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ABSTRACT

Liquidity Coinsurance and Bank Capital*

Banks can deal with their liquidity risk by holding liquid assets (self-insurance), by participating in the interbank market (coinsurance), or by using flexible financing instruments, such as bank capital (risk-sharing). We study how the access to an interbank market affects banks' incentive to hold capital. A general insight is that from a risk-sharing perspective it is optimal to postpone payouts to capital investors when a bank is hit by a liquidity shock that it cannot coinsure on the interbank market. This mechanism produces a negative relationship between interbank activity and bank capital. We provide empirical support for this prediction in a large sample of U.S. commercial banks, as well as in a sample of European and Japanese commercial banks.

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Keywords: bank capital, interbank markets and liquidity coinsurance.

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1 Introduction

The management of liquid resources is an important concern for banks. They typically transform short-term liquid liabilities into long-term illiquid assets and are therefore exposed to a substantial degree of liquidity risk. A simple way to tackle this uncertainty is to hold liquid reserves, which amounts to self-insuring against the occurrence of a liquidity shock. This is costly for banks, as they could instead invest in more productive illiquid or risky assets. Alternatively, banks can participate in the interbank markets, where they can exchange resources with other banks. Interbank markets, however, also represent a partial solution, for at least two reasons. First, part of the liquidity risk is likely to be systematic and, by definition, impossible to insure. Second, interbank markets typically operate over the counter and are based on a limited number of pre-established connections. Even idiosyncratic liquidity shocks may be impossible to coinsure in the absence of such pre-established connections.[1] To the extent that payouts to holders of bank capital are not fixed obligations, bank capital also offers an opportunity to deal with liquidity risk: by adjusting the payouts to bank capital holders, banks can transfer part of the liquidity uncertainty to capital investors. This liquidity risk-sharing function of bank capital, however, also comes at a cost since raising capital is itself costly for banks.[2]

This paper analyzes the interplay between bank capital, interbank market activity, and banks' portfolio choice. In particular, we study to what extent the presence of an interbank market affects the incentives of a bank to hold (costly) capital and to invest in liquid assets. We first introduce a theoretical model where banks face uncertain liquidity needs and show that, as a consequence of its risk-sharing role, bank capital has a negative relation with interbank activity. We then proceed to show that this prediction finds support in a large sample of U.S. banks, and also in a sample of European and Japanese banks.

We model two banks that collect deposits from risk-averse depositors and capital from risk-neutral investors.[3] Banks invest the collected resources into short-term liquid assets (a

[1] Another reason why interbank markets might offer limited coinsurance opportunities is the presence of moral hazard or adverse selection problems (see Bhattacharya and Gale [7]).

[2] Alternatively, bank capital is often considered to either act as a buffer protecting against solvency shocks, or mitigate risk-taking incentives (see, among others, Brusco and Castiglionesi [9], and Morrison and White [24]).

[3] We allow banks to offer fully contingent contracts to both depositors and investors. This assumption makes the role of bank capital as a buffer against insolvency immaterial, and it allows us to focus on the role of bank capital as a risk-sharing device.

storage technology) and long-term illiquid assets. Banks face uncertain liquidity needs: the idiosyncratic liquidity shocks are either asymmetric, that is one bank has a high-liquidity shock and the other bank a low-liquidity shock, or symmetric, that is both banks have the same high-liquidity shock. The two banks participate in an interbank market which allows them to coinsure against asymmetric liquidity shocks. However, the interbank market is of no use in the case of symmetric shocks. We refer to liquidity risk that cannot be coinsured in the interbank market as undiversifiable (liquidity) risk.[4]

The presence of undiversifiable liquidity uncertainty creates scope for the use of bank capital as a risk-sharing device. That is, some of the undiversifiable risk can be transferred to the risk-neutral investors of bank capital. Banks select the amount of capital they raise before the liquidity shock is realized. Since collecting resources from risk-neutral investors is costly, banks would hold no capital were the liquidity shocks only asymmetric. The optimal level of bank capital crucially depends on the probability banks place on the liquidity shock being undiversifiable, and thereby uninsurable in the interbank market.

We show by means of examples that this relationship might not be monotonic. In fact, while we would expect the optimal level of bank capital to decrease when the probability of an undiversifiable shock reduces, this only happens for some parameter configurations. This is due to the fact that a reduction in the probability of the undiversifiable (symmetric) shock also affects a bank's portfolio choices. In particular, a lower level of undiversifiable uncertainty induces banks to reduce the investment in liquid assets and, as in Castiglionesi et al. [10], this can produce higher consumption volatility for depositors. In this case, the optimal level of bank capital can increase because it helps moderate this volatility by transferring it to the risk-neutral investors. An important insight from this analysis is that the amount of liquidity uncertainty that a bank cannot insure in the interbank market can be an important determinant of bank capital.[5]

Unfortunately it is difficult to measure the *ex ante* bank-level undiversifiable liquidity risk. To obtain testable implications we make use of the following general insight of the

[4] We stress the fact that the symmetric liquidity shocks do not necessarily correspond to an aggregate, market-wide shock. They can also be undiversifiable because of bank-specific reasons like, for example, a limited access to the interbank market (Cocco et al. [11] provide evidence of the relevance of pre-established relationships in determining interbank activity).

[5] To the extent that such risk is a persistent bank characteristic, it might be responsible for at least some of the large explanatory power that bank fixed effects have in regressions explaining banks' capital structure (Gropp and Heider [21]).

model: payouts to risk-neutral investors should not be realized in states of the world where the marginal utility of depositors is high. In particular, when the undiversifiable (symmetric) liquidity shock hits, depositors' per-capita consumption is low and its marginal utility high. Hence, it is optimal to postpone payouts to capital investors when interbank market activity is low.

The decision about when to realize a payout clearly affects the value of bank capital. When holders of bank capital are paid, the value of bank capital *ceteris paribus* tends to drop. Since payouts to bank capital holders occur (are postponed) when activity in the interbank market is high (low), the model predicts that a bank's activity in the interbank market has a negative correlation with the value of its capital. This correlation holds independently of whether we consider the book value of capital, defined as total assets minus total liabilities, or its market value, defined as the present value of future payouts.

In the empirical part of the paper we test this prediction by relating a bank's interbank market activity to the book value of its capital for a large sample of U.S. commercial banks.[6] We use banks Call Reports to build a quarterly panel dataset spanning from the first quarter of 2002 till the fourth quarter of 2010. For the banks in our sample we obtain information on their balance-sheet items as well as on their activity in three different interbank markets: (a) Unsecured interbank lending and borrowing, (b) Repos and Reverse Repos with maturity longer than one day, and (c) Lending and borrowing on the overnight Repo and Federal Funds markets.

We perform our analysis considering the activity on the unsecured interbank market (a) alone, as well as the overall interbank activity as the sum of (a), (b) and (c). The reason for the emphasis on (a) is that banks are likely to use the overnight markets considered in (c) mostly to deal with highly transitory liquidity shocks. In turn, these shocks are probably more difficult to manage through the payout policy, which is typically structured on a quarterly basis. In this sense we expect bank capital to be a poor substitute for overnight interbank markets. On the other hand, the transactions on the Repo market considered in (b) are collateralized, and we prefer to focus on the unsecured market considered in (a). In the latter market the role of bank capital as a signal of financial strength should be more relevant and, as a consequence, larger capital buffers should facilitate borrowing activity.

[6] The reason to focus on book value is that, while detailed measures of interbank market activity are available for individual commercial banks, the market values of equity are available mostly for bank holding companies where the commercial activity is often combined with other activities, such as investment banking, merchant banking, insurance etc.

Therefore, the negative relationship between bank capital and interbank activity should be harder to detect in (a) than in (b). As for capital, we adopt a broad definition including book values of equity and reserves, as well as preferred stocks and hybrid capital. In this way we intend to include any source of funding with a long maturity and no collateral, whose remuneration is flexible enough to be potentially used to absorb non diversifiable liquidity shocks.

We use a regression panel approach that allows us to estimate the conditional correlation between a bank's interbank market activity and its capital, controlling for several possible confounding factors and including both bank fixed effects and time dummies. We find evidence of a negative relationship with both specifications of interbank market activity. We run several robustness checks to assess the reliability of our findings, and we also replicate our results in a sample of European and Japanese commercial banks using yearly data from 2005 to 2010. Overall, we consider our evidence as very supportive of the view that an important role of bank capital is to help manage liquidity risk.

These empirical findings would be difficult to rationalize with other theoretical explanations. For example, consider the incentive function of bank capital: to the extent that bank capital provides an incentive to avoid excessive risk taking, more capital should translate into lower insolvency risk, and should result in easier access to the interbank market. This in turn would imply a positive relationship between the level of bank capital and interbank activity, at least for banks that are net borrowers.

Even if our paper does not directly address normative issues, our results may be relevant for the policy debate. The current debate on the regulation of bank capital mainly emphasizes its incentive function (see, among others, Admati et al. [1]). This is clearly an important role of bank capital, but our results show that its risk-sharing function is also relevant and has been essentially overlooked so far. Indeed, any intervention to regulate bank capital is likely to affect the functioning of the markets in which banks coinsure their liquidity risk in a non-trivial way.

It is important to stress that the main goal of the paper is to look at how interbank market activity affects the way liquidity and capital are managed within a bank in the medium/long term horizon. The objective of our paper is neither to focus on the functioning of the interbank market during the crisis nor to study banks' short-term liquidity and capital management. The novelty of our approach comes from looking at the co-determination of banks' capital holding and the interbank market activity. To the best of our knowledge, neither the theoretical nor the empirical banking literature have explicitly studied this relationship so far.

Our paper is related to both theoretical and empirical works in banking. On the theory side, the paper closest to ours is Gale [19]. He also considers the risk-sharing role of bank capital but, contrary to us, his analysis focuses on regulatory aspects without providing an analysis on the relationship between interbank market activity and bank capital. For this purpose, Gale [19] considers spot markets as a way to coinsure against liquidity shocks. Contrary to him, and similarly to Allen and Gale [4] and Castiglionesi et al. [10], we model the interbank market as a device to decentralize the first best allocation of risk. In particular, we assume that banks make ex ante arrangements to coinsure themselves. However, differently from Allen and Gale [4], in our model aggregate uncertainty is perfectly anticipated by economic agents. More importantly, while both in Allen and Gale [4] and Castiglionesi et al. [10] bank capital is ignored, we are able to analyze the interaction between the liquidity insurance provided by the interbank market and by bank capital.[7]

On the empirical side, our paper is the first attempt to investigate the relationship between interbank market participation and bank capital. For this reason it relates to two different strands of the literature: one on bank capital and the other on interbank markets. Flannery and Rangan [14] and Gropp and Heider [21] look at the determinants of banks' capital holdings. Flannery and Rangan [14] argue that the main cause of capital build-up of large U.S. banks in the 1990s was an increased market discipline due to legislative and regulatory changes, resulting in the withdrawal of implicit government guarantees. Gropp and Heider [21] address the question of whether the determinants of banks' capital structure differ from those of non-financial firms. While they do not find evidence on the differences, they argue that the most important determinants of banks' capital structure are time-invariant bank fixed effects. Moreover, deposit insurance and capital regulation do not seem to have a significant impact on banks' capital structure.

Regarding the interbank market, Furfine ([15], [16], and [17]) analyzes banks' screening

[7] There is also an extensive theoretical literature on capital regulation based on the incentive function of bank capital. The results are not conclusive since while bank capital requirements usually decrease risk, the reverse is also possible (see Kim and Santomero [23], Furlong and Keeley [18], Gennotte and Pyle [20], Besanko and Kanatas [8] and Hellman et al. [22]). Among the recent contributions, Diamond and Rajan [13] rationalize bank capital as the trade off between liquidity creation, costs of bank distress and the ability to force borrower repayments. Allen, Carletti and Marquez [3] analyze the role of market discipline as a rationale to hold bank capital.

and monitoring activity in the Federal Funds market, and the behavior of this market during Russia's sovereign default. Cocco et al. [11] look at the importance of relationships among banks as an important determinant of their ability to access the Portuguese interbank market. Finally, Afonso et al. [2] examine the impact of the financial crisis of 2008, specifically the bankruptcy of Lehman Brothers, on the functioning of the Federal Funds market. They argue that while banks became more restrictive in which counterparties they lent to, the financial crisis did not lead to a complete collapse of the Fed Funds market. A comparable analysis has been performed by Angelini et al. [6] for the European interbank market with similar results.

The remainder of the paper is organized as follows. Section 2 presents the model, and Section 3 analyzes the optimal risk-sharing allocation. Section 4 shows how the efficient allocation can be decentralized in the presence of interbank markets. Section 5 characterizes the efficient allocation and analyzes how participation in the interbank market affects bank capital. Section 6 presents the data we used to test the model's predictions and the results of our regressions. Section 7 concludes. Appendix A contains the proofs, and Appendix B reports the detailed description of the variables and their unconditional correlations.

2 The Model

The basic model is similar to Gale [19], and provides a rationale for the use of bank capital based on risk sharing. There are three dates ($t = 0, 1, 2$) and a single good available at each date for both consumption and investment. Two assets are available for investment: a short-term or liquid asset that matures in one period with a return of one, and a long-term or illiquid asset that requires two periods to mature and delivers a return $R > 1$. The short asset represents a storage technology (one unit of the good invested at $t = 0, 1$ produces one unit at $t + 1$), while the long asset captures long-term productive opportunities (one unit invested at $t = 0$ produces R units at $t = 2$, and nothing at $t = 1$). Clearly, the choice of a portfolio of assets reflects a trade-off between returns and liquidity.

We consider two banks $i = A, B$, and two groups of agents. The first group is a continuum of risk-neutral agents that we call *investors*. They are endowed with a large amount of the consumption good at $t = 0$ and nothing at $t = 1, 2$. Investors cannot consume a negative amount at any time, and their utility is

$$\rho_0 c_0 + \rho_1 c_1 + c_2,$$

where $\rho_0 > R$, and $\rho_0 > \rho_1 > 1$.

