\omega_H^{SP})^2}{8} + (1-\lambda)q(2-q)\gamma(2-\gamma)\frac{(\omega_L^{SP})^2}{8}) \qquad (31)$$

Whether an interbank market is beneficial or not depends on the probability of the high state, the probability of a liquidity shock conditional on entry, the monopolistic profits to investment cost in the low aggregate state, and on the difference in the project returns between a high and low state.

Case 6. $\frac{\pi_L^M}{I} < \frac{2}{\gamma(3-\gamma)}$. In the low state, there is no entry with and without interbank market. Therefore, the difference in the expected total consumption depends solely on the difference in total consumption in the high state.

$$E(\Delta TC) = \lambda \Delta TC_H = -\lambda\gamma^2 \frac{(\omega^{SP})^2}{8} \tag{32}$$

It means that the interbank market reduces welfare from the ex-ante perspective.

5.6 Calibration

In Table 2, we provide summary statistics for global sample of syndicated loans. From this table we learn that approximately 1% of loans ($239 billion of loans) are potentially colluded (collusion dummy is one). In the whole sample of almost 108 thousand loans, 32% of these loans were intermediated (chain dummy is one). In this subsection, we show that our stylized model is able to generate similar ratios of colluded loans to total loans and of intermediated loans to total loans.

First, we provide formulas for each one of the observed (or unobserved) quantities. The empirical moments are conditional on loans that have been provided. There are two reasons in our model for a loan not to be provided. Either at least one banker invested in the monitoring technology, but none of the bankers had liquidity, or at least one of the bankers had liquidity, but none of the bankers invested in the technology. The second option is only possible in the market with loans that have low project returns, as both bankers invest in the monitoring technology in markets with high returns. Formally, the fraction of loans that are not provided (call it $\mu_{\text{no lending}}$) is given by

$$\mu_{\text{no lending}} = \lambda(1-\gamma)^2 + (1-\lambda)\left((1-\gamma)^2 + (1-(1-\gamma)^2)(1-q^*)^2)\right) \tag{33}$$

The fraction of loans that are provided is $1-\mu$. These loans are of three types: colluded, intermediated and direct lending. The fraction of colluded loans (μ_{colluded}) among all provided loans is

$$\mu_{\text{colluded}} = \frac{\lambda\gamma^2 + (1-\lambda)\gamma^2(q^*)^2}{1-\mu_{\text{no lending}}} \tag{34}$$

The fraction of intermediated loans ($\mu_{\text{liquidity}}$) among all provided loans is

$$\mu_{\text{liquidity}} = \frac{2\lambda\gamma(1-\gamma) + (1-\lambda)\left(2\gamma(1-\gamma)q^* + 2\gamma^2 q^*(1-q^*)\right)}{1-\mu_{\text{no lending}}} \tag{35}$$

The fraction of colluded loans (equation 34) and intermediated loans for liquidity sharing (equation 35) are a non-linear function of three parameters: fraction of markets with high returns (λ), probability of that a given banker is matched with households (γ) and probability of entry into the business loans market in the low aggregate state (q^*). This probability is provided in equation (13) and by itself depends on γ and monopolistic profits in the market with low project returns ($\pi_\eta^M(R_L^P)$).

We find that the following parameter values allows us to match perfectly the empirical moments of the fraction of colluded loans and intermediated loans: $\lambda = 0.1$, $\gamma = 0.068$, and $q^* = 0.33$. It implies that nine out of ten loans are low profitability. Each banker is able to monitor loans in these markets approximately one third of the time. The calibrated model suggests that a substantial number of loans are not extended, but this is mostly driven by the liquidity shortages rather than bankers' inability to monitor.

The calibrated parameters imply a profitability to investment ratio that corresponds to Case 5 in section 5.5. In this case, there is a welfare loss from the interbank market in the high aggregate state and there is welfare benefit in the low state. The expected welfare loss from the interbank market is given in equation 31.

We find that if $\frac{\pi_H^M}{\pi_L^M} < 137.58$ then the interbank market improves welfare. If this ration is below the threshold, then the interbank market reduces welfare. This calculation is from the ex-ante perspective, before the aggregate state is realized, before bankers decided whether to acquire monitoring technology, before households match with bankers, and before project returns are realized. Monopolistic profits in each state depend on the project returns, cost of monitoring, probability of project's success, and the risk-free rate.

5.7 Policy Implications

The analysis in the previous section sheds light on the dark side of interbank trading. The existing policy focuses on interbank linkages as potential facilitators of financial contagion. If one bank fails, it can cause its trading partners to fail as well. As a result, several policies were introduced to limit the risk of contagion. First, capital and liquidity requirements forced banks to improve their ability to absorb a failure of a counterparty. Second, limitations were put into place to restrict an exposure to a single counterparty. Third, some type of interbank transactions were novated to central counterparty (CCPs). In general, regulation implicitly assumes that interbank trading is needed for efficient allocation of resources in the economy, but the same trading increases fragility of the banking system. After the financial crisis, regulators around the world expressed preference towards higher stability, presumably sacrificing some efficiency.

Our main insight is to show that the trade-off between efficiency and stability is not fundamental. We provide a simple example where restrictions on trading in the interbank market increase welfare. Our empirical analysis suggests that interbank trading can result in collusion. It means that restricting interbank trading can both improve stability and increase efficiency at the same time. In section 5.6, we calibrate the model using the empirical moments in the syndicated loans market. The calibrated model suggests that the profitability in the low aggregate state is such that with interbank market there is some entry by banks, but without interbank market there would be no entry. It means that in the high aggregate state interbank market reduces welfare because of collusion, but in low aggregate state it increases welfare.

The policy implication of our model is that welfare benefits of interbank trading should not be taken for granted, especially when two banks are competitors. Given the enormous size of global and local interbank markets, even a small fraction of loans used to reduce competition could amount to a non-negligible welfare loss. This post-entry welfare loss from collusion are mitigated because collusion incentivizes banks' entry.

Our model also speaks to the benefits of the usury laws that limit the interest rate on business loans and lines of credit. Most states in US have some type of usury laws in place. The limits can depend on the type of a financial institution and on the type of the loan. The maximum interest caps also differ across the states. In the model, the interest rate on the loans to entrepreneurs is higher in the decentralized economy with interbank markets than in the planner's solution. The planner's solution tells us what should be the cap on the interest rate to increase the total welfare. This cap, however, works only when there is enough liquidity to provide socially optimal amount of loans. If liquidity is scarce, the planner's solution would adjust the interest rate to make sure that entrepreneurs with low outside option get their projects financed. The fact that the optimal caps depend on liquidity can make usury laws with static caps ineffective in addressing the collusion problem.[24]

While there are no simple solutions to deal with collusion in provision of loans, we believe the fundamental idea how interbank trading allows banks to commit not to compete goes beyond interbank lending markets. In section OA.1 of the Online Appendix, we extend the analysis to show that our collusion mechanism also applies to the interbank markets for swaps and derivatives. These markets are even larger than markets for interbank loans.[25] From the policy perspective, it suggests that a holistic solution to the collusion problem is needed so that it addresses this problem for different types of interbank markets.

6 Conclusion

Banks compete in the markets for business loans and at the same time provide loans to each other. We build the simplest possible model (with two banks and one loan market) to show how interbank trading can reduce interbank competition. We evaluate the predictions of our model by relying on syndicated loans data.

[24]Benmelech and Moskowitz (2010) use state-level variation in usury laws to show that binding usury law constraints reduce credit and economic activity, especially for smaller firms.

