Can Interbank Money Markets Create Liquidity?

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Abstract

A widely held notion is that interbank markets only redistribute liquidity. We argue that they can also create liquidity by allowing for additional diversification. This tends to ease constraints on banks' funding liquidity and thus mitigates aggregate liquidity shortages.

Keywords interbank money markets, funding liquidity, aggregate liquidity shortage

JEL Classification E43, E5, G01, G21

Highlights

- We develop a model of bilateral interbank transactions.
- We argue that diversification through interbank deposits can improve banks' funding liquidity.
- We show that heterogeneity among banks determines the outcome on interbank markets.

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1 Introduction

On interbank markets, banks trade central bank money and other liquid assets with each other. Trades on these markets are decentralised with pairs of banks concluding bilateral transactions (Craig and von Peter, 2014). A widely held notion is that interbank markets only redistribute liquidity but cannot create it (e.g. Upper and Worms, 2004). Banks with excess holdings of liquid assets lend those to banks with corresponding shortages. According to this view, interbank markets cannot mitigate aggregate liquidity problems in the banking sector. Instead, links among banks merely form a burden to financial stability as they may give rise to contagion when the banking sector faces an aggregate liquidity squeeze (Allen and Gale, 2000).[1]

In this paper we explore conditions under which an interbank market can actually help to mitigate aggregate illiquidity problems by creating liquidity. We focus on aggregate funding liquidity, i.e. the ability of the banking sector to raise liquid assets by borrowing against future asset returns. Since Diamond (1984) it is known that increased diversification can relax financial constraints on banks. We apply this idea to bilateral interbank market transactions. Our starting point is that lending and capital structure decisions of a bank depend on its financial net endowment. With a small endowment, e.g. due to debt overhang, a bank will place a bet on the upside of its asset returns, accepting the risk of future bankruptcy; with a better endowment a bank will issue only little new debt to avoid default, which however may require to cut back on loans (as in Bucher et al., 2013). For a bank of the second type, the counterparty risk associated with lending to a bank of the first type provides a diversification opportunity as long as the correlation of the banks' loan earnings is not perfectly positive. The reduction in the risk of a bank's asset portfolio tends to improve its funding liquidity which eases the borrowing constraint of the bank. Consequently, banks may be willing to supply liquid assets on interbank markets even if they have no respective excess holdings.

In this letter we explore this idea, which is relevant to a wide range of questions. We give two brief examples. First, we look into the effects of changes in yields on riskless investment, e.g. due to changes in monetary policy rates. Second, we argue that the probability of joint bank failures depends, inter alia, on the degree of heterogeneity among banks.

[1] For this argument it is not decisive whether the banks' liquidity position is of temporary nature (due to idiosyncratic liquidity risks), or more permanent (due to structural differences in the banks' business models including their access to the central bank).

2 Set up

We consider two banks $n \in \{1,2\}$ and many potential customers. Bank customers want to save their endowments and compete for bank deposits. All agents are risk neutral, live for one period, have no time preference and are protected by limited liability.

Initially, a bank is endowed with internal funds $\Omega_n \geq 0$, accepts customer deposits $d_n \geq 0$, invests $l_n \geq 0$ in business loans and $a_n \geq 0$ in a safe asset. Bank 1 may deposit $b \geq 0$ with bank 2. The banks' budget constraints then read

$$\Omega_1 + d_1 = l_1 + a_1 + b, \tag{1}$$

$$\Omega_2 + d_2 + b = l_1 + a_1. \tag{2}$$

Interbank deposits rank pari passu with customer deposits. The face value of interbank deposits is β and that of customer deposits with bank n is δ_n.[2]

At the end of the period, the safe asset will yield α. Returns on business loans are state-dependent. In state $s \in \{1,2\}$, which materialises with probability p_s, loans of bank n generate $\lambda_{n,s}$. States are observable only midterm. If depositors learn that the earnings of a bank will not cover all its debts, they will run on the bank. In a run, all bank assets are destroyed and nobody gets anything. Let $I_{n,s}$ be an indicator variable which is 1 when bank n is run in state s and 0 otherwise, and let $\pi_{n,s}$ be the end-of-period book value of bank n in state s, i.e.

$$I_{n,s} = \begin{cases} 1 & \text{if} \quad \pi_{n,s} < 0, \\ 0 & \text{if} \quad \pi_{n,s} \geq 0, \end{cases} \tag{3}$$

$$\pi_{1,s} = \lambda_{1,s} l_1 + \alpha a_1 + (1 - I_{2,s}) \beta b - \delta_1 d_1, \tag{4}$$

$$\pi_{2,s} = \lambda_{2,s} l_2 + \alpha a_2 - \beta b - \delta_2 d_2. \tag{5}$$

Given limited liability, the payoff for bank n in state s is $\max\{\pi_{n,s}, 0\}$.