The second group is given by risk-averse agents that we call *depositors*. They are endowed with 1 unit of the consumption good at $t = 0$, and nothing at $t = 1, 2$. Following Diamond and Dybvig [12], depositors can be of two types: early consumers who only value consumption at $t = 1$, or late consumers who only value consumption at $t = 2$. The type of an agent is not known at $t = 0$. When consumption is valuable, the agent's utility is $u(c)$, where $u : \mathbb{R}_+ \to \mathbb{R}$ is continuously differentiable, strictly increasing and concave, and satisfies the Inada condition $\lim_{c \to 0} u'(c) = \infty$. We assume that each bank has a unitary mass of depositors.

The uncertainty about the preference shocks for the second group of agents is resolved in period 1 as follows. First, a liquidity shock is realized, which determines the fraction ω^i of early consumers in each bank $i = A, B$. Then, preference shocks are randomly assigned to the consumers in each bank so that ω^i agents become early consumers. The preference shock is privately observed by consumers, while the aggregate shocks ω^i are publicly observed.

The bank shock ω^i takes the two values ω_H and ω_L, with $\omega_H > \omega_L$. We assume that with probability $p > 1/2$ the two banks have opposite shocks and, when this happens, there is room for trading on an interbank market. With probability $1 - p$, however, both banks face high liquidity needs and in this case the interbank market cannot work. Formally, there are three possible states of the world $S \in \mathcal{S} = \{HH, LH, HL\}$. In state HH both banks have high liquidity needs, while in states LH and HL they are hit by different shocks. Table 1 summarizes the probability distribution of the liquidity shocks.

Table 1: Banks' liquidity shocks

State S	A	B	Probability
HH	ω_H	ω_H	$(1 - p)$
LH	ω_L	ω_H	$p/2$
HL	ω_H	ω_L	$p/2$

Notice that in states LH and HL, the average fraction of early consumers is constant and equal to

$$\omega_M = \frac{\omega_H + \omega_L}{2},$$

whereas it is clearly ω_H in state HH. Hence, there is some non-diversifiable uncertainty on liquidity needs that is maximum when $p = 1/2$.[8] Notice that, as we assume $p \geq 1/2$, any increase in p represents a reduction in non-diversifiable uncertainty on liquidity needs.

Agents cannot trade directly with one another, but the banking sector makes up for the missing markets. In particular, the activity of each bank develops as follows. At $t = 0$ each bank collects the initial endowment of its depositors and an amount $e \geq 0$ of resources from investors. Therefore, the amount e will henceforth be referred to as bank capital. The bank invests an amount y in the short asset and an amount $1 + e - y$ in the long asset; in period 1, after the aggregate shock S is publicly observed, the consumer reveals his preference shock to the bank and receives the consumption vector $\left(c_1^S, 0\right)$ if he is an early consumer and the consumption vector $\left(0, c_2^S\right)$ if he is a late consumer. Similarly, after the state S has been revealed, investors receive the consumption vector $(d_1^S, d_2^S) \geq 0$.[9] Therefore, a risk sharing contract, also called an allocation, offered by the bank is fully described by an array

$$\{y, e, \left\{c_t^S, d_t^S\right\}_{S \in \mathcal{S}; t=1,2}\}.$$

As in Allen and Gale [4], the existence of different groups of banks with different liquidity needs can capture different level of aggregation. Each bank in the model could indeed correspond to a specific financial institution, or to the representative bank in a specific banking sector, a geographical region, etc. For our purposes, the economy described above represents a set of banks connected through an interbank market together with their depositors and investors. In this sense, the parameter p represents a measure of the deepness of the interbank market, as it gives the probability of finding a bank with different liquidity needs to, potentially, trade with. The parameter p may reflect (1) the degree of connectedness of a certain bank to the overall interbank market network; (2) the relative importance of local (and diversifiable) shocks to aggregate shocks; and (3) the cross-border position of the national banking system.

In what follows we are interested in studying the effects of the interbank market on the incentives to hold bank capital. Since our focus will be on an interbank market that

[8] In fact, the non-diversifiable liquidity uncertainty can be measured by the volatility of the average fraction of early consumers at the two banks. This fraction can either be ω_M with probability p, or ω_H with probability $1 - p$. Clearly, the variance of this binary random variable is maximum when $p = 1/2$.

[9] Agents are in a symmetric position ex-ante, and we assume that they are treated equally, that is, risk averse agents are all given the same contingent consumption plan, summarized by $\left\{c_t^S\right\}_{S \in \mathcal{S}; t=1,2}$ and, similarly, risk neutral agents are all given the same contingent consumption plan $\left\{d_t^S\right\}_{S \in \mathcal{S}; t=1,2}$.

is able to decentralize the first-best allocation, we start in the next section to characterize optimal risk sharing and we will introduce the interbank market in Section 4.

3 Optimal Risk Sharing

In this section we abstract from the interbank market and consider optimal risk sharing in a situation where investors are maintained at their reservation utility. We do so, following Gale [19], to capture a situation where investors are perfectly competitive and their supply of capital is perfectly elastic. Hence, we look for the allocation that maximizes the sum of ex-ante expected utilities of depositors and guarantees to investors the utility they could obtain by consuming their endowment at $t = 0$. We also assume that the fraction of early consumers in each bank (i.e., the state of the world) is observable and verifiable, but the preference shocks of individual depositors are not. Notice that the overall fraction of early consumers is the same in states HL and LH, and it is therefore optimal to move resources from one bank to the other to make the agents' consumption plans constant in this case (i.e., $c_t^{HL} = c_t^{LH}$ and $d_t^{HL} = d_t^{LH}$ for $t = 1, 2$).

With a slight abuse of notation we can define a new state space $\mathcal{S}' = \{H, M\}$ with the understanding that $M = \{HL, LH\}$ and $H = \{HH\}$. An allocation can now be described by an array $\{y, e, \{c_t^s, d_t^s\}_{s \in \mathcal{S}'; t=1,2}\}$, and it is said to be feasible if for each $s \in \mathcal{S}'$ and $t = 1, 2$, we have $e \geq 0$, $d_t^s \geq 0$, and

$$\omega_s c_1^s + d_1^s \leq y, \tag{1}$$

$$(1 - \omega_s) c_2^s + d_2^s \leq (1 + e - y) R + y - \omega_s c_1^s - d_1^s, \tag{2}$$

$$p(\rho_1 d_1^M + d_2^M) + (1 - p)(\rho_1 d_1^H + d_2^H) \geq \rho_0 e. \tag{3}$$

The first two constraints guarantee that there are enough resources at $t = 1$ and $t = 2$ respectively, to deliver the planned amount of consumption in each state s. Whenever $y - \omega_s c_1^s - d_1^s > 0$ we say that there is positive rollover in state s, that is, some resources are stored through the liquid asset between $t = 1$ and $t = 2$. In this case the ex-post social value of liquidity is clearly the lowest possible as it exceeds the overall needs. The third constraint guarantees that investors get at least their reservation utility.[10] To characterize optimal risk sharing, we can think of a planner choosing a feasible allocation to maximize

[10] Notice that we are not explicitly considering the incentive contraints $c_1^s \leq c_2^s$ that prevent late consumers from pretending to be early consumers. This omission is however immaterial as the solution to

$$p\left(\omega_M u(c_1^M) + (1-\omega_M)u(c_2^M)\right) + (1-p)\left(\omega_H u(c_1^H) + (1-\omega_H)u(c_2^H)\right). \qquad (4)$$

Notice that in state H each bank's consumption needs must be satisfied with the resources available within the bank. In fact, in state H, both banks have a total demand for liquidity (from both consumers and investors) equal to $\omega_H c_1^H + d_1^H$ and from (1) we see that the available amount of the short asset within each bank is in fact enough to satisfy the internal demand (i.e., $y \geq \omega_H c_1^H + d_1^H$). Things are different in state M: in this case in order to implement the first best, the planner has to move resources between the two banks. For example, with no rollover in state M, the amount of liquid resources available at $t = 1$ in both banks is $\omega_M c_1^M + d_1^M$. However, one bank has a fraction ω_H of early consumers so that its demand for liquidity is $\omega_H c_1^M + d_1^M$, which results in an excess demand of $(\omega_H - \omega_M)\, c_1^M$. At the same time, the other bank has a fraction ω_L of early consumers so that its demand for liquidity is only $\omega_L c_1^M + d_1^M$, which results in an excess supply of $(\omega_M - \omega_L)\, c_1^M$. Given that

$$(\omega_H - \omega_M) = (\omega_M - \omega_L) = (\omega_H - \omega_L)/2,$$

the excess demand can be cleared up with excess supply at $t = 1$.

At $t = 2$, resources move in the opposite direction in state M to clear up the bank excess demand and excess supply, while in state H each bank must satisfy its own demand with its own resources.

4 Interbank Deposit Market

Consider now the decentralized economy in which each bank directly offers a risk-sharing contract to its depositors and investors. We would like to know whether optimal risk sharing can also be achieved in this case. We assume that the banking sector is perfectly competitive and, as a result, banks maximize the ex-ante utility of their depositors.[11] This

the unrestricted problem automatically satifies such incentives constraints. This means that the first-best allocation is also incentive efficient (see Proposition 1).

[11]Notice that we consider an economy of two banks together with their investor and depositor bases. We take these elements as primitives and look at whether banks are able to exploit the available risk-sharing opportunities provided by the interbank market when they act competitively. Competition among banks is however not modelled directly: it may occur between the two banks explicitly considered, but it may also come from potential entrants as well as other banks.

assumption in turn ensures that the decentralized economy achieves optimal risk sharing if and only if the optimal allocation is feasible for each bank, separately. The first-best consumption levels would not entail any feasibility problem in state H as, in this case, each bank's demand for consumption is entirely satisfied using internal resources.[12] However, in state M both at $t = 1$ and $t = 2$, one bank has an excess demand for consumption while the other bank has an excess supply of exactly the same amount.

One way to overcome this problem is to allow banks to exchange deposits at $t = 0$. To verify if this is feasible, assume that each bank offers the first-best allocation and deposits the amount $\omega_H - \omega_M$ with the other bank, under the same conditions applied to individual depositors. This means that when the fraction of early consumers in bank i is ω_H, bank i will behave as an early consumer and withdraw its interbank deposit at $t = 1$. In this case the bank obtains nothing at $t = 2$, whereas at $t = 1$ it gets $(\omega_H - \omega_M)\, c_1^M$ if the fraction of early consumers in the other bank is ω_L (i.e., if the state is M), and $(\omega_H - \omega_M)\, c_1^H$ otherwise (i.e., if the state is H). If the fraction of early consumers in bank i is ω_L, bank i will behave as a late consumer by holding its interbank deposit until $t = 2$, when it will finally withdraw it. In this case the bank obtains zero at $t = 1$ whereas it gets $(\omega_H - \omega_M)\, c_2^M$ at $t = 2$ as the fraction of early consumers in the other bank is ω_H (i.e., the state is definitely M).

We can now verify that the first-best allocation is feasible in the decentralized economy with interbank markets. To this end, notice that at $t = 0$ the net flow of funds between the two banks is zero so that the first-best level of capital e and liquidity y are still compatible with the first-best level of investment in the long asset given by $1 + e - y$. Thereafter, at $t = 1$ in state H the two banks withdraw their deposits at the same time so that the net flow of funds between banks is zero both at $t = 1$ and $t = 2$. First-best consumption levels are feasible within each bank in state H and will therefore remain so also in the presence of the interbank deposits market. In state M the two banks receive asymmetric liquidity shocks so that one bank will withdraw its interbank deposit at $t = 1$ (the bank with the

[12] Notice that the first-best allocation assigns a contingent consumption stream to the agents in each bank. In state H both banks have a large fraction of early consumers but there is no liquidity shortage as the promised level of consumption in this case, c_1^H, is the lowest possible (see Proposition 1). We also allow for contingent consumption plans in the decentralized economy and we therefore abstract from problems of financial distress and default. In any case, the state H represents a situation of strong pressure for immediate consumption at $t = 1$, which however finds a frictionless (and efficient) solution in a reduction of per-capita consumption levels.

high shock), while the other will withdraw at $t = 2$ (the bank with the low shock). For concreteness, let A be the bank with the high liquidity shock. In this case in both banks the amount of the short asset at $t = 1$ is $y \geq \omega_M c_1^M + d_1^M$ but bank A needs $\omega_H c_1^M + d_1^M$ at $t = 1$ to cover its withdrawals and pay the promised amount to investors. Bank A redeems its interbank deposit at $t = 1$ and receives the amount $(\omega_H - \omega_M)\, c_1^M$. Therefore it is able to satisfy its budget constraint:

$$\omega_H c_1^M + d_1^M = \omega_M c_1^M + d_1^M + (\omega_H - \omega_M)\, c_1^M \leq y + (\omega_H - \omega_M)\, c_1^M.$$

Bank B faces withdrawals from both its depositors and from bank A, and pays d_1^M to investors. Hence, the total amount of resources needed at $t = 1$ by bank B is

$$\omega_L c_1^M + d_1^M + (\omega_H - \omega_M)\, c_1^M.$$

However, it is also able to satisfy its budget constraint:

$$\omega_L c_1^M + d_1^M + (\omega_H - \omega_M)\, c_1^M = \omega_M c_1^M + d_1^M \leq y.$$

Budget constraints are also satisfied at $t = 2$, and the case in which bank B receives the high liquidity shock is similar. Let $m_t^s = (\omega_H - \omega_M)\, c_t^s$ denote the amount that banks can withdraw at $t = 1, 2$, in state $s = H, M$. Table 2 below summarizes the net flow of funds between banks, as well as their net interbank positions, denoted by π_t^s at time t and state s. A bank net position is positive when it is a net borrower (a debtor), and negative when it is a net lender (a creditor).[13] Notice that the interbank net position can only be different from zero at $t = 1$. Indeed, interbank deposits capture a market for liquidity at $t = 1$ and we will mainly refer to π_1^s in what follows.

5 First-Best Allocation

In this section we further characterize the first-best allocation and we study the role of both bank capital and interbank deposit in achieving optimal risk sharing. In a nutshell, interbank markets can only work when bank liquidity needs are asymmetric, that is in

[13]Notice that at $t = 0$ the two banks exchange exactly the same amount of resources and, therefore, the net interbank flows and positions are both equal to zero.