[25]According to BIS report, the notional of all derivatives contracts was $595 trillion at the end of H1 2018, with a market value of $10 trillion. Source: https://stats.bis.org/statx/srs/table/d5.1.

The main result of the paper is to show that trade in the interbank market can be used to help bankers to collude. As a result, aggregate welfare in the economy with an interbank market can be smaller than without the interbank market. This is a surprising result because we would expect that opening more opportunities to trade would help banks to allocate liquidity or risk more efficiently, so it should not reduce welfare. The intuition for this result is that the interbank lending market helps banks to commit not to compete in the market for loans. When one competitor provides an interbank loan to another competitor, it limits its capacity to compete in the loan market. Once the borrower becomes the only bank with resources, it sets a monopolistic level of lending that maximizes its profits. The monopolistic profits can then be split between the banks. The interest on the interbank loan can then be used to compensate the interbank lender.

We derive empirical predictions from the model and test them using data about global syndicated loans. We find that the spread on a corporate loan indeed increases for firms that borrow from banks that have an outstanding loan with another bank and this other bank has lent to the firm in the past. In other words, when two competitor banks lend to each other, it increases firms' cost of capital. This increase in the interest rate on the loan is economically significant. It is quantitatively equivalent to the difference in interest rates paid by BBB rated versus A rated borrowers.

While only $239 billion out of $34.5 trillion of corporate syndicated loans were provided by banks that borrowed from competitors, the syndicated loans are only a fraction of the global interbank lending, which includes unsecured loans, repo loans, non-syndicated loans, etc. It is plausible that we capture only a small fraction of business loans that are affected by collusion facilitated by interbank lending. Our model predicts that collusion can happen for derivatives and swap products as well. Given that interbank markets for these markets are even larger than markets for interbank lending, the empirical results based on the syndicated loans market are only an early indicator of a broader problem.

On the normative side, the model delivers several policy implications. First, it implies that putting restrictions on interbank exposures might not only improve financial stability, the usual argument for such regulation, but also it can induce bank competition leading to increased lending and welfare. While the benefits of interbank lending, as a mechanism to allocate liquidity efficiently, are relatively well understood, we encourage policy makers to be open to the possibility that not all interbank lending is beneficial. Second, our model provides justification for usury laws that put limitations on the interest rate charged by lenders. The benefit of usury laws over restrictions on interbank lending are that interbank trading could be used for welfare-increasing trades between banks with excess funds to banks with investment opportunities. The downside of the usury laws is that the optimal cap depends on the availability of resources.

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7 Appendix

7.1 Tables

Table 1: Variable Definition

Variable	Units	Definition	Source
Collusion	Dummy	One if the lead bank borrowed from a competing bank at the time of loan, the firm did not have any outstanding loan with the competing bank at the start time of the current loan, but had repaid another loan to the competing bank within five years.	Uses DealScan data
Chain	Dummy	One if the lead bank borrowed from another bank at the time of loan, the firm neither had any outstanding loan with the other bank at the start time of the current loan, nor had repaid another loan to the other bank within five years.	Uses DealScan data
Interbank spread		Weighted average of all-in-drawn for outstanding loans borrowed by lead bank(s) from counterparty bank(s) during the entire sample history up to the time of the business loan origination.	Uses DealScan data
Interbank link		Number of times either the lead bank borrowed in the past from the lender it owns money to at the time of the business loans origination, or vice versa, during the entire sample history up to the time of the loan.	Uses DealScan data
`Endogenous variables`			
All-in-drawn spread	Basis points	Describes the amount the borrower pays in basis points over LIBOR for each dollar drawn down. It adds the spread of the loan with any annual (or facility) fee paid to the bank group.	DealScan
`Borrower Characteristics`			
Public	Dummy	One if the borrower is a publicly traded company, zero otherwise	Compustat
Relationship	Dummy	One if over the past five years the same lead bank arranged other loans for the same borrower in the past five years, zero otherwise	DealScan
First time borrower	Dummy	One if a firm did not have a syndicated loan before, zero otherwise	DealScan
Sales at close	Millions USD	Borrower's sales at the loan origination	DealScan
Log(Sales at close)		Natural logarithm of *Sales at close*	DealScan
Assets	Millions USD	Total assets	Compustat
Log(Assets)		Natural logarithm of *Assets*	Compustat
Leverage		Total Liabilities as a fraction of Total Assets	Compustat
ROA		Operating Income Before Depreciation as a fraction of average Total Assets based on most recent two periods	Compustat
`Contract characteristics`			
Facility amount	Millions USD	Size of the facility at the loan origination date	DealScan
Log(Facility amount)		Natural logarithm of *Facility amount*	DealScan
Maturity	Months	Maturity of the facility	DealScan
Collateral	Dummy	One if the loan is secured, zero otherwise	DealScan

Table 2: Descriptive Statistics

Panel A: Full Sample

	Mean	StDev	p10	p50	p90	Obs.
Interbank Characteristics						
Collusion Dummy	0.01	0.11	0	0	0	107,605
Chain Dummy	0.32	0.47	0	0	1	107,605
Interbank link	319	343	13	195	899	35,685
Interbank spread	107	119	25	50	250	31,409
Loan Characteristics						
All-in-drawn	259	174	70	225	475	103,582
Facility amount (mm USD)	257	684	10	80	600	107,566
Maturity	55	28	13	60	84	102,733
Collateral	0.85	0.36	0	1	1	64,923
Firm Characteristics						
Public	0.36	0.48	0	0	1	92,413
Previous lending relationship	0.37	0.48	0	0	1	107,605
First time borrower	0.39	0.49	0	0	1	107,605
Sales at close (mm USD)	3,662	20,255	63	530	6,881	56,862
Assets (mm USD)	9,285	72,101	104	1,025	13,982	53,458
Leverage	0.40	4.84	0.06	0.33	0.66	53,304
ROA	0.12	0.49	0.04	0.13	0.24	50,747

Panel B: Benchmark Regression Sample

	Mean	StDev	p10	p50	p90	Obs.
Interbank Characteristics						
Collusion Dummy	0.01	0.11	0	0	0	13,560
Loan Characteristics						
All-in-drawn	220	150	50	200	400	13,560
Facility amount (mm USD)	557	1,079	50	270	1,250	13,560
Maturity	54	23	12	60	84	13,560
Collateral	1	0	0	1	1	13,560
Firm Characteristics						
Public	0.62	0.49	0	1	1	13,560
Previous lending relationship	0.57	0.50	0	1	1.00	13,560
First time borrower	0.10	0.30	0	0	0.50	13,560
Sales at close (mm USD)	5,158	17,320	236	1,605	11,079	13,560
Assets (mm USD)	10,639	76,870	398	2,111	16,657	13,560
Leverage	0.43	0.28	0.16	0.39	0.74	13,560
ROA	0.14	0.08	0.06	0.13	0.23	13,560