Returns on business loans are negatively correlated across banks, and expected returns cover the opportunity costs of loans, even if a run destroys all values in the 'bad' state $s = n$:

$$0 < \lambda_{1,1} < \alpha < p_2 \lambda_{1,2} \quad \text{and} \quad 0 < \lambda_{2,2} < \alpha < p_1 \lambda_{2,1}. \tag{6}$$

[2]All repayments are per unit.

Loans are associated with non-pecuniary, non-verifiable costs $c(l_n)$. They are increasing and convex with $c(0) = c'(0) = 0$ to reflect that loans differ in their complexity and banks add the least complex loans first to their portfolios. First-best loan volumes l_n^{fb} are defined by $\phi_n'\left(l_n^{\text{fb}}\right) = 0$ with $\phi_n(l_n) := (E[\lambda_{n,s}] - \alpha)\,l_n - c(l_n)$.

Bank customers have access to the safe asset. Hence, they inelastically supply their endowments to a bank as long as

$$\sum_{s=1}^{2}(1 - I_{n,s})\,p_s\delta_n = \alpha. \tag{7}$$

As for the interaction among banks, the following sequence of moves applies. Bank 1 starts by making a take-it-or-leave-it offer $\langle b^*, \beta^* \rangle$ to bank 2. If accepted, the offer is implemented, else $b = \beta = 0$. For a given interbank deposit contract, a bank's decision problem reads

$$\max_{l_n, a_n, d_n \in \mathbb{R}^+} \sum_{s=1}^{2} p_s \max\{\pi_{n,s}, 0\} - c(l_n) \text{ subject to (1) to (7).} \tag{8}$$

3 Analysis

We proceed in two steps. The first is to explore each bank's actions when bank 2 rejects the offer $\langle b^*, \beta^* \rangle$. The second is to characterise the offer bank 1 will make.

Without interbank deposits, a bank chooses from two modes m_n of operation. It operates in a safe mode $\mathscr{S}$ when it can repay all customer deposits regardless of the state, i.e. $I_{n,s} = 0$ for all s. It operates in a risky mode $\mathscr{R}$ when it repays them only in the state with high returns, i.e. $I_{n,s} = 0$ only if $s \neq n$. The safe mode $\mathscr{S}$ allows to always collect all earnings. However, business loans are constrained by their funding liquidity because this mode requires

$$\tfrac{\alpha - \lambda_{n,s}}{\alpha} l_n \leq \Omega_n \quad \text{for} \quad s = n. \tag{9}$$

As the opportunity costs of business loans exceed the loan returns in the bad state, a bank cannot fully refinance its loans with customer deposits. The resulting gap (LHS) must be covered by internal funds (RHS). Since internal funds are limited, the volume of business loans is limited too in mode $\mathscr{S}$. In the risky mode $\mathscr{R}$, the face value of customer deposits can be as large as the high return in the 'good' state

$s \neq n$. According to (6), $\lambda_{n,s} > \frac{\alpha}{p_s}$ such that a bank in mode $\mathscr{R}$ does not face a funding constraint. The downside of mode $\mathscr{R}$ is that loans are less valuable, for a run will destroy all values in state $s = n$.

When internal funds Ω_n are plenty such that (9) is not binding even for the first-best loan volume l_n^{fb}, a bank does not suffer from a funding constraint in mode $\mathscr{S}$. It will operate in this mode and grant business loans according to the first-best. With less internal funds, the funding constraint becomes binding. A bank will respond by granting fewer loans, unless internal funds are even below some threshold $\bar{\Omega}_n$, for which mode $\mathscr{S}$ would imply a very tight restriction on lending. In order to get around this constraint, a bank will then sacrifice loan earnings in the bad state and operate in mode $\mathscr{R}$. These conclusions are summarised in the following lemma.