Table 2: Net interbank flows and positions

State		A				B			
$\mathcal{S}$	$\mathcal{S}'$	$\text{flows}^s_{t=1}$	π^s_1	$\text{flows}^s_{t=2}$	π^s_2	$\text{flows}^s_{t=1}$	π^s_1	$\text{flows}^s_{t=2}$	π^s_2
HH	H	$m^H_1 - m^H_1 = 0$	0	0	0	$m^H_1 - m^H_1 = 0$	0	0	0
HL	M	m^M_1	m^M_1	$-m^M_2$	0	$-m^M_1$	$-m^M_1$	m^M_2	0
LH	M	$-m^M_1$	$-m^M_1$	m^M_2	0	m^M_1	m^M_1	$-m^M_2$	0

state M. The existence of undiversifiable liquidity uncertainty (i.e., the possibility of liquidity shocks that cannot be diversified away through the interbank market) creates a scope for bank capital. In fact, by raising bank capital, part of this undiversifiable risk can be transferred to risk-neutral investors. The following result summarizes some basic properties of the first-best allocation.

Proposition 1 *Assume $p < 1$ and consider the first-best allocation. We have*

$$c^H_1 < c^M_1 \leq c^M_2 < c^H_2.$$

Moreover, $d^M_1 \geq d^H_1 = 0$; $d^H_2 \geq d^M_2 = 0$; and positive rollover either occurs in state M, in which case $c^M_1 = c^M_2$, or it never occurs, in which case $c^M_1 < c^M_2$.

This result is proved in Appendix A and clarifies that as bank capital is costly, undiversifiable uncertainty makes it impossible for banks to offer full insurance to risk-averse depositors. In particular, first-period (second-period) consumption tends to decrease (increase) with the overall fraction of early consumers. Risk-neutral investors can bear the uncertainty more efficiently. Banks can partially transfer the undiversifiable uncertainty to investors by collecting part of their resources at $t = 0$, in the form of bank capital, in exchange for a contingent payout at $t = 1, 2$. The optimal way of arranging this form of risk sharing is to avoid any bank capital remuneration (i.e., payout to investors) when the marginal utility of depositors is high, that is, in state H at $t = 1$, and in state M at $t = 2$.

In principle, banks could raise enough capital to completely insure depositors against liquidity uncertainty, but this turns out to be suboptimal because bank capital is costly. In fact, when $c^H_2 = c^M_2$, the marginal value of insurance is zero but the marginal cost of capital is positive, as investors incur a marginal cost $\rho_0 > R$ to postpone consumption to $t = 2$, and a marginal cost $\rho_0/\rho_1 > 1$ to postpone consumption to $t = 1$. In any case, the cost of capital is higher than the returns of the available investment opportunities (see

Allen and Gale [5]) and this makes the use of bank capital costly. To conclude this section notice that the first-best level of capital may be zero. This trivial case emerges for example if ρ_0 is too large with respect to ρ_1, and bank capital becomes too costly to be used for risk-sharing purposes. In what follows we therefore exclude this case.

5.1 Bank Capital

The optimal amount of bank capital clearly depends on the scope of the interbank market as measured by p. Let us use the notation $e(p)$ to make this relationship explicit. The variation of the parameter p may capture a change in (1) the degree of connectedness of a bank to the overall interbank market network; (2) the relative importance of local (and diversifiable) shocks to aggregate shocks; and (3) the cross-border position of the national banking system. Intuitively, if p increases, the interbank market can more often be used to smooth liquidity shocks and, as a consequence, the incentive to raise bank capital should be smaller. This intuition is indeed correct when we consider the extreme case of $p = 1$. In this case, an allocation can be simply thought of as an array $(y, e, c_1^M, c_2^M, d_1^M, d_2^M)$, as whatever happens in state H has zero probability and is therefore irrelevant. In this case, the optimal allocation has $e \geq 0$, $d_t^M \geq 0$, and solves

$$\max \omega_M u(c_1^M) + (1 - \omega_M) u(c_2^M) \tag{5}$$

subject to

$$\begin{aligned} \omega_M c_1^M + d_1^M &\leq y, & (6)\\ (1 - \omega_M) c_2^M + d_2^M &\leq (1 + e - y)R + y - \omega_M c_1^M - d_1^M, & (7)\\ \rho_1 d_1^M + d_2^M &\geq \rho_0 e. & (8) \end{aligned}$$

Notice that (6)-(8) must all bind at the solution, and it is possible to verify that the first-order conditions imply

$$e(R - \rho_0) u'(c_2^M) = 0. \tag{9}$$

Clearly, as $\rho_0 > R$ and $u'(c_2^M) > 0$, equation (9) implies that $e = 0$. Hence, with no aggregate uncertainty, the interbank market is sufficient to smooth away liquidity shocks, and there is no need for costly bank capital. A continuity argument now immediately implies

Proposition 2 *If $p' > p$ and p' is sufficiently close to one, whenever $e(p) > 0$ we also have $e(p') < e(p)$.*

In other words, whenever there is some scope for bank capital for risk-sharing purposes, a *substantial* reduction in undiversifiable uncertainty also reduces the optimal level of bank capital. Figure 1 shows a numerical example in which bank capital is decreasing for all values of $p \geq 1/2$, not only for sufficiently high values. The example assumes $R = 1.8$, $\rho_0 = 2$, $\rho_1 = 1.75$, $\omega_H = 0.6$, $\omega_L = 0.4$, and depositors have a constant relative risk aversion of $\gamma = 2$. From panel (a) we can see that bank capital over total assets is indeed decreasing for all values of $p \geq 1/2$. Panel (b) shows that investors receive a payout at $t = 2$ in state H for any $p \in (1/2, 1)$, while a payout at $t = 1$ in state M is only realized when p is below approximately 0.68.

[FIGURE 1]

Surprisingly, however, the negative relationship between the level of bank capital and p is not a general property of the model. This result can be explained since, as shown in Castiglionesi et al. [10] for the case without bank capital, a reduction in the undiversifiable liquidity uncertainty (i.e., an increase in p) can induce a bank to reduce its liquidity ratio and, in some cases, this can ultimately lead to a higher consumption volatility. A similar effect shows up in this case, and can induce banks to increase their capital to moderate the increased consumption volatility brought about by the smaller liquidity ratio induced by a larger p. Eventually, bank capital decreases with p as it approaches one (i.e., as the overall liquidity uncertainty tends to vanish).

Figure 2 shows a numerical example with $R = 1.4$, $\rho_0 = 1.55$, $\rho_1 = 1.50$, $\omega_H = 0.6$, $\omega_L = 0.4$, and in which depositors have a constant relative risk aversion of $\gamma = 2$. From panel (a) we can see that bank capital is indeed slightly increasing until about $p = 0.65$ and decreasing thereafter. Panel (b) shows that the liquidity ratio, defined as $y/(1 + e)$, is always decreasing in p, both when bank capital is optimally set to the levels shown in panel (a), and when it is forced to zero. Panels (c) and (d) show the first- and, respectively, second-period consumption volatility, both with and without bank capital.

[FIGURE 2]

Notice that in the absence of bank capital, consumption volatilities are higher. This confirms that bank capital is used to partially insure depositors against liquidity uncertainty. Notice also that, in the absence of bank capital, the consumption volatility both in the first and in the second period increases with p, for values of p below some threshold. This effect is the result of the reduced liquidity ratio documented in panel (b), and induces banks to increase their capital ratio to deal with the tendency toward an increased consumption volatility. Finally, notice that in the specific example of Figure 2, whenever the undiversifiable liquidity uncertainty decreases (i.e., p increases), the consumption volatility in the second period always decreases in the presence of bank capital, but this is not always the case in the first period, despite the use of increasing levels of capital.

5.2 Bank Capital and Interbank Market Activity

The relationship between bank capital and p is intuitive but difficult to study empirically because of the unobservability of p. What we do observe is a bank's activity in the interbank market at $t = 1$ which is captured by π_1^s, that is, the net borrowing position at $t = 1$. For our purposes it does not matter whether a bank is a net borrower or a net lender (i.e., whether π_1^s is positive or negative) so we take the absolute value of the net position, $|\pi_1^s|$, as our measure of activity in the interbank market. We can now explore how this measure correlates with other observable quantities at $t = 1$. Based on the optimal risk-sharing allocation analyzed in Section 5, Table 3 reports a bank's activity on the interbank market and payouts to investors. Since the net position in the interbank market is taken in absolute value, the distinction between bank A and bank B is immaterial.

Table 3: Payouts and net interbank positions

State	Interbank Activity	Payouts
H	$\left\|\pi_1^H\right\| = 0$	$d_1^H = 0 \quad d_2^H \geq 0$
M	$\left\|\pi_1^M\right\| > 0$	$d_1^M \geq 0 \quad d_2^M = 0$

Let us consider the market value of bank capital at $t = 1$. This can be thought of as the present value of (expected) future payouts to investors. However, after the observation of the state at $t = 1$, the uncertainty about future payouts is completely resolved. The market value of bank capital (in terms of $t = 1$ consumption) in state s is therefore given by d_2^s/ρ_1. It is immediate to see from Table 3 that banks activity on the interbank market $|\pi_1^s|$ has a positive relation with contemporaneous payouts (d_1^s) and a negative relation with future payouts (d_2^s). Since the market value of bank capital is equal to d_2^s/ρ_1, Table 3 shows that it also has a negative relationship with interbank activity.

Consider now the book value of capital, defined as the difference between total assets and total liabilities. It is useful to first look at the balance sheet at $t = 0$, given below, which is the same for both banks. The book capital is e in this case.

Balance sheet at $t = 0$ (both banks)

Assets		Liabilities	
Liquid asset	y		
Long-term asset	$1 + e - y$	Deposits	1
Interbank assets	$\omega_H - \omega_M$	Interbank liabilities	$\omega_H - \omega_M$
Total assets	$1 + e + \omega_H - \omega_M$	Total Liabilities	$1 + \omega_H - \omega_M$
Book capital = e			

At $t = 1$ the composition of the balance sheet varies across states, and in state M it also varies between the two banks since they have different liquidity shock. Consider state H. In this case both banks have a proportion ω_H of early consumers and the total value of deposits before any withdrawal takes place is c_1^H (this is what depositors are entitled, in aggregate, to withdraw at $t = 1$). Because a fraction ω_H of them actually withdraw, the value of remaining deposits ends up being $(1 - \omega_H)c_1^H$. Similarly, the value of interbank deposits before any withdrawal take place is $(\omega_H - \omega_M)c_1^H$, and both banks actually withdraw so the corresponding assets and liabilities disappear from the balance sheet. Finally, no early payout is realized in state H, that is $d_1^H = 0$. The balance sheet of both banks looks therefore as follows.[14]

[14]Notice that the value of the long asset is unchanged at $t = 1$. We use its historical value in the balance sheet because there is no uncertainty on the long-asset return. For our purposes, however, any other criterion producing a constant valuation across states would work as well.

Balance sheet at $t = 1$ in state H (both banks)

Assets		Liabilities	
Liquid asset	$y - \omega_H c_1^H$		
Long-term asset	$1 + e - y$	Deposits	$(1 - \omega_H)c_1^H$
Interbank assets	0	Interbank liabilities	0
Total assets	$1 + e - \omega_H c_1^H$	Total Liabilities	$(1 - \omega_H)c_1^H$
Book capital $= 1 + e - c_1^H \equiv cap_1^H$			

Consider now state M. In this case both banks make an early payout $d_1^M \geq 0$, which is possibly different from zero. The total value of deposits before any withdrawal takes place is c_1^M. Banks however face different fractions of early consumers and behave differently on interbank markets so that their balance sheets are also different. Consider first the balance sheet of the bank facing a fraction ω_H of early consumers. This bank withdraws its interbank deposit but does not face a similar withdrawal from the other bank. Hence, the total amount of liquid resources is $y + (\omega_H - \omega_M)c_1^M$ which is used to pay $\omega_H c_1^M$ to early consumers and d_1^M to investors. The leftover liquidity is $y - \omega_M c_1^M - d_1^M$, which we know to be a non negative amount. The balance sheet of the high-liquidity-need bank looks as follows.

Balance sheet at $t = 1$ in state M (high-liquidity-need bank)

Assets		Liabilities	
Liquid asset	$y - \omega_M c_1^M - d_1^M$		
Long-term asset	$1 + e - y$	Deposits	$(1 - \omega_H)c_1^M$
Interbank assets	0	Interbank liabilities	$(\omega_H - \omega_M)c_1^M$
Total assets	$1 + e - \omega_M c_1^M - d_1^M$	Total Liabilities	$(1 - \omega_M)c_1^M$
Book capital $= 1 + e - c_1^M - d_1^M \equiv cap_1^M$			

Consider still state M but now the bank facing a low fraction of early consumers ω_L. This bank faces a withdrawal from the other bank but does not withdraw its own interbank deposit. The amount of liquid resources available is therefore y and is used to pay $\omega_L c_1^M$ to early consumers, $(\omega_H - \omega_M)c_1^M$ to the other bank, and d_1^M to investors. It can be checked that the leftover liquidity is again $y - \omega_M c_1^M - d_1^M$. The balance sheet of the low-liquidity-need bank is given below.

Balance sheet at $t = 1$ in state M (low-liquidity-need bank)

Assets		Liabilities	
Liquid asset	$y - \omega_M c_1^M - d_1^M$		
Long-term asset	$1 + e - y$	Deposits	$(1 - \omega_L)c_1^M$
Interbank assets	$(\omega_H - \omega_M)c_1^M$	Interbank liabilities	0
Total assets	$1 + e - \omega_L c_1^M - d_1^M$	Total Liabilities	$(1 - \omega_L)c_1^M$
Book capital $= 1 + e - c_1^M - d_1^M = cap_1^M$			

Notice that in state M the book value of bank capital does not depend on the bank's idiosyncratic liquidity shock, even if the structure of the bank's balance sheet does depend on it. Since $c_1^M + d_1^M > c_1^H$, it immediately follows that $cap_1^M < cap_1^H$, which shows that the model also predicts a negative relationship between interbank activity $|\pi_1^s|$ and the book value of bank capital.[15]

The negative relationship between interbank activity and book capital is a consequence of optimal risk sharing. To gain intuition, notice that in state M banks have asymmetric liquidity shocks and use the interbank market essentially to smooth the fraction of early consumers to ω_M. In state H both banks have instead a fraction of early consumers equal to ω_H, which is larger than ω_M. Hence, banks face a larger fraction of late consumers in state M than in state H and, accordingly, their outstanding deposit liabilities at $t = 1$ are larger in state M than in state H. *Ceteris paribus*, this implies a smaller book value of capital in state M than in state H. Moreover, the possible realization of an early payout to investors in state M but not in H, also reduces book capital in M with respect to H.