Table 3: Main results

This table reports regression results of `All-in-drawn loan spreads` on `Collusion Dummy` and controls. `Collusion dummy` equals one if the lead bank borrowed from a competitor at the time of the loan. The rest variables are defined in Table 1. S&P rating FEs comes from Standard & Poor's long-term issuer credit rating. Dependent variable and all regressors except dummy and categorical variables are winsorized at the 1% and 99% levels. Robust standard errors are clustered by bank. *, ** and *** denote p-values less than 0.1, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Collusion Dummy	32.44***	40.16***	36.77***	39.26***	39.57***	33.40***	31.26***
	(8.036)	(12.37)	(11.11)	(10.43)	(10.50)	(10.20)	(10.16)
Public		-18.84***	-15.08***	-9.194***	-8.910***	-6.389***	-5.321**
		(3.475)	(2.691)	(2.510)	(2.497)	(2.415)	(2.167)
Relationship		-11.02***	-10.91***	-4.034	-3.980	-3.321	-1.476
		(3.052)	(3.005)	(2.668)	(2.657)	(2.451)	(2.365)
First time borrower		0.244	6.945	4.740	4.908	5.866	5.072
		(4.975)	(4.453)	(4.164)	(4.240)	(4.000)	(3.898)
Log(Sales at close)		-6.789***	-8.395***	-6.639***	-6.488***	-5.617***	-4.440***
		(1.872)	(1.874)	(1.627)	(1.649)	(1.459)	(1.310)
Log(Assets)		19.49***	11.61***	11.04***	10.92***	8.086***	8.208***
		(2.245)	(2.229)	(2.110)	(2.115)	(1.989)	(1.952)
Leverage		7.734	9.353	18.46***	19.36***	11.42*	9.153
		(7.388)	(7.063)	(6.642)	(6.634)	(6.599)	(6.779)
ROA		-54.59***	-60.58***	-97.27***	-96.53***	-94.68***	-81.21***
		(21.01)	(17.77)	(18.25)	(18.22)	(17.94)	(17.88)
Log(Facility amount)		-13.23***	-14.17***	-15.30***	-15.39***	-16.47***	-14.30***
		(2.413)	(2.015)	(1.904)	(1.920)	(1.638)	(1.434)
Maturity		-0.0199	0.246***	0.0277	0.0302	-0.400***	-0.316***
		(0.0665)	(0.0641)	(0.0608)	(0.0608)	(0.0859)	(0.0777)
Collateral		75.05***	68.90***	56.57***	56.08***	48.02***	42.96***
		(6.632)	(6.875)	(6.629)	(6.641)	(5.632)	(5.450)
Constant	257.5***	61.92***	250.2***	227.0***	285.3***	246.6***	156.1***
	(8.823)	(15.32)	(67.35)	(48.16)	(47.84)	(48.74)	(48.05)
S&P rating FEs	No	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	No	No	Yes	Yes	Yes	Yes	Yes
Loan Purpose FEs	No	No	No	Yes	Yes	Yes	Yes
Borrower Country FEs	No	No	No	No	Yes	Yes	Yes
Loan Type FEs	No	No	No	No	No	Yes	Yes
Lender FEs	No	No	No	No	No	No	Yes
Observations	103,582	13,560	13,560	13,560	13,560	13,560	13,560
Adj. R-squared	0.000	0.456	0.534	0.563	0.564	0.613	0.654

Table 4: Collusion vs. Intermediation Regression Results

This table reports regression results of `all-in-drawn loan spreads` on `collusion dummy` and controls. Each specification includes S&P rating FE, year FE, loan purpose FE, borrower country FE, loan type FE, and lender FE. Variables are defined in Table 1. Dependent variable and all regressors except dummy and categorical variables are winsorized at the 1% and 99% levels. Robust standard errors are clustered by bank. *, ** and *** denote p-values less than 0.1, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)
Collusion Dummy	32.13***	-2.788	31.50**	26.12*
	(10.50)	(14.96)	(15.25)	(15.60)
Chain Dummy	2.850	2.182	-2.033	-1.440
	(3.920)	(4.926)	(5.579)	(5.147)
Interbank spread collusion		0.245**		
		(0.101)		
Interbank spread chain		0.0225		
		(0.0361)		
Interbank two-way link collusion			0.0185	
			(0.361)	
Interbank two-way link chain			0.0132	
			(0.0104)	
Interbank one-way link collusion				0.331
				(0.709)
Interbank one-way link chain				0.0206
				(0.0174)
Public	-5.366**	-5.279**	-5.301**	-5.324**
	(2.178)	(2.242)	(2.167)	(2.180)
Previous lending relationship	-1.440	-1.764	-1.388	-1.321
	(2.372)	(2.344)	(2.369)	(2.362)
First time borrower	4.949	4.833	4.950	4.885
	(3.878)	(4.006)	(3.858)	(3.860)
Log(Sales at close)	-4.404***	-4.791***	-4.338***	-4.346***
	(1.318)	(1.337)	(1.305)	(1.307)
Log(Assets)	8.267***	8.779***	8.185***	8.165***
	(1.937)	(1.973)	(1.934)	(1.938)
Leverage	9.269	8.938	9.169	9.158
	(6.804)	(6.906)	(6.787)	(6.780)
ROA	-80.69***	-84.49***	-80.84***	-80.76***
	(17.78)	(17.91)	(17.72)	(17.73)
Log(Facility amount)	-14.17***	-14.22***	-14.13***	-14.09***
	(1.451)	(1.497)	(1.447)	(1.451)
Maturity	-0.312***	-0.319***	-0.312***	-0.314***
	(0.0772)	(0.0780)	(0.0767)	(0.0769)
Collateral	42.87***	42.36***	42.94***	42.99***
	(5.403)	(5.474)	(5.385)	(5.361)
Constant	155.4***	153.8***	155.8***	156.0***
	(47.82)	(48.31)	(47.73)	(47.73)
All FEs	Yes	Yes	Yes	Yes
Observations	13,560	13,251	13,560	13,560
Adj. R-squared	0.654	0.654	0.654	0.654

Table 5: Robustness Results

This table reports regression results of `all-in-drawn loan spreads` on `collusion dummy` and controls. The variables are defined in Table 1. Specification (1) includes pre-crisis subperiod (before 2007), (2) only includes post-crisis period (2010-2018), (3) includes only US borrowers, (4) includes only US lenders, (5) includes only loans to private firms, and (6) `collusion dummy` using a three-year gap instead of a five-year gap. Dependent variable and all regressors except dummy and categorical variables are winsorized at the 1% and 99% levels. Robust standard errors are clustered by bank. *, ** and *** denote p-values less than 0.1, 0.05 and 0.01, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Collusion Dummy	23.48**	67.44***	32.36***	30.98***	65.82***	20.98**
	(11.84)	(20.30)	(10.74)	(11.00)	(21.19)	(9.911)
Public	-2.906	-7.508*	-5.371**	-3.934*		-5.253**
	(2.364)	(3.804)	(2.187)	(2.195)		(2.174)
Previous lending relationship	-2.741	-0.758	-1.207	-1.176	-4.932	-1.658
	(2.863)	(4.758)	(2.435)	(2.407)	(5.578)	(2.377)
First time borrower	-1.333	22.04	3.904	5.686	11.14	4.783
	(4.222)	(14.02)	(3.836)	(4.127)	(7.361)	(3.884)
Log(Sales at close)	-2.126	-12.42***	-4.554***	-4.537***	-3.145	-4.416***
	(1.630)	(2.200)	(1.335)	(1.395)	(1.993)	(1.311)
Log(Assets)	9.854***	8.521**	8.681***	10.37***	6.136**	8.139***
	(2.052)	(3.529)	(1.949)	(2.120)	(2.647)	(1.951)
Leverage	17.61**	-17.35*	10.07	8.666	4.296	9.013
	(7.176)	(9.956)	(6.677)	(6.905)	(9.574)	(6.774)
ROA	-111.6***	-25.58	-83.12***	-85.03***	-115.7***	-81.65***
	(16.35)	(38.13)	(18.75)	(19.55)	(33.99)	(17.93)
Log(Facility amount)	-16.30***	-7.910***	-14.60***	-14.96***	-17.27***	-14.37***
	(1.508)	(2.066)	(1.427)	(1.539)	(1.758)	(1.443)
Maturity	-0.483***	0.567**	-0.322***	-0.399***	-0.134	-0.318***
	(0.0925)	(0.257)	(0.0774)	(0.0741)	(0.139)	(0.0777)
Collateral	59.95***	-6.457	44.07***	41.12***	62.10***	42.87***
	(4.026)	(9.235)	(5.492)	(5.831)	(8.215)	(5.439)
Constant	144.9***	494.4***	143.7***	501.1***	111.3***	157.0***
	(48.03)	(30.96)	(46.68)	(30.83)	(41.55)	(48.09)
S&P rating FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Loan Purpose FEs	Yes	Yes	Yes	Yes	Yes	Yes
Borrower Country FEs	Yes	Yes	No	Yes	Yes	Yes
Loan Type FEs	Yes	Yes	Yes	Yes	Yes	Yes
Lender FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,482	3,677	13,058	11,619	5,182	13,560
Adj. R-squared	0.659	0.692	0.656	0.663	0.625	0.653