Lemma 1 *When $b = \beta = 0$, banks will maximise expected profits if for all n and $s = n$*

$$\begin{array}{llll} \hat{m}_n = \mathscr{S} & \text{and} & \hat{l}_n = l_n^{fb} & \text{if} \quad \Omega_n \geq \frac{\alpha - \lambda_{n,s}}{\alpha} l_n^{fb} \\ \hat{m}_n = \mathscr{S} & \text{and} & \hat{l}_n = \frac{\alpha}{\alpha - \lambda_{n,s}} \Omega_n & \text{if} \quad \Omega_n \in \left[\bar{\Omega}_n, \frac{\alpha - \lambda_{n,s}}{\alpha} l_n^{fb}\right) \\ \hat{m}_n = \mathscr{R} & \text{and} & \hat{l}_n = l_n^{\mathscr{R}} & \text{if} \quad \Omega_n \in \left[0, \bar{\Omega}_n\right) \end{array} \tag{10}$$

with $l_n^{\mathscr{R}} : \phi_n'\left(l_n^{\mathscr{R}}\right) = p_s \lambda_{n,s}$ and $\bar{\Omega}_n : \phi_n\left(l_n^{\mathscr{R}}\right) - \phi_n\left(\frac{\alpha}{\alpha - \lambda_{n,s}} \bar{\Omega}_n\right) = p_s \lambda_{n,s} l_n^{\mathscr{R}}$.

When the offer $\langle b^*, \beta^* \rangle$ of bank 1 is accepted, interbank deposits will affect the funding liquidity of loans in the safe mode. With $b = b^*$, $\beta = \beta^*$, a bank run is prevented for all states if

$$\frac{\alpha - \lambda_{1,1}}{\alpha} l_1 \leq \Omega_1 + \frac{\beta - \alpha}{\alpha} b \tag{11}$$

$$\frac{\alpha - \lambda_{2,2}}{\alpha} l_2 \leq \Omega_2 + \frac{\alpha - \beta}{\alpha} b. \tag{12}$$

These constraints differ from (9) with respect to the second term on RHS. For bank 1, any dollar raised from customers at a cost of α and deposited with bank 2 will increase the collectible amount in the bad state $s = 1$ by β. If $\beta > \alpha$, the bank can use the difference $\beta - \alpha$ to attract additional customer deposits in order to refinance additional business loans. By contrast, bank 2 will have scope for additional business loans if $\beta < \alpha$.

Bank 1 would never agree on interbank deposits with $\beta < \alpha$ as they neither cover their refinancing costs nor help to grant more business loans. Bank 2 would never accept interbank deposits with $\beta > \alpha$ unless it operates in the risky mode, i.e. when the bank will repay β only with probability p_1.

Accordingly, there is no reason for the emergence of interbank deposits unless bank 1 is safe and bank 2 is risky.

Since loan earnings are negatively correlated, bank 1's counterparty risk associated with interbank deposits tends to offset its risk associated with business loans. As long as $\beta > \alpha$, the lower total risk enables the bank to commit to a higher face value of customer deposits. It can raise more funds because the funding liquidity of its portfolio is improved. Bank 2 accepts interbank deposits from bank 1 as long as they do not cost more than customer deposits, i.e $p_1\beta \leq \alpha$. We conclude

Proposition 1 *For $\Omega_1 \geq \bar{\Omega}_1$ and $\Omega_2 \in \left[0, \bar{\Omega}_2\right)$, bank 1 will maximise expected profits by offering a contract $\langle b^*, \beta^* \rangle$ such that*

$$\begin{array}{llll} b^* \leq l_2^{\mathscr{R}} - \Omega_2, \ \ \beta^* = \frac{\alpha}{p_1}, \ \ l_1^* = l_1^{fb}, \ \ l_2^* = l_2^{\mathscr{R}} & if \ \ \frac{\alpha - \lambda_{1,1}}{\alpha} l_1^{fb} - \Omega_1 \leq \frac{p_2}{p_1}\left(l_2^{\mathscr{R}} - \Omega_2\right) \\ b^* = \tilde{l}_2 - \Omega_2, \ \ \beta^* < \frac{\alpha}{p_1}, \ \ l_1^* = \tilde{l}_1, \ \ l_2^* = \tilde{l}_2 & if \ \ \frac{\alpha - \lambda_{1,1}}{\alpha} l_1^{fb} - \Omega_1 > \frac{p_2}{p_1}\left(l_2^{\mathscr{R}} - \Omega_2\right) \end{array} \tag{13}$$

where $\tilde{l}_1 \in \left(\frac{\alpha}{\alpha - \lambda_{1,1}}\Omega_1, l_1^{fb}\right)$ and $\tilde{l}_2 > l_2^{\mathscr{R}}$ are jointly determined by

$$\frac{\alpha - \lambda_{1,1}}{\alpha}\tilde{l}_1 - \Omega_1 = \frac{p_2}{p_1}\left(\tilde{l}_2 - \Omega_2\right) - \frac{1}{p_1\alpha}\int_{l_2^{\mathscr{R}}}^{\tilde{l}_2}\left[p_2\lambda_{2,2} - \phi_2'(l_2)\right] dl_2 \tag{14}$$

$$\left(\frac{p_2}{p_1}\alpha - \frac{1}{p_1}\left[p_2\lambda_{2,2} - \phi_2'\left(\tilde{l}_2\right)\right]\right)\frac{\phi_1'\left(\tilde{l}_1\right)}{\alpha - \lambda_{1,1}} = p_2\lambda_{2,2} - \phi_2'\left(\tilde{l}_2\right) \tag{15}$$