The previous results can be summarized in the following proposition.

Proposition 3 *The activity on the interbank market at $t = 1$, as measured by $|\pi_1^s|$, has a negative relationship with the level of bank capital at $t = 1$, measured both in book and market values.*

[15] The model predicts also a negative relationship between interbank activity and bank capital when we consider values normalized by total assets (as we do in the empirical part). This result follows immediately if total assets in state M are at least as large as in state H, independently of the idiosyncratic liquidity shock faced by banks. In state M, the total assets of the low-liquidity-need bank are smaller than total asset of the high-liquidity-need bank. It is therefore sufficient to check that a bank's total assets in state H are not larger than total asset of the high-liquidity-need bank in state M. This occurs whenever $\omega_H c_1^H \geq \omega_M c_1^M + d_1^M$, which certainly holds because there is no rollover in state H, that is $\omega_H c_1^H = y$, and feasibility requires $\omega_M c_1^M + d_1^M \leq y$.

We now turn to the empirical part of the paper, where we measure bank capital in book value and relate it to banks activity on the interbank market. The advantage of using book capital is that it is available for all commercial banks, which are the objective of our theoretical analysis. The availability of market values for individual commercial banks is instead very limited. Share prices are mostly available for bank holding companies, which often include several different banks and a variety of other non-bank entities, and for which we lack detailed information on the interbank activity.

6 Empirical Analysis

6.1 Data

To test the prediction obtained in the previous section, we need to measure banks' activity in the interbank market. Banks' transactions on the interbank market typically take place over the counter and detailed data are not publicly available. However, information on banks' interbank activity can be obtained from the quarterly Federal Financial Institutions Examination Council (FFIEC) Reports of Condition and Income (briefly, "Call Reports"), which all regulated commercial banks file with their primary regulator. Call Reports contain detailed on- and off-balance-sheet information for all banks.[16] We build a quarterly panel dataset spanning from the first quarter of 2002 to the fourth quarter of 2010. After excluding banks that do not report their interbank market exposure or their capital, we end up with an unbalanced panel of 3,311 banks.[17]

To measure the activity of a bank on the interbank market, we consider its position vis-a-vis other banks at the time of the quarterly balance-sheet closure. We look at three different types of interbank transactions: (a) Unsecured interbank lending and borrowing;

[16] We consider the Call Reports for banks with foreign offices (FFIEC031) and for banks with domestic offices (FFIEC041). Data are retrieved from the FFIEC repository database available at https://cdr.ffiec.gov/public.

[17] The FFIEC repository database contains information on 10,092 banks. Only banks with total assets of at least $300 million must report their positions on the unsecured interbank market, otherwise they have discretion to report this information. Banks with total assets below $300 million represent 15% of our sample of 3,311 banks. We present the results with the sample of all banks that report the information, however all our results (with one exception, see Section 6.3) still hold if we exclude banks with total assets below $300 million.

(b) Securities purchased under agreements to resell and securities sold under agreements to repurchase, i.e. Repos and Reverse Repos, with a maturity longer than one day; (c) Lending and borrowing on the overnight Federal Funds market that also includes overnight Repos. We focus our analysis on the unsecured interbank lending and borrowing positions normalized by total assets (*Interbank_ a*) and the overall interbank activity, adding Repo and Fed Funds positions to those in the unsecured market, normalized by total assets (*Interbank_ abc*). We take the absolute value of the difference between borrowing and lending positions as the empirical counterpart of $|\pi_1|$.

As for bank capital (*Capital*), we consider a broad definition that includes equity and reserves as well as preferred stock and hybrid capital. Our model focuses on the risk-sharing function of bank capital, that is, on the possibilities it offers to deal with banks' liquidity shocks. For this reason any source of funding with a long maturity and no collateral could be considered as a good proxy for the capital variable included in our model. We measure bank capital with its book value normalized by total assets.

To test the contemporaneous negative relationship between a bank's activity in the interbank market and the level of its capital (Proposition 3), we include a series of balance-sheet variables to control for other factors that might induce a spurious correlation.[18] Indeed, other variables can affect the determination of bank capital and the ability of a bank to borrow (and in general to be active) in the interbank markets.

The first set of control variables contains measures related to the liquidity holding of banks. The first variable is cash and government securities (*Liquidity*), while the second is the amount of money deposited with the FED (*DepositsFED*). We also control for the amount of outstanding loans (*Loans*) and deposits (*Deposits*) a bank has. We use risk-weighted assets (*RWA*) as a measure of the riskiness of a bank. Furthermore, we include the return on assets (*ROA*) to capture the impact of a bank's profitability on the relationship between bank capital and interbank market activity. All the previous control variables are normalized by total assets. We also control for bank size (*Size*), measured by total assets.

Finally, the activity of an individual bank in the interbank market can be affected by the size of the market itself. We use three proxies for the size of the interbank market. First, for each bank we calculate the total amount lent and borrowed in the interbank market by other banks located in the same state as the given bank, normalized by their

[18] In this Section we quickly describe the main variables used in the analysis. Table B1 (panel A) in Appendix B contains detailed definitions for all variables.

total assets (*Other_ Banks_ Lend* and *Other_ Banks_ Borrow*, respectively). Second, for each bank we calculate the liquidity holdings of other banks located in the same state, normalized by their total assets (*Other_ Banks_ Liquidity*).

Table 4 provides descriptive statistics for our main variables, and shows that the sample exhibits considerable heterogeneity. The average unsecured interbank market activity (*Interbank_ a*) is 2.27% of total assets, and the median is 0.91% of total assets. Including Repos and Fed Funds, the average interbank activity (*Interbank_ abc*) becomes 5.50% of total assets with a median of 3.14%. Notice that the dispersion is rather significant: the variable *Interbank_ a* ranges from 0.03% at the 5th percentile to 8.46% at the 95th percentile, and if we consider *Interbank_ abc* the dispersion is even larger (0.18% to 18.25%). The same applies to bank capital. On average the variable *Capital* is 10.61% of total assets but the standard deviation is 6.33%. Finally, notice that the mean of the variable *Size* is $5,079 million and the median is $567 million.

[TABLE 4]

6.2 Results

To test for the existence of a negative relationship between bank capital and our measure of interbank activity, we use a regression panel approach to estimate their conditional correlation.[19] In the basic specification, we perform the following panel regression:

$$Interbank_{i,t} = \alpha + \beta Capital_{i,t} + \boldsymbol{\gamma}\mathbf{X}_{i,t} + d_i + d_t + \varepsilon_{i,t}, \tag{10}$$

where $Interbank_{i,t}$ is our measure of interbank activity of bank i at time t, $Capital_{i,t}$ is the capital ratio of bank i at time t, $\mathbf{X}_{i,t}$ contains control variables, and $\varepsilon_{i,t}$ is an error term. We also include bank fixed effects (d_i) and time dummies (d_t) to account for unobserved heterogeneity at the bank level and across time that may be correlated with the explanatory variables. Standard errors are clustered at the bank level to account for heteroscedasticity and serial correlation of errors (see Petersen [25]). The results of the panel estimation of equation (10) are reported in Table 5.

[19] The unconditional correlations of all the variables used in the main regressions are reported in Table B2 in Appendix B.

[TABLE 5]

Regressions (1) and (3) in Table 5 show that interbank market activity is indeed negatively related to bank capital after controlling for banks' risk exposures, liquidity holdings, size, and profitability. The coefficient of the variable *Capital* is -0.094 in regression (1), where the dependent variable is *Interbank_ a*. The same coefficient is -0.085 in regression (3) where the dependent variable is *Interbank_ abc*. These coefficients are significant at the 1% and 5% levels, respectively. The economic significance of these estimates seems relevant as well. For example, in regression (1) a one-standard-deviation increase in the amount of bank capital is associated with a reduction of 0.59% in interbank activity, which represents 26% of its mean and as much as 65% of its median.

The control variables have the expected sign and some of them are also significant. In particular, the variables *Liquidity* and *DepositsFED* are negatively related to interbank market activity. Both these variables are significant at the 1% level. Including the three proxies for the size of the interbank market (regressions (2) and (4) in Table 5) does not affect our results. The variable *Other_ Banks_ Lend* have an insignificant coefficient, while the effect of *Other_ Banks_ Borrow* is positive and significant at the 10% level in regression (2) and insignificant in regression (4). The variable *Other_ Banks_ Liquidity* has instead a negative and significant coefficient. This latter effect indicates that the interbank activity of a given bank reduces when other banks located in the same state hold on to more liquid assets. These results give support to the predictions of the theoretical part of the paper and hence provide evidence of the risk-sharing role of bank capital.

6.3 Robustness

In this section we perform various robustness checks to see whether the empirical results we obtain with the basic specification also hold in a number of different sub-samples of particular interest.

Crisis vs. pre-crisis period. Our theoretical model describes a general mechanism without delivering different predictions for crisis and non-crisis periods. However, it might well be the case that during a crisis the relationship between bank capital and interbank activity is driven by other factors, which are not captured in our theoretical analysis. Indeed, from the third quarter of 2007, the interbank markets were affected by one of the strongest financial crisis ever recorded. We define the pre-crisis period as the time period between the first quarter of 2002 and the second quarter of 2007, while the rest of the sample period is considered as the crisis period. Table 6 shows that the predicted negative relationship is present both in the pre-crisis and in the crisis periods. The coefficient of the variable *Capital* is negative and significant at 1% in both cases. However, it has a larger magnitude in the crisis period when we take *Interbank_ a* as the dependent variable, suggesting that bank capital and interbank markets might have been even closer substitute during the crisis.[20]

[TABLE 6]

Net Lender vs. Net Borrower banks. A possible concern about our results is that they could be driven by some accounting mechanism. To simplify, assume that the balance sheet of a bank only contains Liquidity (LI), Loans (LO), and Interbank Assets (I_A) on the asset side, and Deposits (D) and Interbank Liabilities (I_L) on the liability side. To abstract from any particular economic mechanism, assume also that these quantities are determined independently of one another. Now, the accounting value of Capital (C) is given by the difference between total assets and total liabilities, that is, $C = LI + LO + I_A - D - I_L$. In this case, the interbank positions I_A and I_L do have a mechanical relation with the level of capital. However, our measure of interbank activity is based on the absolute value of the net borrowing position, that is, $|I_L - I_A|$, and its mechanical relation with bank capital is ambiguous.

We can easily check for the relevance of this accounting issue by separately looking at the sub-samples of net borrowers and net lenders on the interbank market. In fact, our measure of interbank activity coincides with the normalized net borrowing position ($I_L - I_A$) in the sub-sample of banks with $I_L - I_A > 0$, i.e., for net borrower banks in the interbank market. In this case, because $I_L - I_A = LI + LO - D - C$, the accounting relationship between interbank activity and capital is negative. On the other hand, we use the normalized net lending position ($I_A - I_L$) to measure interbank activity in the sub-sample of banks with $I_L - I_A < 0$, i.e., for interbank net lenders. The accounting relationship between interbank activity and capital in this subsample is positive, as $I_A - I_L = C + D - LI - LO$.

[20] A similar result obtains if we alternatively take the third quarter of 2008 as the beginning of the crisis period.

If accounting were a relevant issue we should find regression coefficients of *opposite* signs in the sub-samples of net borrowers and lenders. Regressions (1) and (2) in Table 7 shows that this is not the case. The dependent variable is *Interbank_ a* and the regression coefficients on bank capital are negative and significant in both sub-samples. The regression coefficient is significant at the 1% level for net borrowers and at 10% for net lenders. In regressions (3) and (4) we look separately at the pre-crisis and crisis periods for net lenders, and the significance level rises to 5% before the crisis.[21]

[TABLE 7]

Constrained vs. unconstrained banks. Even if in our theoretical model regulation plays no role, in practice banks do face capital regulation. Hence, it is conceivable that a bank's ability to use its payout policy to deal with liquidity uncertainty is affected by how close it is to the regulatory capital requirement. Table 8 provides regression results for banks that hold a total regulatory capital ratio above 10% and for banks that hold a total regulatory capital ratio below 10%.[22] We can notice that the variable *Capital* has a negative coefficient which is significant at least at the 5% level in all regressions. Moreover, the coefficient of the variable *Capital* has a larger magnitude for banks with a capital ratio below 10% than for those above this threshold.

[TABLE 8]

Alternative interbank market selection. We now check to what extent the negative relationship between bank capital and interbank activity holds when we consider the Repo (*Interbank_ b*) and Fed Funds (*Interbank_ c*) markets separately. We report summary statistics for these two markets in Table 9, and regression results in Table 10.[23]

[21] The negative relationship between interbank activity and bank capital remains negative and significant at 1% when we look separately at the pre-crisis and crisis periods for net borrowers. Moreover, results are similar if we alternatively use *Interbank_ abc* to measure interbank activity. These regressions are available upon request.

[22] Regulatory capital is defined as the sum of Tier 1 and Tier 2 capital over risk-weighted assets. Tier 1 capital mainly includes common equity and disclosed reserves (or retained earnings), whereas Tier 2 is mainly composed of such items as undisclosed reserves, revaluation reserves, general provisions, hybrid instruments, and subordinated debt.

[23] The unconditional correlations of the alternative variables used in the regressions in Tables 10 and 11 are reported in Table B3 in Appendix B.

[TABLES 9 AND 10]

Regression (1) in Table 10 shows that when we take *Interbank_ b* as dependent variable the predicted negative relationship still holds, and the coefficient of the variable *Capital* is significant at the 1% level. However, in regression (2) we use *Interbank_ c* as dependent variable and the coefficient of the variable *Capital* is insignificant. One possible explanation for this result is that banks might use the overnight market mainly to deal with highly transitory liquidity shocks. As payouts to investors are usually realized quarterly, it is less likely that the payout policy can be efficiently used to absorb transitory liquidity shocks. In this sense a flexible payout policy might be a poor substitute for overnight markets.[24]

Finally, regression (3) in Table 10 reports the result when the sum of (net) activities in the unsecured interbank market and in the Repo market (*Interbank_ ab*) is used as a dependent variable. We look at the conditional correlation between bank capital and this variable controlling for the amount of Fed Funds sold and purchased (*Fed_ Funds_ Asset* and *Fed_ Funds_ Liability,* respectively). The latter variables capture a bank's activity on the Fed Funds market and control for the potential substitutability between Fed Funds, Repos, and the unsecured interbank market. Regression (3) shows that the coefficient of the variable *Capital* is significant at the 1% level. Finally, greater activity in the Fed Funds market leads to a lower amount of interbank market activity in the other two markets.