7.2 Proofs

Proof of Proposition 1. To proof this proposition, we solve the planner's problem. The roadmap for the proof is as follows. First, we solve for the optimal deposit rate. Then we solve for the interbank loan price and quantity. Finally, we solve for the level of lending and the interest rate on bank loans.

Households will agree to provide funds to the banker if $R^D \geq \overline{R}$. The banker will set R^D to be equal to $\overline{R} = 1$. It guarantees that $D_i = \overline{D_i}$ for both bankers.

To determine f and F, we proceed as follows. First, we will solve for B that maximizes the joint profits of the bankers. Then we solve for F given f.

The joint profits of the bankers are the highest when there is no competition and one of the bankers is a monopolist. Any level of competition will reduce the joint profits. Without loss of generality, let banker A to be the monopolist in the market for business loans. So the key question is what level of $f > 0$ would assure that banker A is the monopolist. If banker B does not have resources to lend to entrepreneurs, then banker A will be a monopolist. Banker B has $D = \overline{D}$ level of deposits. Therefore, $f = \overline{D}$ is the unique solution that maximizes the joint profits of two bankers.[26] With this loan, banker A has $2D = 2\overline{D}$ funds to lend to entrepreneurs and banker B has zero.

The next step is to compute the optimal level of lending by banker A and the amount of monopolistic profits (π^M_η) that this level of investment generates. The monitoring strategy and the reporting strategy are such that entrepreneurs report truthfully and bankers monitor when the report says that the project failed.

The repayment of the loan (F) by banker A to banker B depends on (π^M_η). Without the loan ($f = 0$), both banks compete and receive zero profits (see section 5.3). With the loan ($f = D$), they jointly generate the monopolistic profit π^M_η, collected by banker A. Therefore,

[26] If banker B keeps some of the resources, she will have incentives to lend them to entrepreneurs at a rate slightly below the monopolistic rate charged by banker A. This will result in a smaller joint profit of banker B and banker A relative to the case when $f = \overline{D}$.

the surplus from trade (joint profits minus outside options) is equal to π^D. Assuming banker B's bargaining power is $\theta \in [0,1]$, $F = f + \theta\frac{\pi_\eta^M}{2}$, which means that the "interest" on the interbank loan reflects part of the profit generated by the lack of competition. Conceptually, banker B commits not to compete with banker A by lending her the available resources. With restricted lending capacity, the competition disappears and both bankers benefit.

Next, we calculate π_η^M by solving the problem of banker A when she is a monopolist with $2\overline{D}$ funds to be allocated between loans and the risk-free storage. Given our assumption that $\overline{D} \geq \omega^{SP}$, it is obvious that the addition funds from banker B are not needed to provide the optimal level of investment. These funds are deposited at the risk-free storage by banker A. Banker A will also deposit her own excess deposits at the risk-free storage after she first uses the funds to provide monopolistic level of business loans. She chooses a gross interest rate on business loans (R) to maximize:

$$\max\left\{\left[pR - (1-p)c\right]\ell + \overline{R}(D-\ell) - \overline{R}D\right\}. \tag{36}$$

where ℓ, is the supply of loans to entrepreneurs.[27]

The demand for loans is determined by the entrepreneurs' decision between investing and the outside option. An entrepreneur of type ω chooses to take out a loan from banker B if and only if

$$p \cdot \left(R^P - R\right) \geq \omega. \tag{37}$$

Hence all entrepreneurs with $\omega \leq \omega_i^* = p \cdot \left(R^P - R\right)$ demand for loans from banker A is given by

$$L^d = p \cdot \left(R^P - R\right) \tag{38}$$

Notice, the demand is decreasing with the interest on the loan.

Market clearing requires: $\ell = L^d$.

Now, we can express R as a function of ℓ. Rearranging, $\ell = p \cdot \left(R^P - R\right)$, we get $R = R^P - \frac{\ell}{p}$. Next, we substitute it into banker's optimization problem (36) and after

[27] We drop the subscript because only one bank provides the loans.

dropping constants we get:

$$\max\left\{\left[pR^P-(1-p)c-\ell\right]\ell-\overline{R}\ell\right\}. \tag{39}$$

The FOC with respect to ℓ gives us:

$$\left[pR^P-(1-p)c-2\ell\right]-\overline{R}=0 \tag{40}$$

From that we get:

$$\ell^*=\frac{pR^P-(1-p)c-\overline{R}}{2} \tag{41}$$

Now, we can compute the loan rate that results in this level of lending.

$$R^*=\frac{R^P+((1-p)c+\overline{R})/p}{2} \tag{42}$$

With this interest rate on the business loans to entrepreneurs, the monopolisitc profit from lending is:

$$\pi_\eta^M=\frac{\left(pR^P-(1-p)c-\overline{R}\right)^2}{4} \tag{43}$$

Then, the repayment of the interbank loan is:

$$F=f+\theta\pi_\eta^M=D+\theta\frac{\left(pR^P-(1-p)c-\overline{R}\right)^2}{4} \tag{44}$$

□

Proof of Proposition 2. First, we start by simplifying the objective function by noticing that payments between entrepreneurs and a banker are simply transfers. They cancel out of the objective function because both agents are risk-neutral. Of course, they can affect other constraints which impact the objective. Notice that payments between households and a banker (R^D) are also transfers, but they do not cancel out of the objective function because households are risk-averse and a banker is risk-neutral.

Second, given that the entrepreneurs are risk-neutral, they care only about the expected payoff and not about the transfer in each state. On the other hand, the state-contingent transfers are important for the incentive compatibility constraint because they change the incentives to misreport the outcome of the project. The feasibility constraint states that $\tau_f(\omega)$ cannot be positive. For any ω, as the $\tau_f(\omega)$ becomes more negative, the higher is the incentive to lie about the state of the project. Therefore, the planner would set $\tau_f(\omega)=0$

for all ω to reduce incentives to lie that the project failed.

Third, given that the investment in the project is not scalable, a banker cannot use investment quantity as part of the mechanism. The mechanism is restricted to EOP transfers for one unit of investment at the BOP. If the transfers were to depend on the unobservable type (ω), entrepreneurs would always report a type that minimizes the transfer. Therefore, to get truthful reporting, the planner needs to set the transfer not to depend on type. The incentive compatibility constraint (IC Type) for revealing the true ω is satisfied if τ_σ does not depend on ω.