According to (13), the optimal offer $\langle b^*, \beta^* \rangle$ as well as the resulting loan volumes depend on the relative importance of two factors. One is the funding gap of bank 1 associated with the first-best loan volume, i.e. $\frac{\alpha - \lambda_{1,1}}{\alpha} l_1^{\text{fb}} - \Omega_1$. The other is the maximum amount, which bank 1 can mobilise at no extra costs by placing interbank deposits with bank 2. This amount is given by $\frac{p_2}{p_1}\left(l_2^{\mathscr{R}} - \Omega_2\right)$ and has two components. First, interbank deposits with bank 2 are costless for bank 1 as long as the refinancing costs α of these deposits are equal to their expected return $p_1\beta$. Accordingly, each unit of these costless interbank deposits contributes to close bank 1's funding gap by $\frac{\beta - \alpha}{\alpha} = \frac{p_2}{p_1}$. Second, bank 2 needs no more than $l_2^{\mathscr{R}} - \Omega_2$ from external sources to refinance its favoured loan volume $l_2^{\mathscr{R}}$ in the risky mode.

When the banks differ quite substantially in terms of their endowments, the volume of interbank deposits required to completely eliminate the financial constraint on bank 1 is small relative to the overall funding need of bank 2. Interbank deposits will then cost the same as customer deposits, i.e. diversification is not costly for bank 1. Consequently, bank 1 will diversify its portfolio such that the first-best loan volume becomes financially feasible in mode $\mathscr{S}$. Bank 2 then acts as if there is no interbank market in terms of both, its mode of operation and its loan volume $l_2^{\mathscr{R}}$. Interbank deposits merely crowd out customer deposits at bank 2.

If the endowment of bank 1 is relatively small and its funding gap thus large, it wishes to diversify its portfolio to an even larger extent by increasing the volume of interbank deposits beyond $l_2^{\mathscr{R}} - \Omega_2$. However, bank 2 will be unwilling to accept more funds than necessary to refinance $l_2^{\mathscr{R}}$ and to grant additional loans unless it receives compensation for this. Hence, bank 1 has to offer a contract with β so low that interbank deposits are cheaper for bank 2 than customer deposits. In that sense, diversification becomes costly for bank 1 because expected returns on interbank deposits do not cover their refinancing cost. The optimum then is given by (14) and (15). According to (14), the compensation for bank 2 (second term on the RHS) will reduce the funding gap that bank 1 can close with the help of interbank deposits (LHS). According to (15), the marginal cost of compensating bank 2 for granting business loans above $l_2^{\mathscr{R}}$ (RHS) will just offset the marginal gains from raising funds for one more unit of loans (LHS). In this case, bank 1 does not completely escape its financial constraint as its business lending is smaller than in the first-best.[3]

4 Applications

Using the above argument, we can shed light on the question of how the volume of interbank deposits is affected by changes in risk-free rates. When α is lower, the required rate on customer deposits will be lower too. On the one hand, this will ease the funding constraint on business loans. To grant a given loan volume, bank 1 can thus rely less on diversification and interbank deposits shrink. On the other hand, a lower α implies that banks want to grant more loans as their costs are smaller. One reason is that customers require a lower return on their deposits. Another is that the cost of diversification in terms of expected losses associated with interbank deposits is also smaller. Both effects tend to increase banks' demand for diversification through interbank deposits.