Alternative measure of interbank activity. A possible drawback of the net interbank position in a given quarter is its dependence on the net position in previous quarters, and this might lead to a distorted assessment of interbank activity.[25] We then consider the sum of the borrowing and lending positions in the interbank market as an alternative measure of interbank activity. Notice that this alternative measure might be misleadingly large for banks that, apart from insuring their own liquidity shocks, also act as intermediaries in the market and take, possibly large, borrowing and lending positions at the same time. Consistently with the previous analysis, we indicate with *Sum_ Interbank_ a* and *Sum_ Interbank_ abc* the two measures of interbank activity. Their summary statistics are

[24] The coefficient of the variable *Capital* in regression (2) in Table 10, however, becomes negative and significant if we exclude banks with total assets below $300 million.

[25] For example, assume a bank has a positive net position at the beginning of a certain quarter, i.e., has been a net borrower in the past. Assume also the same bank during the quarter lends an amount that exactly offsets the existing borrowing position. The resulting net position at the end of the quarter is zero, even if the bank has been active in the interbank market.

reported in Table 9. Table 11 shows that also in this case, the coefficient of the variable *Capital* is negative and highly significant in all specifications.[26]

[TABLE 11]

Bankscope data. Finally, we perform a further robustness check by using data on non-U.S. banks. In particular, we use Bankscope to collect yearly balance-sheet information for a sample of 863 European and Japanese commercial from 2005 to 2010. The data does not allow us to distinguish between unsecured interbank lending and Repos, hence our measure of interbank activity (*Interbank*) includes both.[27] Summary statistics are reported in Table 12, which shows that interbank activity in this sample of banks is on average 12.97% of total assets, almost two times what we observe for U.S. banks. The average level of capitalization is instead lower and less dispersed than in the U.S. sample.

[TABLE 12]

The results of the panel estimation of equation (10) with the Bankscope data are reported in Table 13. As before, we include both bank fixed effects and time dummies, and standard errors are clustered at the bank level. Given the relatively short time horizon of the sample, the bank fixed effects are absorbing most of the explanatory power. Nevertheless, we still find a negative and significant coefficient of the variable *Capital*.

[TABLE 13]

[26] We also repeated all the previous robustness checks using the sum of borrowing and lending positions as a measure of interbank activity, and the qualitative results (available upon request) are unaffected.

[27] The detailed description of the variables constructed from the Bankscope dataset is reported in Table B1 (panel B) in Appendix B. The correlation matrix of the Bankscope variables is shown in Table B4 in the same Appendix.

7 Conclusions

In this paper we analyzed a model of multiple banks to study how interbank market activity affects the incentives to hold bank capital for liquidity risk-sharing purposes. We discuss under which conditions the level of bank capital decreases when the coinsurance opportunities offered by interbank markets improve. Moreover, the model predicts a negative relationship between bank capital and interbank market activity. We use the FFIEC quarterly dataset for U.S. banks and Bankscope for European and Japanese banks to empirically validate this theoretical prediction. Our findings are consistent with the view that the risk-sharing role of bank capital is relevant, and should be given more attention in the policy debate. Future research should try to understand how imposing capital requirements affects banks' behavior on interbank markets and, more generally, their ability to handle liquidity shocks. The analysis in this paper suggests that a useful first step in this direction would be the identification of measures of a bank's undiversifiable liquidity risk.

Appendix A: Proofs

To simplify the exposition it is useful to determine optimal levels of consumption for assigned values of y and e when the fraction of early consumers is ω and the stream of dividends paid to investors is d_1, d_2. Formally, given (y, e, d_1, d_2, ω) with $y \in [0, 1+e]$, $\omega \in (0,1)$, $e \geq 0$, $y > d_1 \geq 0$, $(1+e-y)R > d_2 \geq 0$, we consider the value function

$$\begin{aligned} V(y, e, d_1, d_2, \omega) \;\; &\equiv \;\; \max_{c_1, c_2} \{\omega u(c_1) + (1-\omega) u(c_2) \\ &\qquad \text{s.t. } \omega c_1 + d_1 \leq y \text{ and } (1-\omega)c_2 + d_2 \leq (1+e-y) R + y - \omega c_1 - d_1\}, \end{aligned} \tag{11}$$

and we denote with $C_t(y, e, d_1, d_2, \omega)$ the corresponding optimal consumption at t. Lemmas 1 and 2 below summarize some important properties of the value function and the associated consumption policies.

Lemma 1 *The value function V is strictly concave, continuous and differentiable in (y, e, d_1, d_2) with*

$$\partial V / \partial y = u'(C_1) - Ru'(C_2), \tag{12}$$

$$\partial V / \partial e = Ru'(C_2), \tag{13}$$

$$\partial V / \partial d_t = -u'(C_t). \tag{14}$$

The policies C_1 and C_2 are given by

$$\begin{aligned} C_1 &= \min\left\{\frac{y-d_1}{\omega}, y+(1+e-y)\,R-d_1-d_2\right\}, \\ C_2 &= \max\left\{\frac{(1+e-y)\,R-d_2}{1-\omega}, y+(1+e-y)\,R-d_1-d_2\right\}. \end{aligned}$$

Proof. To show the strict concavity of the value function note that if $c=(c_1,c_2)$ and $c'=(c_1',c_2')$ are optimal with $\xi=(y,e,d_1,d_2,\omega)$ and, respectively, $\xi'=(y',e',d_1',d_2',\omega)$, then given $\alpha\in(0,1)$, $c^\alpha=\alpha c+(1-\alpha)c'$ is feasible for $\xi^\alpha=\alpha\xi+(1-\alpha)\xi'$. Now, the strict concavity of u implies that if $\xi\neq\xi'$ then also $c\neq c'$ and, therefore, the strict concavity of V follows from the strict concavity of u. Continuity follows from the theorem of the maximum, and differentiability follows using concavity and a standard perturbation argument to find a differentiable function which bounds V from below. To obtain (12), note that from the envelope theorem

$$\partial V/\partial y=\lambda+(1-R)\,\mu,$$

where λ and μ are the Lagrange multipliers on the two constraints. The problem's first order conditions are

$$\begin{aligned} u'(C_1) &= \lambda+\mu, \\ u'(C_2) &= \mu, \end{aligned}$$

which substituted in the previous expression give (12). Expressions (13) and (14) are obtained similarly, and considering separately the cases $\lambda>0$ (no rollover) and $\lambda=0$ (rollover), it is possible to derive the optimal consumption policies. ■

Lemma 2 *$C_1\le C_2$ for all admissible (y,e,d_1,d_2,ω). In particular given*

$$\widehat{y}=\frac{\omega(R(1+e)-d_2)+(1-\omega)d_1}{1-\omega+\omega R}$$

we distinguish two cases:

(i) *If $y>\widehat{y}$ there is rollover and we have*

$$\frac{y-d_1}{\omega}>C_1=C_2=y+R\,(1+e-y)-d_1-d_2>\frac{(1+e-y)\,R-d_2}{1-\omega},$$

(ii) *If $y \leq \widehat{y}$ there is no rollover and we have*

$$C_1 = \frac{y - d_1}{\omega} \leq y + R(1 + e - y) - d_1 - d_2 \leq \frac{(1 + e - y) R - d_2}{1 - \omega} = C_2,$$

where the inequalities are strict if $y < \widehat{y}$ or otherwise hold as equalities.

Proof of Lemma 2. The proof follows from inspection of C_1 and C_2 in Lemma 1. ■

Since $C_1 \leq C_2$ late consumers never have an incentive to mimic early consumers. Clearly, the opposite is also true so that, even if consumers have private information on their preference shocks, incentive compatibility is not an issue here.

The first best allocation can now be characterized in terms of the value function defined in (11). In particular, consider the following problem

$$\max_{\left(y,e,d_1^M,d_2^M,d_1^H,d_2^H\right)} pV(y, e, d_1^M, d_2^M, \omega_M) + (1 - p)V(y, e, d_1^H, d_2^H, \omega_H) \tag{15}$$

subject to

$$p\left(\rho_1 d_1^M + d_2^M\right) + (1 - p)\left(\rho_1 d_1^H + d_2^H\right) \geq \rho_0 e; \tag{16}$$

$$(d_1^s, d_2^s) \geq 0; \; s = H, M \tag{17}$$

$$e \geq 0. \tag{18}$$

The solution to the above problem provides the first-best values for $\left(y, e, d_1^M, d_2^M, d_1^H, d_2^H\right)$, while first-best consumption levels are given by

$$c_t^s = C_t(y, e, d_1^s, d_2^s, \omega_s).$$

Proof of Proposition 1. The proof is given assuming $e > 0$. In the trivial case $e = 0$ the proof follows similar steps with the understanding that $d_t^s = 0$ for all s and t. Notice that positive rollover cannot be optimal in both states H and M as, in this case, keeping the level of capital and the payouts to investors constant, it would be possible to slightly increase the investment in the long asset without affecting the first-period consumptions levels of depositors. The additional returns could, however, be used to increase second-period consumption levels, clearly yielding a better allocation. Let η be the Lagrange multipliers for (16). Using Lemma 1 and noting that at the optimum $c_t^s = C(y, e, d_1^s, d_2^s, \omega_s)$, first order conditions are

$$pu'(c_1^M) + (1-p)u'(c_1^H) = R\left(pu'(c_2^M) + (1-p)u'(c_2^H)\right) \tag{19}$$

$$R\left(pu'(c_2^M) + (1-p)u'(c_2^H)\right) = \eta\rho_0 \tag{20}$$

$$u'\left(c_1^s\right) \geq \eta\rho_1 \tag{21}$$

$$d_1^s(u'\left(c_1^s\right) - \eta\rho_1) = 0 \tag{22}$$

$$u'\left(c_2^s\right) \geq \eta \tag{23}$$

$$d_2^s(u'\left(c_2^s\right) - \eta) = 0 \tag{24}$$

From (20) we have $\eta > 0$, so that $p\left(\rho_1 d_1^M + d_2^M\right) + (1-p)\left(\rho_1 d_1^H + d_2^H\right) = \rho_0 e$. Since $e > 0$, d_t^s cannot be zero for all s and t. Notice that fixed t it is impossible that d_t^H and d_t^M are both strictly positive. In fact, if $d_1^H > 0$ and $d_1^M > 0$, (22) implies that $u'(c_1^H) = u'(c_1^M) = \eta\rho_1$ which is incompatible with (19) and (20) taken together. Similarly, if $d_2^H > 0$ and $d_2^M > 0$, (24) implies that $u'(c_2^H) = u'(c_2^M) = \eta$ which is incompatible with (20).

The proof is now organized in three steps.

Step 1 shows that we always have $d_1^H = 0$ and $d_2^M = 0$. First, assume by contradiction that $d_1^H > 0$, which immediately implies $d_1^M = 0$. Moreover, (21) - (22) imply $c_1^M \leq c_1^H$, and from Lemma 2 we must have

$$\begin{aligned} c_1^M &= \min\left\{\frac{y}{\omega_M}, y + R\left(1+e-y\right) - d_2^M\right\} \\ &\leq \min\left\{\frac{y - d_1^H}{\omega_H}, y + R\left(1+e-y\right) - d_1^H - d_2^H\right\} = c_1^H, \end{aligned}$$

which is possible only if there is positive rollover in state M. It follows that

$$\begin{aligned} c_1^M &= y + R\left(1+e-y\right) - d_2^M \leq \\ c_1^H &\leq y + R\left(1+e-y\right) - d_1^H - d_2^H, \end{aligned}$$

which in turn implies $d_2^M \geq d_1^H + d_2^H > 0$. As a consequence, (23) - (24) imply $c_2^H \leq c_2^M$, and given that there must be rollover in state M, Lemma 2 implies

$$\begin{aligned} y + R\left(1+e-y\right) - d_1^H - d_2^H &\leq c_2^H \leq \\ c_2^M &= y + R\left(1+e-y\right) - d_2^M \end{aligned}$$

which in turn implies $d_2^M \leq d_1^H + d_2^H$. It follows that $d_2^M = d_1^H + d_2^H$. Hence, $d_2^H < d_2^M$ and we therefore have

$$\begin{aligned} \frac{R(1+e-y)-d_2^H}{1-\omega_H} &> \frac{R(1+e-y)-d_2^M}{1-\omega_M} > \\ y+R(1+e-y)-d_2^M &= y+R(1+e-y)-d_1^H-d_2^H, \end{aligned}$$

meaning that there must also be positive rollover in state H, which is clearly a contradiction. The assumption $d_2^M > 0$ leads to a similar contradiction, so that it must be $d_1^H = 0$ and $d_2^M = 0$ as claimed.

Step 2 establishes that positive rollover is impossible in state H. Assume by contradiction that we do have positive rollover in state H. It follows that $c_1^H = c_2^H$ and (21), (23), and (24) imply $d_2^H = 0$. Hence $d_1^M = e\rho_0/\rho_1 > 0$ is the only positive payout to investors, and (21) - (22) imply $c_1^M \geq c_1^H$. Now we have

$$y+R(1+e-y)-d_1^M \geq c_1^M \geq c_1^H = y+R(1+e-y),$$

which is clearly a contradiction as $d_1^M > 0$.

Step 3 shows how consumption levels are ordered. From Lemma 2 we know that $c_1^M \leq c_2^M$ and this weak inequality holds as an equality if and only if there is positive rollover in state M. It is therefore sufficient to show that $c_1^H < c_2^M$ and $c_2^M < c_2^H$. We distinguish three cases.

(i) $d_2^H > 0$ and $d_1^M > 0$. In this case, (23) and (24) with $d_2^H > 0$ imply $c_2^M \leq c_2^H$ and the inequality must be strict as we would otherwise have $u'(c_2^M) = u'(c_2^H) = \eta$ which is incompatible with (20). Similarly, (21) and (22) with $d_1^M > 0$ imply $c_1^H \leq c_1^M$, and the inequality must be strict as we would otherwise have $u'(c_1^M) = u'(c_1^H) = \eta\rho_1$, which is incompatible with (19) and (20) taken together.