If τ_s is independent of ω and $\tau_f = 0$, then the left hand side of (PC ENT) is independent of ω, while the right hand side is an increasing function of ω, so there is a single crossing point $\omega^{SP} \in [0, M]$ such that[28]

$$p \cdot \left(R^P - \tau_s\right) = \omega^{SP} \tag{45}$$

and for all $\omega \leq \omega^{SP}$, we have $\mathbf{1}_\omega(\sigma) = 1$ while $\omega > \omega^{SP}$ we have $\mathbf{1}_\omega(\sigma) = 0$. All entrepreneurs with $\omega > \omega^{SB}$ will not invest and all entrepreneurs with $\omega < \omega^{SB}$ will invest. We can use this threshold property of the optimal contract to simplify the objective function. Specifically, instead of the indicator function $\mathbf{1}_\omega$, which indicated for each entrepreneur whether he gets funding or not, now we have two groups of entrepreneurs: those below the threshold outside option and those above the threshold.

We can use equation (45), we can compute the transfer from an entrepreneur to the banker (τ_s) that implements planner's level of investment (ω^{SP}).

$$\tau_s = R^P - \frac{\omega^{SP}}{p} \tag{46}$$

The planner will choose that the banker always monitors an entrepreneur who reports a failed project ($h_f^{SP} = 1$). There is no need to monitor if the report is that the project succeeded ($h_s^{SP} = 0$). This monitoring strategy assures that both IC constraints (IC Success and IC Failure) are satisfied with inequality and are not binding.

[28] We assume that R^P is such that the crossing point does not exceed M.

We simplified the problem of the planner to choose R^D, τ_s and ω^{SB}. Using the threshold property, and canceling transfers we can write the objective as

$$\int_{\omega^{SP}}^{M} \omega d\omega + \int_{0}^{\omega^{SP}} \left[p \cdot R^P - (1-p)c\right] d\omega + \left[D - \int_{0}^{\omega^{SP}} d\omega\right] \overline{R} - DR^D + Dlog(R^D) + (\overline{D} - D)log(\overline{R}). \quad (47)$$

We start with analysis of the optimal R^D. To satisfy households' participation constraint R^D should be at least equal to the risk-free return. The planner will not want to set R^D higher than $\overline{R}$ because households' marginal utility from consumption is decreasing so any surplus transfer from a banker to a household results in a reduction in the aggregate welfare. It is easy to see it when we differentiate the objective function with respect to R^D: $-D + \frac{D}{R^D} = 0$. Solving for optimal R^D, without accounting for constraints, we get that the planner would want to set $R^D = 1$, which is the same as the risk-free return $\overline{R}$. Bankers play a role of intermediaries in the model because they are able to diversify idiosyncratic risk and offer risk-free deposits to risk-averse households like in Diamond (1984).

This optimal choice of the deposit rate might not be feasible because of the constraints. R^D enters only participation constraints of the households and the banker. The participation constraint of households is satisfied with equality when $R^D = \overline{R}$ because of the assumption that $\overline{R} = 1$.[29] The participation constraint of the banker is not binding when $R^D = \overline{R}$ because the banker also has access to the risk-free storage technology.

For $R^D = \overline{R} = 1$, households are indifferent between storing their endowment at the risk-free storage technology or providing the funds to banker as a deposit, so according to our assumption they make the deposit at the offered rate. Therefore, $D = \overline{D}$, meaning that resources of all matched households become available to the banker. We assume that these funds are sufficient to provide socially optimal investment, therefore the feasibility constraint (RF BOP) is not binding.[30]

Next, we solve for the optimal level of investment in the projects. We simplify the

[29] If the return on the risk-free technology was above 1, the planner would set $R^D = \overline{R}$ because the participation constraint would be binding.

[30] Our goal is to show that bankers undersupply loans in the decentralized economy. If both the planner's solution and the decentralized solution undersupply loans because banker's resources are limited, it would not be surprising.

objective function (47) further by dropping constants:

$$-\frac{\left(\omega^{SP}\right)^2}{2} + (pR^P - (1-p)c)\omega^{SP} - \overline{R}\omega^{SP}. \tag{48}$$

The objective is strictly concave in ω^{SB} (due to the presence of the negative quadratic term). Intuitively, the entrepreneur's outside option is part of the marginal cost of making a loan and which is increasing.[31] The first order condition with respect to ω^{SP} is given by

$$-\omega^{SP} + pR^P - (1-p)c - \overline{R} = 0 \tag{49}$$

The FOC states that at the optimal amount of funds provided for projects, the marginal benefit of higher investment (pR^P) is equal to the marginal cost of taking the project: the expected monitoring cost, the outside option of the entrepreneur (ω^{SP}) and of opportunity cost of the funds ($\overline{R}$). As we noticed earlier, ω^{SP} is both the quantity of loans provided and the price of investing in the marginal project and foregoing the outside option.

Given our assumption that this a sufficient amount of deposits to fund loans, we can solve (49) for ω^{SP}:

$$\omega^{SP} = pR^P - (1-p)c - \overline{R}. \tag{50}$$

Now we can substitute (50) in (46) to compute the optimal transfer from the borrower to the banker if the project succeeds:

$$\tau_s = \frac{(1-p)c + \overline{R}}{p}. \tag{51}$$

This transfer makes the entrepreneur with ω^{SP} outside option indifferent between investing or not. All entrepreneurs with $\omega < \omega^{SP}$ have a strictly positive utility from investing. The banker is compensated for not using the risk-free technology, but her utility is zero because all the transfers from entrepreneurs are paid back to the depositors. Despite zero profits to the banker, the participation constraint (PC BK) and the EOP resource feasibility (RF EOP) are satisfied given the solution for ω^{SP} and τ_s.

We need to ensure that the optimal provision of loans does not exceed the feasible number

[31] The marginal cost to provide a loan from the social planner's perspective is constant.

of projects. That results in an upper bound on R^P:

$$\omega^{SP} = pR^P - (1-p)c - \overline{R} \leq M \iff R^P \leq \frac{M + (1-p)c + \overline{R}}{p}. \tag{52}$$

The last part of the proof is to compare the planner's solution and the decentralized solution (equation 1).

$$\frac{\omega^{SP}}{\ell^*} = \frac{pR^P - (1-p)c - \overline{R}}{(pR^P - (1-p)c - \overline{R})/2} = 2. \tag{53}$$

□

Proof of Proposition 3. We can compute the welfare loss from the lack of competition as the difference between the total surplus achieved by the planner and that of a decentralized market.

The total surplus in the decentralized solution with interbank trading is given by

$$\int_{\ell^*}^{M} \omega d\omega + \int_0^{\ell^*} \left[p \cdot R^P - (1-p)c - \overline{R}\right] d\omega \tag{54}$$

Substituting $\ell^* = \frac{pR_P - (1-p)c - \overline{R}}{2}$ we get:

$$\frac{M^2}{2} + \frac{3(pR^P - (1-p)c - \overline{R})^2}{8} \tag{55}$$

Therefore, the welfare loss is given by:

$$\frac{M^2}{2} + \frac{(pR^P - (1-p)c - \overline{R})^2}{2} - \left(\frac{M^2}{2} + \frac{3(pR^P - (1-p)c - \overline{R})^2}{8}\right) = \frac{(pR^P - (1-p)c - \overline{R})^2}{8} \tag{56}$$

□

Proof of Proposition 4. There are two thresholds on $\frac{\pi_\eta^M}{I}$ for entry in the decentralized solution. If $\frac{\pi_\eta^M}{I} < \frac{2}{\gamma(3-\gamma)}$ then there is no investment in the monitoring technology in the decentralized solution. If $\frac{\pi_\eta^M}{I} \geq \frac{2}{\gamma}$ then both bankers enter with probability one. The high state is characterized by entry by both banks with probability one, while the low state is when bankers enter with probability less than one.