The effect of α on the expected cost of diversification plays no role if bank 1's funding gap associated with the first-best loan volume $\frac{\alpha-\lambda_{1,1}}{\alpha} l_1^{\text{fb}} - \Omega_1$ is not larger than the maximum amount $\frac{p_2}{p_1}\left(l_2^{\mathscr{R}} - \Omega_2\right)$ which bank 1 can mobilise at no extra costs by placing interbank deposits with bank 2, e.g. when the endowment of bank 1 is large relative to that of bank 2. A lower risk-free rate then unambiguously results in less interbank deposits if $\varepsilon < \frac{\lambda_{1,1}}{\alpha-\lambda_{1,1}}$, with ε being the absolute value of the elasticity of the

[3]This result broadly corresponds with the empirical findings by Iyer et al. (2014).

	state A	state B	state C	state D
	p_A	p_B	p_C	p_D
bank 1	$\lambda_{1,l}$	$\lambda_{1,l}$	$\lambda_{1,h}$	$\lambda_{1,h}$
bank 2	$\lambda_{2,h}$	$\lambda_{2,h}$	$\lambda_{2,l}$	$\lambda_{2,l}$
bank 3	$\lambda_{3,l}$	$\lambda_{3,h}$	$\lambda_{3,l}$	$\lambda_{3,h}$

Table 1: Probability distribution for $n \in \{1,2,3\}$, $s \in \{A,B,C,D\}$ and $p_s > 0$ for all s

first-best loan volume of bank 1 with respect to the risk-free rate α. Intuitively, a low elasticity means that a decrease in α is associated with only a small increase in the funds required to finance the first-best loan volume.[4] The easing of the funding constraint implied by the decrease in the interest rate will thus outweigh the increase in the external borrowing needs of bank 1. As a consequence, the bank relies less on diversification and thus reduces its interbank deposits. The above condition is particularly likely to hold when α is already very low. A low-interest environment due to, e.g., very expansionary monetary policy could thus contribute to less interbank market activity, in particular when banks differ substantially in their financial endowments Ω_n.

Our argument can also be used to discuss the likelihood of joint bank failures. For the sake of simplicity, consider three banks and four possible states. For each bank n there are two states with high loan earnings $\lambda_{n,h}$ and two states with low earnings $\lambda_{n,l}$ (Table 1). Assumption (6) changes to

$$0 < \lambda_{1,l} < \alpha < (p_C + p_D)\lambda_{1,h}, \quad 0 < \lambda_{2,l} < \alpha < (p_A + p_B)\lambda_{2,h} \quad \text{and} \quad 0 < \lambda_{3,l} < \alpha < (p_B + p_D)\lambda_{3,h}.$$

Let bank 1 be the one making deposits with one of the other banks. The relationship between bank 1 and bank 2 replicates the one in the previous section with $p_A + p_B = p_1$ and $p_C + p_D = p_2$. As a consequence, optimal diversification will be costly for bank 1 if $\frac{\alpha-\lambda_{1,l}}{\alpha} l_1^{\text{fb}} - \Omega_1 > \frac{p_C+p_D}{p_A+p_B}\left(l_2^{\mathscr{R}} - \Omega_2\right)$. Alternatively, bank 1 can make deposits with bank 3. If bank 3 is financially much weaker than bank 2 (in terms of endowments and/or earnings prospects), bank 1 can deposit quite a large amount with bank 3 and still charge interbank rates that cover the refinancing cost of interbank deposits. Hence, interbank deposits would be less costly with bank 3 than with bank 2. The downside of interbank deposits with bank 3 is that bank 1 cannot prevent a bank run if state A materialises. Hence, expected loan earnings will be smaller compared to the case of interbank deposits with bank 2.

This tradeoff eventually determines the probability of joint bank failures. The probability of at least one bank failing will be $p_A + p_C + p_D$ regardless where interbank deposits are placed. If, however, the

[4] Possible reasons are firms being pessimistic about the economic outlook or the existence of already idle capacities.

endowment Ω_2 of bank 2 is not too small and the probability p_A is not too large, bank 1 wishes to deal with bank 3. In this case, the probability of two banks failing at the same time is $p_A + p_C$, whereas it is only p_C when deposits are placed with bank 2 instead.

References

Allen, F. and D. Gale (2000). Financial contagion. *Journal of Political Economy 108*(1), pp. 1–33.

Bucher, M., D. Dietrich, and A. Hauck (2013). Business cycles, bank credit and crises. *Economics Letters 120*(2), 229 – 231.

Craig, B. and G. von Peter (2014). Interbank tiering and money center banks. *Journal of Financial Intermediation 23*(3), 322 – 347.

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The Review of Economic Studies 51*(3), 393–414.

Iyer, R., J.-L. Peydró, S. da Rocha-Lopes, and A. Schoar (2014). Interbank liquidity crunch and the firm credit crunch: Evidence from the 2007-2009 crisis. *Review of Financial Studies 27*(1), 347–372.

Upper, C. and A. Worms (2004). Estimating bilateral exposures in the German interbank market: Is there a danger of contagion? *European Economic Review 48*(4), 827 – 849.