(ii) $d_2^H > 0$ and $d_1^M = 0$. In this case, $c_2^M < c_2^H$ follows from $d_2^H > 0$ as in (i). Furthermore, if there is no rollover in state M we immediately have

$$c_1^H = \frac{y}{\omega_H} < \frac{y}{\omega_L} = c_1^M,$$

whereas in the case of rollover in state M we obtain

$$c_1^M = c_2^M = y+(1+e-y)R > y+(1+e-y)R-d_2^H \geq c_1^H.$$

(iii) $d_2^H = 0$ and $d_1^M > 0$. In this case, $c_1^H < c_1^M$ follows from $d_1^M > 0$ as in (i). Furthermore, if there is no rollover in state M we immediately have

$$c_2^M = \frac{(1+e-y)R}{1-\omega_M} < \frac{(1+e-y)R}{1-\omega_H} = c_2^H,$$

whereas in the case of rollover in state M we obtain

$$c_2^M = c_1^M = y + (1 + e - y)R - d_1^M < y + (1 + e - y)R \leq c_2^H.$$

■

8 Appendix B: Variable Description

We provide here the description of all the variables used in the paper. Panel A in Table B1 reports the detailed description and how the variables have been constructed using the FFIEC dataset, while Panel B shows the variables obtained from the Bankscope dataset.

[TABLE B1]

Moreover, we present unconditional pairwise correlations of the variables of interest. Table B2 shows the correlation matrix of the variables used in the regressions of Table 5. Table B3 reports the correlations between the variables used in the regressions of Table 10 and Table 11. Finally, Table B4 reports the correlations between the variables constructed using Bankscope data.

[TABLES B2, B3 AND B4]

References

[1] Admati, A., P. DeMarzo, M. Hellwig and P. Pfleiderer (2010), "Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive", Stanford GSB Research Paper No. 2065.

[2] Afonso, G., A. Kovner and A. Schoar (2011), "Stressed, not Frozen: The Federal Funds Market in the Financial Crisis", *Journal of Finance*, forthcoming.

[3] Allen, F., E. Carletti and R. Marquez (2011), "Credit Market Competition and Capital Regulation", *Review of Financial Studies*, **24**(4): 983-1018.

[4] Allen, F. and D. Gale (2000), "Financial Contagion", *Journal of Political Economy*, **108**: 1-33.

[5] Allen, F. and D. Gale (2007), "*Understanding Financial Crises*", Oxford University Press, Oxford.

[6] Angelini, P., A. Nobili and C. Picillo (2010), "The Interbank Market after August 2007: What Has Changed, and Why? ", Bank of Italy Working Paper 731.

[7] Bhattacharya, S. and D. Gale (1987), "Preference Shocks, Liquidity and Central Bank Policy" in W. Barnett and K. Singleton (eds.), *New Approaches to Monetary Economics*, Cambridge University Press, Cambridge.

[8] Besanko, D. and G. Kanatas (1996), "The Regulation of Bank Capital: Do Capital Standards Promote Bank Safety?", *Journal of Financial Intermediation*, **5**: 160-183.

[9] Brusco, S. and F. Castiglionesi (2007), "Liquidity Coinsurance, Moral Hazard and Financial Contagion", *Journal of Finance*, **62** (5): 2275-2302.

[10] Castiglionesi, F., F. Feriozzi, and G. Lorenzoni (2010), "Financial Integration and Liquidity Crises", Manuscript, MIT and Tilburg University.

[11] Cocco, J., Gomes F. and N. Martins (2009), "Lending Relationships in the Interbank Market", *Journal of Financial Intermediation*, **18**: 24–48.

[12] Diamond, D., and P. Dybvig (1983), "Bank Runs, Deposit Insurance and Liquidity", *Journal of Political Economy*, **91**: 401-419.

[13] Diamond, D. and R. Rajan (2000), "A Theory of Bank Capital", *Journal of Finance*, **55**(6): 2431-2465.

[14] Flannery, M. and K. Rangan (2008), "What Caused the Bank Capital Build-up of the 1990s?", *Review of Finance*, **12:** 391-429.

[15] Furfine, C. H. (2000), "Interbank Payments and the Daily Federal Funds Rate", *Journal of Monetary Economics*, **46:** 535-553.

[16] Furfine, C. H. (2001), "Banks as Monitors of Other Banks: Evidence from the Overnight Federal Funds Market", *The Journal of Business*, **74**: 33-57.

[17] Furfine, C. H. (2002), "The Interbank Market During a Crisis", *European Economic Review*, **46:** 809-820.

[18] Furlong, F. and M. Keeley (1989), "Capital Regulation and Bank Risk-Taking: A Note", *Journal of Banking and Finance*, **13**: 883-891.

[19] Gale, D. (2004), "Notes on Optimal Capital Regulation" in P. St-Amant and C. Wilkins (eds.), *The Evolving Financial System and Public Policy*, Bank of Canada, Ottawa.

[20] Genotte, G. and D. Pyle (1991), "Capital Controls and Bank Risk", *Journal of Banking and Finance*, **15**: 805-824.

[21] Gropp, R. and F. Heider (2010), "The Determinants of Bank Capital Structure", *Review of Finance*, **14**: 1-36.

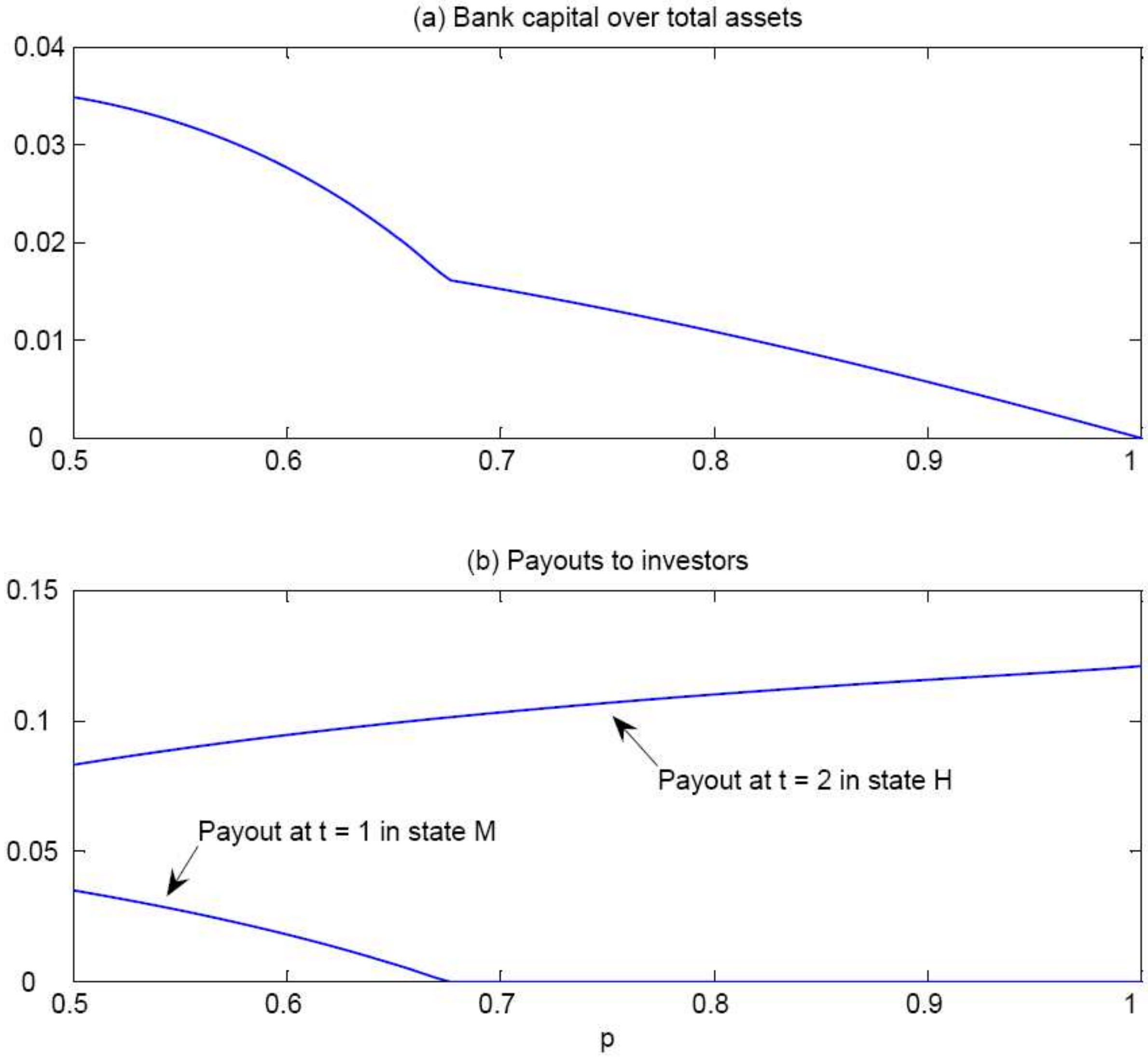
[22] Hellman, T. F., K. Murdock and J. Stiglitz (2000) "Liberalization, Moral Hazard in Banking and Prudential Regulation: Are Capital Requirements Enough?", *American Economic Review*, **90**(1), 147-165.

[23] Kim, D. and A. Santomero (1988), "Risk in Banking and Capital Regulation", *Journal of Finance*, **43**: 1219-1233.

[24] Morrison, A. and L. White (2005), "Crises and Capital Requirements in Banking", *American Economic Review*, **95** (5): 1548-1572.

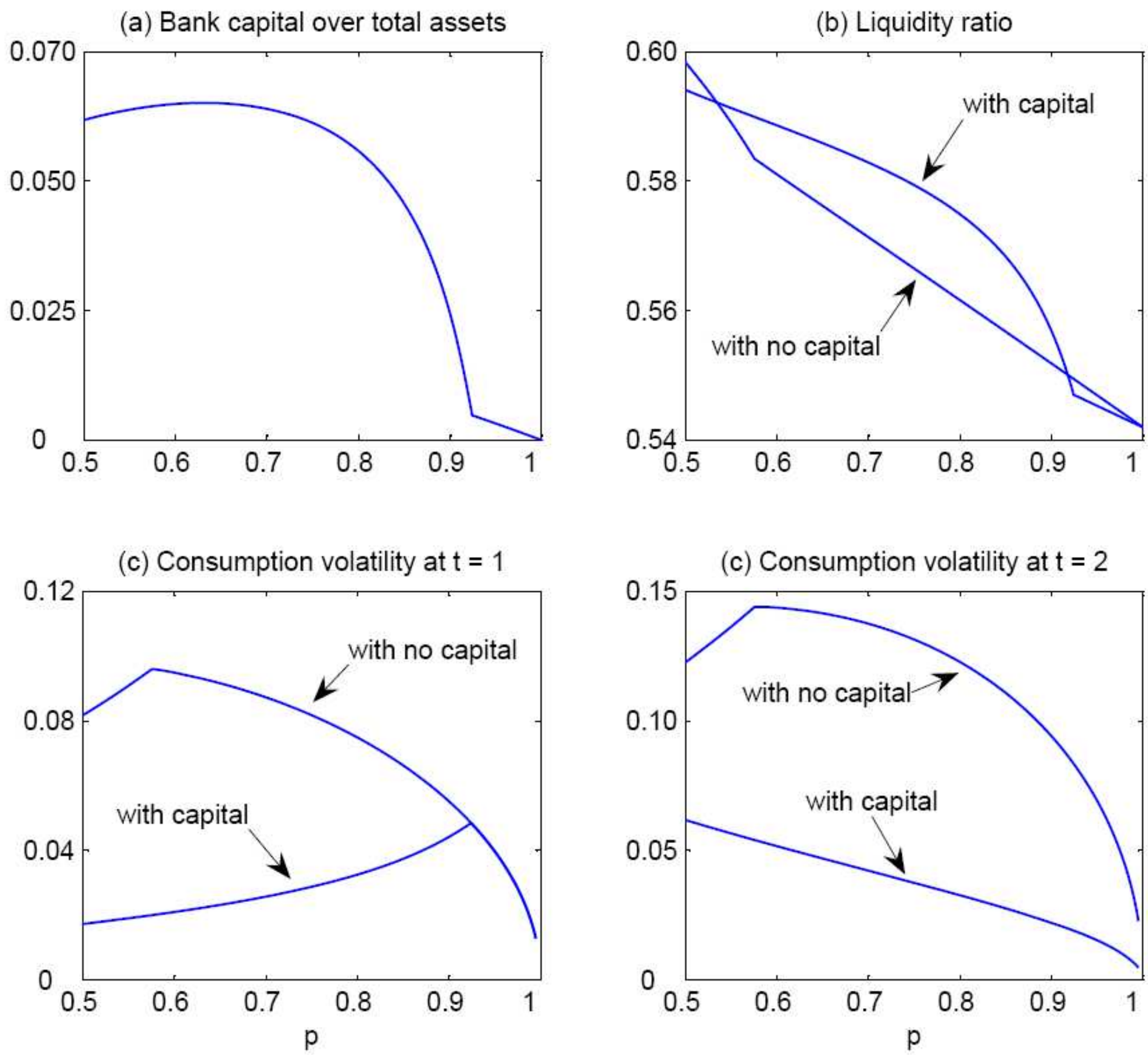
[25] Petersen, M. (2009), "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches", *Review of Financial Studies*, **22**: 435-480.

Figure 1 – Bank capital and payouts for different values of p



Note: This numerical example assumes a constant relative risk aversion of 2. Other parameters are $R = 1.8$, $\rho_0 = 2$, $\rho_1 = 1.75$, $\omega_H = 0.6$, and $\omega_L = 0.4$.

Figure 2 – Bank capital and consumption volatility for different values of p



Note: This numerical example assumes a constant relative risk aversion of 2. Other parameters are $R = 1.4$, $\rho_0 = 1.55$, $\rho_1 = 1.50$, $\omega_H = 0.6$, and $\omega_L = 0.4$.