There is a single thresholds on $\frac{\pi_\eta^M}{I}$ for entry in the planner's solution. If $\frac{\pi_\eta^M}{I} < \frac{1}{\gamma(2-\gamma)}$ then there is no investment in the monitoring technology in the decentralized solution. If $\frac{\pi_\eta^M}{I} \geq \frac{1}{\gamma(2-\gamma)}$ then one banker enters with probability one.

First, we show that the planner's threshold for entry is lower than the threshold for entry in the decentralized solution.

$$\frac{1}{\gamma(2-\gamma)} < \frac{2}{\gamma(3-\gamma)} \tag{57}$$

After we rearranging, we get a condition when inequality 57 holds

$$\gamma(1-\gamma) > 0 \tag{58}$$

This condition is satisfied for all $0 < \gamma < 1$. Therefore, when $\frac{1}{\gamma(2-\gamma)} < \frac{\pi_\eta^M}{I} < \frac{2}{\gamma(3-\gamma)}$, there is no entry in the decentralized solution, but there is an entry by one banker in the planner's solution.

When $\frac{2}{\gamma(3-\gamma)} < \frac{\pi_\eta^M}{I} < \frac{2}{\gamma}$, bankers enter with probability q^* given in equation 13. In means that there is $(1-q^*)^2 > 0$ probability that there is no banker that can monitor loans in the decentralized equilibrium in this range of parameters. In the same parameter region, the probability that there is no banker to monitor loans in the planner's solution is zero. This completes the proof of the first part of the proposition.

Second, in the high state both bankers enter. Given that $\frac{2}{\gamma(3-\gamma)} < \frac{2}{\gamma)}$ and $\frac{2}{\gamma(3-\gamma)} > \frac{2}{\gamma(3-\gamma)}$, we can conclude that there are two bankers that enter in the high state in the decentralizes solution and only one banker in the planner's solution. So there is too much entry in the decentralized solution, completing the proof of the second part of the proposition. □

***Proof of Proposition 5**.* The optimal monitoring decision in the decentralized solution is the same as in the planner's solution. With $c_1 = c_2$, both banks will verify project's outcome if a borrower reports a failed project. Given this verification strategy, borrowers will truthfully report failure. They do not have incentives to report success when the project fails because it will make them pay back the loan. They will not report failure when the project succeeds because they will be verified and found to be lying, requiring them to pay all the proceeds from the project. Bankers do not want to commit not to verify projects because it will result in false reports by entrepreneurs.

The allocations at the market for loans to entrepreneurs depend on the prices bankers charge. These prices will crucially affect the total surplus generated in the decentralized economy.

Bank i's problem is to choose R_i to maximize expected EOP profits. Bankers supply loans to meet demand for loans that they face given prices (R_i, R_{-i}).

Bank i's maximization problem is:

$$\max\left\{[pR_i - (1-p)c]\,\ell_i + \overline{D}S_i - \overline{R}D_i, 0\right\}. \tag{59}$$

where ℓ_i is the supply of loans by banker i. The BOP balance sheet identity for bank i is

$$S_i = D_i - \ell_i \tag{60}$$

Funds that were not invested in projects (S_i) are stored by the bankers in the risk-free storage technology. Market clearing for $i = \{1,2\}$ requires:

$$\ell_i = L_i^d \tag{61}$$

where L_i^d is demand for loans provided by banker i.

The borrower's problem is, given his realization of ω, to decide whether to borrow or choose the outside option and if to borrow, from whom. A borrower of type ω chooses to take out a loan if and only if

$$p \cdot \left(R^P - \min\{R_i, R_{-i}\}\right) \geq \omega. \tag{62}$$

Hence all borrowers with $\omega \leq \omega_i^* = p \cdot \left(R^P - \min\{R_i, R_{-i}\}\right)$ would want to invest, the loan demand from banker i is given by

$$L_i^d = \begin{cases} 0 & \text{if } R_i > R_{-i} \\ p \cdot \left(R^P - R_i\right) & \text{if } R_i < R_{-i} \\ p \cdot \left(R^P - R_i\right)/2 & \text{if } R_i = R_{-i} \end{cases} \tag{63}$$

In that case, bank i should choose $R_i \in [\frac{(1-p)c+\overline{R}}{p}, R_{-i}]$. Both banks have the same marginal cost of providing loans and they have enough lending capacity to meet demand of the whole market. Unique Nash equilibrium in pure strategies is:

$$R_i^* = \frac{(1-p)c + \overline{R}}{p} \text{ for i=\{1,2\}}. \tag{64}$$

When both bankers charge this rate, no banker can reduce it any further because it would lead to a loss. Increasing the rate would just result that the other bank provides all the loans. At the equilibrium rate, the aggregate demand for loans is given by

$$L^d = \int_0^{\omega_i^*} d\omega = \omega_i^* = p \cdot \left(R^P - (1-p)c - \frac{\overline{R}}{p} \right). \tag{65}$$

Each banker's demand is half of the aggregate demand (the bankers split the market). Both bankers make zero profits at this rate. Both the interest rate and the amount of lending is the same in the decentralized solution as in the planner's solution. It completes the proof. □

Proof of Theorem 1. To proof the theorem we compute the expected difference in total consumption with and without interbank market for each one of the six cases.

Case 1. $\frac{\pi_L^M}{I} > \max\{\frac{1}{\gamma(1-\gamma)}, \frac{2}{\gamma}\}$. The change in consumption when interbank market is open in the low aggregate state (ΔTC_L) is computed similar to that in the high aggregate state (equation 26). The expected welfare loss prior to realization of the aggregate state is

$$E(\Delta TC_L) = -\gamma^2 \frac{(\omega_L^{SP})^2}{8} < 0 \tag{66}$$

where $\Delta TC_L = TC_L^w - TC_L^{wo}$ is the difference in the total consumption with and without interbank market in the low aggregate state.

Case 2. $\frac{1}{\gamma(1-\gamma)} < \frac{\pi_L^M}{I} < \frac{2}{\gamma}$ and $\gamma < \frac{1}{2}$. In this case, bankers enter with probability 1 when there is no interbank market, and with probability $0 \leq q \leq 1$ when there is interbank market. Given that bankers play a mixed strategy, they are indifferent between entering and not entering because the expected consumption is the same. The expected consumption of the entrepreneurs increases with the probability of entry because without entry entrepreneurs consume their outside option. Therefore, the upper bound on the expected consumption of entrepreneurs and bankers in the low state with interbank market is given by the expected consumption when bankers enter with probability 1. We already computed the difference in aggregate consumption when bankers enter with probability 1 in Case 1 (equation 66). If interbank market reduces welfare in the low aggregate state in Case 1, and the expected total consumption in Case 2 is smaller than in Case 1, then it has to be that interbank market reduces welfare in Case 2 as well. The formula for the expected total consumption in the low state without interbank market is

$$E(TC_L^{wo}) = \left(4\gamma^2 + 6\gamma(1-\gamma)\right)\frac{(\omega_L^{SP})^2)}{8} + \frac{M^2}{2} \tag{67}$$

With probability γ^2, both bankers get liquidity and compete. The total consumption in this state is $\frac{(\omega^{SP})^2}{2} + \frac{M^2}{2}$ as we computed in equation (TC Social Planner). With probability $2\gamma(1-\gamma)$ only one banker will receive liquidity, in which case the total consumption is $3\frac{(\omega^{SP})^2}{8} + \frac{M^2}{2}$, which corresponds to the total consumption with monopolistic lending.

The expected total consumption in the low state with interbank market is

$$E(TC_L^{w}) = \gamma(2-\gamma)(2 + q^*(2-q^*))\frac{(\omega_L^{SP})^2}{8} + \frac{M^2}{2} \tag{68}$$

Given mixing, bankers expected consumption is the same as if they entered with probability one. With probability $1-(1-\gamma)^2$ at least one banker is matched with households and monopolistic lending generates consumption of $\frac{(\omega^{SP})^2}{4}$. Entrepreneurs' expected consumption is $\frac{(\omega^{SP})^2}{8}$ and it happens when at least one banker has liquidity and can monitor, which happens with probability $\gamma(2-\gamma)q^*(2-q^*)$.

Now, we can compute the difference in total consumption in the low state

$$E(TC_L) = \left(\gamma(2-\gamma)(2 + q^*(2-q^*)) - 4\gamma^2 - 6\gamma(1-\gamma)\right)\frac{(\omega_L^{SP})^2}{8} < 0 \tag{69}$$

Case 3. $\frac{2}{\gamma} < \frac{\pi_L^M}{I} < \frac{1}{\gamma(1-\gamma)}$ and $\gamma > \frac{1}{2}$. In this case, bankers enter with probability 1 when there interbank market and with probability $0 \le q_{wo} \le 1$ when there is no interbank market, where q_{wo} is given in equation (25).

The expected total consumption with interbank market is

$$E(TC_L^{w}) = \gamma(2-\gamma)\frac{3(\omega_L^{SP})^2}{8} + \frac{M^2}{2} \tag{70}$$

The expected total consumption without interbank market is equal to the expected consumption of entrepreneurs and bankers. Bankers are indifferent between entering and not, so their expected consumption must be the same. For the welfare calculation we use bankers' expected consumption if they enter with probability 1. In this case, they receive profit of $\frac{(\omega^2)^2}{4}$ with probability $2\gamma(1-\gamma)$, which is the probability that only one bank receives liquidity. The computation of the expected consumption of entrepreneurs requires to account for all 16 states because bankers play a mixed strategy equilibrium. However, only in seven states the consumption of entrepreneurs is positive. It happens when both bankers enter the market and at least one is matched with households (three states), when one banker enters and both bankers are matched with households (two states), when one banker enters and this banker is matched with households (two states). The surplus of entrepreneurs in six of these states is $\frac{(\omega^{SP})^2}{8}$, which corresponds to surplus with monopolistic level of lending. If both bankers enter and have liquidity, entrepreneurs receive a surplus from borrowing from competing banks of $\frac{(\omega^{SP})^2}{2}$. After integrating out over all the states and simplifying, we get that the expected consumption of entrepreneurs is $2\gamma q_{wo}(1+\gamma q_{wo})\frac{(\omega^{SP})^2}{8} + \frac{M^2}{2}$. The difference in the expected total consumption is given by

$$E(\Delta TC_L) = (3\gamma(2-\gamma) - 2\gamma q_{wo}(1+\gamma q_{wo}) - 4(\gamma(1-\gamma))\frac{(\omega_L^{SP})^2}{8} \tag{71}$$

We substitute solution for q_{wo} (equation 25) and simplify to get

$$E(\Delta TC_L) = (-4 + \gamma(2+\gamma) + \frac{6}{\gamma\frac{\pi_L^M}{I}} - \frac{2}{\gamma^2(\frac{\pi_L^M}{I})^2})\frac{(\omega_L^{SP})^2}{8} \tag{72}$$

Solving for $\frac{\pi_L^M}{I}$ suggests that we need to consider two cases: Case 3.1 in which $0.5 < \gamma < -1 + \frac{\sqrt{10}}{2} \approx 0.58$ and Case 3.2 in which $-1 + \frac{\sqrt{10}}{2} < \gamma$. In Case 3.1, $E(\Delta TC_L) > 0$ if $\frac{2}{\gamma} < \frac{\pi_L^M}{I} < \frac{2}{\gamma\left(3-\sqrt{1+2\gamma(2+\gamma)}\right)}$ and $E(\Delta TC_L) < 0$ if $\frac{2}{\gamma\left(3-\sqrt{1+2\gamma(2+\gamma)}\right)} < \frac{\pi_L^M}{I} < \frac{1}{\gamma(1-\gamma)}$. In Case 3.2, $E(\Delta TC_L) > 0$ if $\frac{2}{\gamma} < \frac{\pi_L^M}{I} < \frac{1}{\gamma(1-\gamma)}$.

Case 4. $\frac{1}{\gamma} < \frac{\pi_L^M}{I} < \min\{\frac{1}{\gamma(1-\gamma)}, \frac{2}{\gamma}\}$. In this case, bankers play a mixed strategy Nash equilibrium of the entry game regardless of the presence of an interbank market. If bankers play a mixed strategy it means they are indifferent between entering or not. If they don not enter, their joint consumption is $2I$ in case with and without interbank market. Given that the expected consumption of bankers is the same, the only difference in the expected aggregate welfare with and without interbank market depends on the consumption of the entrepreneurs.

With interbank market, when there is entry by at least one banker, entrepreneurs' consumption is given by

$$\int_0^{\frac{\omega_L^{SP}}{2}} p(R_L^P - R^*)d\omega + \int_{\frac{\omega_L^{SP}}{2}}^{M} \omega d\omega = \frac{M^2}{2} + \frac{(\omega_L^{SP})^2}{8} \tag{73}$$

where the monopolistic interest rate (R^*) on the business loans is given in equation (2) and $\omega_L^{SP} = pR_L^P - (1-p)c - \overline{R}$. In this calculation, we rely on the fact that a monopolist provides half the amount of loans provided by the social planner (equation 1). This level of entrepreneurs' consumption is achieved with probability $q_w(2-q_w)\gamma(2-\gamma)$, where q_w is the probability of entry with interbank market (equation (13).

Without interbank market, enterpreneur's consumption is the same as in equation (73) when only one banker has liquidity and this banker is also able to monitor. If both bankers can monitor and have liquidity, the perfect competition between them will result in planner's level of lending in which entrepreneurs receive $\frac{M^2}{2} + \frac{(\omega^{SP})^2}{2}$. The probability of perfect competition in the provision of loans is $\gamma^2 q_{wo}^2$, where q_{wo} is given in equation (25) and it represents the probability of entry without interbank market.

We substitute formulas for q_w and q_{wo} (equations 13 and 25 respectively) to study the welfare implications of the interbank market in the low aggregate state. After, we make this substitution and simplify, we get

$$E(\Delta TC_L) = (\frac{8 - \gamma\frac{\pi_L^M}{I}(-20 + 6\gamma - \gamma(-12 + \gamma(9 + (\gamma-4)\gamma))\frac{\pi_L^M}{I}}{(\gamma-2)\gamma^2(\frac{\pi_L^M}{I})^2})\frac{(\omega_L^{SP})^2}{8} \tag{74}$$

The expected welfare benefit from the interbank market in the low state exists when

$$\frac{-10\gamma + 3\gamma^2 + \sqrt{4\gamma^2 + 12\gamma^3 - 23\gamma^4 + 8\gamma^5}}{-12\gamma^2 + 9\gamma^3 - 4\gamma^4 + \gamma^5} < \frac{\pi_L^M}{I} < \frac{-10\gamma + 3\gamma^2 - \sqrt{4\gamma^2 + 12\gamma^3 - 23\gamma^4 + 8\gamma^5}}{-12\gamma^2 + 9\gamma^3 - 4\gamma^4 + \gamma^5} \tag{75}$$

If $\frac{2}{\gamma(3-\gamma)} < \frac{\pi_L^M}{I} < \frac{1}{\gamma}$ (Case 4) then the above condition holds. It implies that in Case 4, there is a welfare benefit in the low aggregate state from having an interbank market.