Table 4 – Summary statistics (I)

Variable	Mean	Stan. Dev.	p5%	Median	p95%
Interbank_a	2.27%	5.17%	0.03%	0.91%	8.46%
Interbank_abc	5.50%	8.04%	0.18%	3.14%	18.25%
Capital	10.61%	6.33%	6.58%	9.28%	17.55%
DepositsFED	1.26%	3.47%	0.00%	0.19%	6.32%
RWA	72.49%	15.14%	46.36%	73.91%	92.96%
Liquidity	19.01%	12.98%	1.57%	16.85%	42.93%
Loans	66.74%	16.34%	35.24%	69.79%	87.03%
Deposits	60.01%	14.42%	36.41%	61.94%	78.58%
ROA	0.55%	1.42%	-0.59%	0.49%	1.63%
Size ($ million)	5,079	48,700	134	567	9,559
Other_Banks_Lend_a	1.27%	1.29%	0.35%	1.00%	3.14%
Other_Banks_Borrow_a	0.51%	0.51%	0.03%	0.36%	1.47%
Other_Banks_Lend_abc	4.18%	3.34%	1.13%	3.18%	10.80%
Other_Banks_Borrow_abc	6.71%	3.90%	2.58%	5.99%	13.04%
Other_Banks_Liquidity	19.35%	6.66%	10.56%	18.27%	32.42%

Note: The sample consists of 66,342 observations from 2002Q1 till 2010Q4. Data is obtained from FFIEC repository database.

Table 5 – Interbank market activity and bank capital

	Interbank_a						Interbank_abc					
	(1)			(2)			(3)			(4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.094	0.033	***	-0.094	0.033	***	-0.085	0.037	**	-0.086	0.037	**
DepositsFED	-0.097	0.020	***	-0.098	0.020	***	-0.427	0.044	***	-0.428	0.044	***
RWA	0.004	0.012		0.003	0.012		-0.022	0.013	*	-0.022	0.013	*
Liquidity	-0.131	0.014	***	-0.132	0.014	***	-0.302	0.023	***	-0.302	0.023	***
Loans	-0.141	0.021	***	-0.141	0.021	***	-0.367	0.023	***	-0.368	0.023	***
Deposits	-0.054	0.008	***	-0.055	0.008	***	-0.103	0.012	***	-0.103	0.012	***
ROA	-0.039	0.036		-0.039	0.036		-0.051	0.050		-0.053	0.049	
Size	-0.008	0.002	***	-0.008	0.002	***	-0.014	0.003	***	-0.014	0.003	***
Other_Banks_Lend_a				0.011	0.016							
Other_Banks_Borrow_a				0.168	0.089	*						
Other_Banks_Lend_abc										-0.020	0.013	
Other_Banks_Borrow_abc										0.020	0.019	
Other_Banks_Liquidity				-0.021	0.009	**				-0.030	0.013	**
Constant	0.290	0.036	***	0.296	0.036	***	0.625	0.050	***	0.633	0.050	***
N. of observations	66,342			66,342			66,342			66,342		
N. of clusters	3,311			3,311			3,311			3,311		
Sample period	2002 Q1: 2010 Q4			2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1428			overall = 0.1463			overall = 0.2305			overall = 0.2331		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table 6 – Interbank market activity and bank capital: crisis vs. pre-crisis period

	Interbank_a						Interbank_abc					
	Pre-crisis (1)			Crisis (2)			Pre-crisis (3)			Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.067	0.023	***	-0.167	0.060	***	-0.131	0.047	***	-0.132	0.045	***
DepositsFED	-0.404	0.098	***	-0.176	0.032	***	-0.557	0.097	***	-0.445	0.045	***
RWA	0.002	0.017		-0.011	0.018		-0.027	0.016	*	-0.032	0.016	*
Liquidity	-0.126	0.019	***	-0.203	0.036	***	-0.354	0.031	***	-0.350	0.042	***
Loans	-0.141	0.035	***	-0.222	0.038	***	-0.428	0.034	***	-0.416	0.035	***
Deposits	-0.035	0.009	***	-0.113	0.016	***	-0.083	0.014	***	-0.183	0.019	***
ROA	-0.062	0.054		-0.058	0.047		-0.021	0.091		-0.079	0.055	
Size	-0.006	0.003	*	-0.020	0.004	***	-0.012	0.005	**	-0.020	0.005	***
Other_Banks_Lend_a	0.014	0.014		0.012	0.038							
Other_Banks_Borrow_a	0.059	0.126		0.038	0.105							
Other_Banks_Lend_abc							-0.025	0.016		-0.012	0.023	
Other_Banks_Borrow_abc							0.018	0.019		0.038	0.022	*
Other_Banks_Liquidity	0.006	0.010		-0.031	0.010	***	-0.052	0.019	***	-0.019	0.016	
Constant	0.249	0.058	***	0.595	0.071	***	0.677	0.078	***	0.828	0.077	***
N. of observations	37,326			29,016			37,326			29,016		
N. of clusters	2,815			2,554			2,815			2,554		
Sample period	2002 Q1: 2007 Q2			2007 Q3: 2010 Q4			2002 Q1: 2007 Q2			2007 Q3: 2010 Q4		
Adjusted R-Squared	overall = 0.0964			overall = 0.1852			overall = 0.2277			overall = 0.2495		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample is split into pre-crisis period (2002Q1 – 2007Q2) and crisis period (2007Q3 – 2010Q4). Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending position of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table 7 – Interbank market activity and bank capital: net lender vs. net borrower banks

	Interbank_a						Interbank_a					
	Net Lenders (1)			Net Borrowers (2)			Net Lenders - Pre-crisis (3)			Net Lenders - Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.073	0.039	*	-0.230	0.036	***	-0.062	0.026	**	-0.131	0.071	*
DepositsFED	-0.139	0.027	***	0.064	0.035	*	-0.357	0.108	***	-0.232	0.040	***
RWA	-0.021	0.011	*	0.086	0.037	**	-0.019	0.020		-0.030	0.012	**
Liquidity	-0.141	0.016	***	-0.035	0.022		-0.142	0.022	***	-0.225	0.043	***
Loans	-0.156	0.024	***	-0.071	0.051		-0.170	0.042	***	-0.230	0.041	***
Deposits	-0.005	0.005		-0.251	0.025	***	-0.005	0.006		-0.019	0.011	*
ROA	0.001	0.042		-0.131	0.067		-0.094	0.057	*	0.018	0.041	
Size	-0.010	0.002	***	-0.020	0.007	***	-0.009	0.003	***	-0.017	0.005	***
Other_Banks_Lend_a	0.030	0.017	*	-0.164	0.072	**	0.019	0.013		0.065	0.038	*
Other_Banks_Borrow_a	0.025	0.067		0.802	0.321	**	-0.005	0.092		0.023	0.101	
Other_Banks_Liquidity	-0.017	0.009	*	-0.022	0.019		0.010	0.010		-0.027	0.009	***
Constant	0.304	0.038	***	0.478	0.097	***	0.311	0.065	***	0.501	0.089	***
N. of observations	54,678			11,215			31,725			22,953		
N. of clusters	3,065			1,265			2,588			2,328		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2007 Q2			2007 Q3: 2010 Q4		
Adjusted R-Squared	overall = 0.1778			overall = 0.2177			overall = 0.1247			overall = 0.2461		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample in split into net lenders and net borrowers in regressions (1) and (2), where net lenders (borrowers) are the banks with less (more) interbank liabilities than assets. In regressions (3) and (4) the sample of net lender banks is further split into pre-crisis period (2002Q1 – 2007Q2) and crisis period (2007Q3 – 2010Q4). The interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table 8 – Interbank market activity and bank capital: constrained vs. unconstrained banks

	Interbank_a						Interbank_abc					
	Unconstrained (CapitalRatio>10%) (1)			Constrained (CapitalRatio<10%) (2)			Unconstrained (CapitalRatio>10%) (3)			Constrained (CapitalRatio<10%) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.088	0.035	**	-0.516	0.194	***	-0.081	0.038	**	-0.454	0.183	**
DepositsFED	-0.107	0.022	***	-0.079	0.082		-0.425	0.044	***	-0.186	0.090	**
RWA	0.005	0.012		-0.062	0.045		-0.020	0.014		-0.052	0.042	
Liquidity	-0.131	0.014	***	-0.047	0.074		-0.301	0.023	***	-0.187	0.081	**
Loans	-0.142	0.022	***	-0.012	0.065		-0.369	0.024	***	-0.154	0.078	**
Deposits	-0.049	0.008	***	-0.317	0.052	***	-0.099	0.012	***	-0.295	0.049	***
ROA	-0.022	0.038		0.132	0.170		-0.025	0.055		-0.065	0.112	
Size	-0.007	0.002	***	-0.022	0.019		-0.014	0.003	***	0.003	0.016	
Other_Banks_Lend_a	0.004	0.015		0.844	0.664							
Other_Banks_Borrow_a	0.142	0.087		0.296	0.804							
Other_Banks_Lend_abc							-0.021	0.013		0.169	0.094	*
Other_Banks_Borrow_abc							0.019	0.019		-0.002	0.106	
Other_Banks_Liquidity	-0.023	0.008	***	0.215	0.184		-0.031	0.013	**	-0.062	0.075	
Constant	0.279	0.036	***	0.555	0.234	**	0.624	0.051	***	0.435	0.213	**
N. of observations	64,862			1,480			64,862			1,480		
N. of clusters	3,298			517			3,298			517		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1424			overall = 0.2275			overall = 0.2249			overall = 0.6008		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample is split into unconstrained banks, i.e., banks with regulatory capital in excess of 10% of risk-weighted assets, and constrained banks, i.e., banks with regulatory capital below 10% of risk-weighted assets. Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table 9 – Summary statistics (II)

Variable	Mean	Stan. Dev.	p5%	Median	p95%
Interbank_b	2.37%	4.63%	0.00%	0.56%	9.50%
Interbank_c	2.84%	5.41%	0.00%	1.15%	10.60%
Interbank_ab	3.77%	6.54%	0.07%	1.82%	13.23%
Fed_Fund_Asset	2.21%	4.85%	0.00%	0.41%	9.15%
Fed_Fund_Liability	0.95%	3.65%	0.00%	0.00%	4.68%
Other_Banks_Lend_b	1.03%	2.27%	0.00%	0.23%	5.59%
Other_Banks_Borrow_b	3.72%	2.75%	0.75%	3.08%	8.62%
Other_Banks_Lend_c	1.87%	1.75%	0.24%	1.46%	4.55%
Other_Banks_Borrow_c	2.48%	3.28%	0.18%	1.67%	7.74%
Other_Banks_Lend_ab	2.30%	2.73%	0.47%	1.47%	7.35%
Other_Banks_Borrow_ab	4.23%	2.75%	1.12%	3.61%	8.89%
Sum_Interbank_a	2.75%	5.70%	0.05%	1.17%	10.49%
Sum_Interbank_abc	8.45%	9.87%	0.63%	5.71%	25.57%

Note: The sample consists of 66,342 observations from 2002Q1 till 2010Q4. Data is obtained from FFIEC repository database.

Table 10 – Interbank market activity and bank capital: Alternative interbank-market selection

	Interbank_b (1)			Interbank_c (2)			Interbank_ab (3)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.104	0.019	***	0.034	0.035		-0.170	0.033	***
DepositsFED	-0.136	0.030	***	-0.363	0.034	***	-0.321	0.036	***
RWA	0.024	0.014	*	-0.047	0.012	***	0.015	0.016	
Liquidity	-0.036	0.017	**	-0.222	0.019	***	-0.222	0.026	***
Loans	-0.127	0.030	***	-0.198	0.024	***	-0.314	0.033	***
Deposits	-0.044	0.006	***	-0.029	0.008	***	-0.099	0.010	***
ROA	0.009	0.022		0.008	0.043		-0.041	0.041	
Size	0.003	0.003		-0.008	0.002	***	-0.008	0.003	**
Other_Banks_Lend_b	-0.003	0.015							
Other_Banks_Borrow_b	0.062	0.027	**						
Other_Banks_Lend_c				0.020	0.015				
Other_Banks_Borrow_c				0.000	0.012				
Other_Banks_Lend_ab							-0.025	0.013	*
Other_Banks_Borrow_ab							0.043	0.039	
Other_Banks_Liquidity	-0.005	0.008		0.001	0.010		-0.028	0.011	***
Fed_Fund_Asset							-0.305	0.033	***
Fed_Fund_Liability							-0.166	0.033	***
Constant	0.091	0.047	*	0.361	0.041	***	0.469	0.059	***
N. of observations	66,342			66,342			66,342		
N. of clusters	3,311			3,311			3,311		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1405			overall = 0.1293			overall = 0.1652		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. *Interbank_b* measures banks activity on the market for Repos with maturities longer than one day. *Interbank_c* measures banks' activity in the overnight market, including overnight Fed Funds and overnight Repos. *Interbank_ab* measures banks' activity on the unsecured interbank market and on the market for Repos with maturities longer than one day. In each case, the interbank activity is measured as the absolute value of the difference between the borrowing and lending positions. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table 11 – Interbank market activity and bank capital: alternative measure of interbank activity

	Sum_Interbank_a						Sum_Interbank_abc					
	(1)			(2)			(3)			(4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.111	0.032	***	-0.112	0.031	***	-0.261	0.047	***	-0.261	0.047	***
DepositsFED	-0.107	0.021	***	-0.107	0.021	***	-0.695	0.035	***	-0.695	0.035	***
RWA	0.002	0.013		0.002	0.013		-0.018	0.017		-0.018	0.017	
Liquidity	-0.148	0.015	***	-0.148	0.015	***	-0.460	0.029	***	-0.461	0.028	***
Loans	-0.152	0.021	***	-0.152	0.021	***	-0.527	0.025	***	-0.528	0.025	***
Deposits	-0.067	0.008	***	-0.068	0.008	***	-0.160	0.013	***	-0.160	0.013	***
ROA	-0.035	0.037		-0.035	0.037		-0.056	0.072		-0.058	0.072	
Size	-0.010	0.002	***	-0.010	0.002	***	-0.013	0.004	***	-0.013	0.004	***
Other_Banks_Lend_a				0.019	0.019							
Other_Banks_Borrow_a				0.166	0.094	*						
Other_Banks_Lend_abc										-0.015	0.014	
Other_Banks_Borrow_abc										0.033	0.021	
Other_Banks_Liquidity				-0.024	0.009					-0.019	0.016	
Constant	0.337	0.039	***	0.344	0.040	***	0.837	0.061	***	0.842	0.061	***
N. of observations	66,342			66,342			66,342			66,342		
N. of clusters	3,311			3,311			3,311			3,311		
Sample period	2002 Q1: 2010 Q4			2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1438			overall = 0.1482			overall = 0.2855			overall = 0.2876		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. Interbank market activity is measured in *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions t*o Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table 12 – Summary statistics: Bankscope data

Variable	Mean	Stan. Dev.	p5%	Median	p95%
Interbank	12.97%	16.48%	0.68%	6.84%	50.24%
Capital	7.88%	4.92%	2.67%	6.60%	17.92%
RWA	67.20%	52.72%	25.18%	59.17%	107.62%
Liquidity	4.59%	9.11%	0.00%	0.29%	23.15%
Loans	63.94%	21.96%	13.89%	68.70%	90.62%
Deposits	56.97%	27.88%	0.61%	59.15%	93.06%
ROA	0.59%	1.22%	-0.59%	0.47%	1.95%
Size ($ million)	65,477	291,715	8	1,507	292,400
Other_Banks_Lend	13.02%	5.19%	6.11%	13.48%	20.56%
Other_Banks_Borrow	14.50%	7.60%	0.55%	16.49%	24.05%
Other_Banks_Liquidity	7.96%	5.79%	1.15%	6.60%	21.74%

Note: The sample includes banks from the EU and Japan from 2005 till 2010. Data is obtained from Bankscope Database.