Case 5. $\frac{2}{\gamma(3-\gamma)} < \frac{\pi_L^M}{I} < \frac{1}{\gamma}$. In this case, there is no entry without interbank market and there is an entry with a positive probability when there is interbank market. The fact that bankers play a mixed strategy in the latter case means that their expected consumption is $2I$ as they are indifferent between entering and not entering. This is the same as the consumption of the bankers in case when there is no interbank market. Therefore, the difference in the expected aggregate consumption is equal to the difference in the expected consumption of the entrepreneurs. Without interbank market there is not entry the entrepreneurs take their outside option. Their consumption is $\frac{M^2}{2}$ in this case. With interbank market, entrepreneurs receive a monopolistic level of loans with probability $q(2-q)\gamma(2-\gamma)$, which is the probability that at least one banker enters the market and that at least one banker is matched with households. The probability of entry (q) is given in equation (13). Entrepreneurs' expected consumption conditional on entry is given by equation (73). The surplus created by the interbank market is that it induces entry by bankers and that in turn results in additional consumption by entrepreneurs. Combining the probability of the loans to entrepreneurs and the additional consumption created by these loans we get that the expected benefit of an interbank market in the low aggregate state is

$$E(\Delta TC_L) = q(2-q)\gamma(2-\gamma)\frac{(\omega_L^{SP})^2}{8} > 0 \tag{76}$$

Case 6. $\frac{\pi_L^M}{I} < \frac{2}{\gamma(3-\gamma)}$. When bankers do not invest in the monitoring technology, the aggregate consumption in the low state is like in autarky and it does not depend on the presence of the interbank market. □

Online Appendix

OA.1 Derivatives Trading and Collusion

In this section, we provide the simplest example to convey the intuition how interbank trading can facilitate collusion in the market for derivative contracts. Assume there are two bankers and one customer. In this example, the customer can be either a high wealth individual, a non-financial company or a financial institution, like a life insurance company. All three have zero resources at the BOP, they own a risky endowment of consumption goods at the EOP. All agents consume at the EOP. Bankers are risk neutral, and the customer is risk averse with log utility over consumption at the EOP. There are two possible states of the world at the EOP: $\sigma = \{s, f\}$ with equal probability.

Assume customer's risky endowment is 2 units of consumption if $\sigma = \{s\}$ and 0 if $\sigma = \{f\}$. Banker B's risky endowment is 0 units of consumption if $\sigma = \{s\}$ and 2 if $\sigma = \{f\}$. Banker A's risky endowment is 2 units of consumption if $\sigma = \{s\}$ and 4 if $\sigma = \{f\}$. It is easy to see that the risky endowment of the customer is perfectly negatively correlated with that of the bankers, and that bankers' endowment is perfectly positively correlated with each other.

Similar to the interbank lending case, we are going to solve for the planner's solution, decentralized solution without interbank trading and a decentralized solution with interbank trading. The goal is to show that opening an interbank market for derivatives reduces aggregate welfare because bankers use this market to enforce collusion.

OA.1.1 Planner's solution

The planner maximizes the expected aggregate welfare in the economy. Without any trading, the expected aggregate welfare is $-\infty$ because with 50% probability the utility of the customer is $\log(0) = -\infty$. The planner would want to provide insurance to the customer. Without loss of generality, the planner will choose banker A to sign a swap contract with the customer. The contract will give the customer a payoff of 1 in each state of the world, such that the expected utility of the customer is $\log(0) = 1$. Obviously, the customer strongly prefers this allocation to the initial one because it increases his utility from $-\infty$ to 0. To implement this contract, banker A will receive from the customer one unit of consumption if the state of the world is s and will provide one unit of consumption if state of the world is f. This contract satisfies the participation constraint of banker A as the expected consumption is 3 (gets 3 in each state of the world), which is the same as her expected consumption without the swap contract. Banker B's participation constrain is trivially satisfied because she consumes her initial endowment. The aggregate expected welfare in the planner's solution is $\sum u_i = u_{\text{customer}} + u_{\text{banker B}} + u_{\text{banker A}} = 0 + 1 + 3 = 4$.

OA.1.2 Decentralized solution without interbank markets

Next, we solve for the decentralized equilibrium without interbank trading. Each banker offer's a contract to the customer that specifies transfers between the costumer and the banker in each state of the world at the EOP. The customer picks a contract that provides her with the highest expected utility. In this case, bankers face competition and in equilibrium one of them will offer the same contract as the contract in the planner's solution. Competition between banks ensures that they make zero profit on the swap contract. The intuition is that banks are risk neutral so for any payoff that they provide in state f they need to be compensated the same amount in state s. Customer's marginal utility in state f is 1 when the consumption is 1 in this state, which is the same as the marginal utility of the bankers. Therefore, in equilibrium both bankers will offer a swap contract that would equalize the marginal utility of the customer across the states and make it equal to their own marginal utility, which is one. Without loss of generality, we assume that in equilibrium the customer chooses a contract from banker A.

OA.1.3 Decentralized solution with interbank markets

In this subsection, we allow bankers to trade in the interbank market before they make offers to the customer. Without interbank trading, bankers make zero profits as we showed in the previous subsection. With interbank market, bankers sign a swap contract that limits ability of banker B to provide insurance to the customer. Banker B will not be able to provide insurance if her consumption in state of the world f is 0. Therefore, the first lag of the swap contract would say that banker B will pay to banker A two units of consumption if $\sigma = \{f\}$. With this contract, banker B cannot provide insurance to the customer in this state of the world as its only resources will be transferred to banker A. The second lag of the swap is that banker A will transfer to banker B $2 + \delta$ units of consumption if $\sigma = \{s\}$, where $0 \leq \delta < 2$. By adjusting δ, the surplus from collusion transfer from banker B to banker A. The surplus is created because in the second stage when bankers submit their offers to the customer, banker B will offer to pay 0 in state f and banker A will offer to pay ϵ. In return, banker B can ask to be paid at most 0 in state s, and banker A can ask to be paid $2 - \epsilon$. Effectively, banker A is a monopolist and it can extract the full surplus from the customer by offering a positive consumption in state f. In return, the customer is forced to give up almost all of its consumption in state s. As $\epsilon \to 0$, the expected surplus that is created by collusion goes to 1, which is the expected endowment of the customer.

The aggregate welfare is $(\log(\epsilon) + (0.5(2 + \delta) + 0.5 * 0) + (0.5(3 - \epsilon - \delta) + 0.5(6 - \epsilon))$. The welfare drops relative to the planner's solution and to the decentralized solution without interbank market because in this solution the customer's utility is finite but can be arbitrary small as $\epsilon \to 0$. Similar to the interbank lending market, the role of the interbank market for derivatives is twofold. First, it allows the first banker to commit not to compete in the market for insurance. Second, it allows bankers to split profits from collusion by specifying the terms of the swap contract.

There is another similarity between the two types of the interbank markets. In the interbank lending market, a banker who borrows from another bank does not need liquidity. The borrowed funds are stored in the risk-free rate. In the market for interbank derivatives, the banker who gets insurance does not need this insurance. In the above example, bankers trade insurance even though their positions are perfectly positively correlated. If bankers were to use interbank market to hedge, we would expect that bankers with negatively correlated positions are more likely to trade with each other.