Table 13 – Interbank market activity and bank capital: Bankscope data

	Interbank (1)			Interbank (2)		
	Coeff.	**Robust SE**		**Coeff.**	**Robust SE**	
Capital	-0.612	0.266	**	-0.554	0.264	**
RWA	0.001	0.003		0.003	0.003	
Liquidity	-0.244	0.105	**	-0.257	0.105	**
Loans	-0.276	0.151	*	-0.270	0.152	*
Deposits	-0.229	0.090	**	-0.219	0.091	**
ROA	-0.004	0.004		-0.005	0.004	
Size	-0.085	0.033	**	-0.083	0.033	**
Other_Banks_Lend				0.082	0.118	
Other_Banks_Borrow				0.287	0.116	**
Other_Banks_Liquidity				0.015	0.097	
Constant	1.215	0.312	***	1.132	0.309	***
N. of obs	1,987			1,987		
N. of clusters	758			758		
Sample period	2005:2010			2005:2010		
Adjusted R-Squared	overall = 0.0321			overall = 0.0361		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. Interbank market activity is measured as the absolute value of the difference between the borrowing and lending positions of an individual bank, normalized by total assets. Definitions of the other variables are given in Table B1 in Appendix B. The sample includes yearly data for banks from the EU and Japan from 2005 till 2010. All regressions include bank fixed effects and time dummies. For both model specifications we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table B1 – Variable Description

PANEL A: U.S. quarterly data from FFIEC

Variable	Description
Interbank_a	Interbank market activity measured as the absolute value of the difference between unsecured borrowing (Deposits due to Banks) and lending (Deposits from Banks) positions of an individual bank, normalized by total assets.
Interbank_abc	Interbank market activity measured as the absolute value of the difference between unsecured borrowing + REPO Liabilities (Securities sold under agreements to repurchase) + Fed Funds Liabilities (Fed Funds purchased) and unsecured lending + REPO Assets (Securities purchased under agreements to resell) + Fed Funds Assets (Fed Funds sold) positions of an individual bank, normalized by total assets.
Capital	Bank capital measured as the sum of the book value of common stocks, preferred stocks (including treasury stocks transactions and related surplus) and hybrid capital, normalized by total assets.
DepositsFED	Balances due from Federal Reserve Banks, normalized by total assets.
RWA	Risk weighted assets measured as total assets, derivatives and off-balance sheet items multiplied by their risk-weight factors + market risk equivalent assets – (allocated transfer risk reserve +excess allowance for loan and lease losses), normalized by total assets.
Liquidity	Liquidity measured as available-for-sale securities+ cash items in process of collection+ unposted debits + currency and coin, normalized by total assets.
Loans	Loans measured as the sum of loans for sales and loans and leases for investment (net of unearned income), normalized by total assets.
Deposits	Deposits correspond to individuals, partnerships, and corporations (include all certified and official checks), normalized by total assets.
ROA	Return on assets measured as net income (including interest income, interest expenses, provision for loans and lease losses, non-interest income, realized gains and losses, non- interest expenses, applicable taxes) normalized by total assets.
Size	Total assets ($ thousand).
Other_Banks_Lend_a	Total amount of unsecured lending position by other banks per quarter and state, normalized by their total assets.
Other_Banks_Borrow_a	Total amount of unsecured borrowing position by other banks per quarter and state, normalized by their total assets.
Other_Banks_Lend_abc	Total amount of interbank lending position (unsecured+REPO+FED FUNDS) by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Borrow_abc	Total amount of interbank borrowing position (unsecured+REPO+FED FUNDS) by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Liquidity	Total amount of liquid assets hold by the other banks per quarter and state, normalized by their total assets.
Interbank_b	Interbank market activity measured as the absolute value of the difference between Securities sold under agreements to repurchase (REPO Liabilities) and Securities purchased under agreements to resell (REPO Assets) positions, normalized by total assets.
Interbank_c	Interbank market activity measured as the absolute value of the difference between Fed Funds purchased (FedFLiab) and Fed Funds sold (FedFAss) positions, normalized by total assets.

Table B1 – Variable Description (Cont.)

Variable	Description
Interbank_ab	Interbank market activity measured as the absolute value of the difference between unsecured borrowing (Due To Banks) + Securities sold under agreements to repurchase (REPO Liabilities) and unsecured lending (Deposit From Banks) + Securities purchased under agreements to resell (REPO Assets) positions over total assets.
Fed_Fund_Asset	Fed Funds sold normalized by total assets.
Fed_Fund_Liability	Fed Funds purchased normalized by total assets.
Other_Banks_Lend_b	Total amount of lending position in the REPO market by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Borrow_b	Total amount of borrowing position in the REPO market by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Lend_c	Total amount of lending position in the FED FUNDS market by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Borrow_c	Total amount of borrowing position in the FED FUNDS market by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Lend_ab	Total amount of interbank lending (unsecured+REPO) by the other banks per quarter and state, normalized by their total assets.
Other_Banks_Borrow_ab	Total amount of interbank borrowing (unsecured+REPO) by the other banks per quarter and state, normalized by their total assets.
Sum_Interbank_a	Interbank market activity measured as the sum of unsecured borrowing and lending positions, normalized by total assets.
Sum_Interbank_abc	Interbank market activity measured as the sum of unsecured+REPO+FED FUNDS borrowing and lending positions, normalized by total assets.

PANEL B: EU and Japanese yearly data from Bankscope

Variable	Description
Interbank	Interbank market activity measured as the absolute value of the difference between the borrowing and lending positions (unsecured+REPO) of individual banks, normalized by total assets.
Capital	Capital measured as the sum of equity, preferred shares, hybrid capital accounted for as equity and retained earnings, normalized by total assets.
RWA	Risk weighted assets measured as tier 1 capital divided by tier 1 capital ratio, normalized by total assets.
Liquidity	Liquidity measured by trading securities, normalized by total assets.
Loans	The sum of customer, mortgages and retail, corporate and commercial, and government loans over total assets.
Deposits	The sum of customer, government, and commercial deposits over total assets.
ROA	Return on assets measured as net income normalized by total assets.
Size	Total assets ($ million).
Other_Banks_Lend	Total amount of lending position in the interbank market by other banks in the same country per year, normalized by their total assets.
Other_Banks_Borrow	Total amount of borrowing position in the interbank market by other banks in the same country per year, normalized by their total assets.
Other_Banks_Liquidity	Total liquid assets held by other banks in the same country per year, normalized by their total assets

Table B2 – Correlation matrix for Table 5

	Interbank_a	Interbank_abc	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_a	Other_Banks_Borrow_a	Other_Banks_Lend_abc	Other_Banks_Borrow_abc	Other_Banks_Liquidity
Interbank_a	1.000														
Interbank_abc	0.581	1.000													
Capital	0.222	0.241	1.000												
DepositsFED	0.053	-0.006	0.014	1.000											
RWA	-0.089	-0.234	-0.082	-0.118	1.000										
Liquidity	-0.139	-0.032	-0.040	-0.089	-0.500	1.000									
Loans	-0.147	-0.323	-0.278	-0.121	0.717	-0.644	1.000								
Deposits	-0.241	-0.352	-0.386	-0.052	0.126	-0.071	0.259	1.000							
ROA	0.037	0.022	0.261	-0.114	0.027	0.052	-0.106	-0.178	1.000						
Size	-0.138	0.008	-0.071	0.026	0.101	-0.008	-0.027	-0.058	0.025	1.000					
Other_Banks_Lend_a	-0.004	0.014	-0.005	0.003	-0.063	0.056	-0.068	-0.014	0.013	0.018	1.000				
Other_Banks_Borrow_a	0.052	0.036	-0.025	0.086	0.057	-0.060	0.027	0.065	-0.076	-0.058	-0.039	1.000			
Other_Banks_Lend_abc	-0.025	0.019	0.012	-0.073	-0.076	0.087	-0.097	-0.050	0.053	0.074	0.530	-0.122	1.000		
Other_Banks_Borrow_abc	-0.010	0.055	-0.027	-0.086	0.004	0.025	0.003	-0.069	0.022	0.040	0.216	-0.052	0.204	1.000	
Other_Banks_Liquidity	-0.080	-0.053	-0.062	-0.037	-0.203	0.159	-0.135	0.037	0.008	0.002	0.113	-0.195	0.072	0.039	1.000

Table B3 – Correlation Matrices for Tables 10 and 11

PANEL A: Repos	Interbank_b	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_b	Other_Banks_Borrow_b	Other_Banks_Liquidity
Interbank_b	1.000											
Capital	-0.074	1.000										
DepositsFED	-0.042	0.014	1.000									
RWA	-0.190	-0.082	-0.118	1.000								
Liquidity	0.207	-0.040	-0.089	-0.500	1.000							
Loans	-0.256	-0.278	-0.121	0.717	-0.644	1.000						
Deposits	-0.186	-0.386	-0.052	0.126	-0.071	0.259	1.000					
ROA	-0.003	0.261	-0.114	0.027	0.052	-0.106	-0.178	1.000				
Size	0.221	-0.071	0.026	0.101	-0.008	-0.027	-0.058	0.025	1.000			
Other_Banks_Lend_b	0.038	0.025	-0.012	-0.053	0.043	-0.063	-0.047	0.019	0.087	1.000		
Other_Banks_Borrow_b	0.199	-0.068	-0.078	-0.106	0.075	-0.050	-0.066	-0.005	0.048	0.356	1.000	
Other_Banks_Liquidity	0.025	-0.062	-0.037	-0.203	0.159	-0.135	0.037	0.008	0.002	-0.036	0.352	1.000

Table B3 – Correlation Matrices for Tables 10 and 11 (Cont.)

PANEL B: Fed Funds	Interbank_c	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks _Lend_c	Other_Banks _Borrow_c	Other_Banks _Liquidity
Interbank_c	1.000											
Capital	0.195	1.000										
DepositsFED	-0.065	0.014	1.000									
RWA	-0.131	-0.082	-0.118	1.000								
Liquidity	-0.074	-0.040	-0.089	-0.500	1.000							
Loans	-0.194	-0.278	-0.121	0.717	-0.644	1.000						
Deposits	-0.210	-0.386	-0.052	0.126	-0.071	0.259	1.000					
ROA	0.007	0.261	-0.114	0.027	0.052	-0.106	-0.178	1.000				
Size	-0.017	-0.071	0.026	0.101	-0.008	-0.027	-0.058	0.025	1.000			
Other_Banks_Lend_c	0.052	-0.006	-0.126	-0.030	0.068	-0.054	-0.023	0.066	0.015	1.000		
Other_Banks_Borrow_c	0.036	0.029	-0.049	0.085	-0.025	0.042	-0.036	0.041	0.016	-0.046	1.000	
Other_Banks_Liquidity	-0.041	-0.062	-0.037	-0.203	0.159	-0.135	0.037	0.008	0.002	0.101	-0.218	1.000

Table B3 – Correlation Matrices for Tables 10 and 11 (Cont.)

PANEL C: Unsecured+Repo	Interbank_ab	Capital	Fed_Fund_Asset	Fed_Fund_Liability	DepoitsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_ab	Other_Banks_Borrow_ab	Other_Banks_Liquidity
Interbank_ab	1.000													
Capital	0.143	1.000												
Fed_Fund_Asset	0.036	0.200	1.000											
Fed_Fund_Liability	0.015	0.017	0.032	1.000										
DepositsFED	0.023	0.014	-0.065	0.001	1.000									
RWA	-0.185	-0.082	-0.172	0.040	-0.118	1.000								
Liquidity	0.017	-0.040	-0.065	-0.039	-0.089	-0.500	1.000							
Loans	-0.274	-0.278	-0.258	0.022	-0.121	0.717	-0.644	1.000						
Deposits	-0.312	-0.386	-0.091	-0.313	-0.052	0.126	-0.071	0.259	1.000					
ROA	0.027	0.261	-0.012	0.039	-0.114	0.027	0.052	-0.106	-0.178	1.000				
Size	0.034	-0.071	-0.104	0.171	0.026	0.101	-0.008	-0.027	-0.058	0.025	1.000			
Other_Banks_Lend_ab	0.022	0.018	0.013	-0.006	-0.008	-0.074	0.062	-0.085	-0.046	0.022	0.081	1.000		
Other_Banks_Borrow_ab	0.104	-0.072	-0.024	-0.024	-0.062	-0.096	0.064	-0.045	-0.054	-0.019	0.037	0.349	1.000	
Other_Banks_Liquidity	-0.043	-0.062	-0.017	-0.048	-0.037	-0.203	0.159	-0.135	0.037	0.008	0.002	0.023	0.316	1.000

Table B3 – Correlation Matrices for Tables 10 and 11 (Cont.)

PANEL D: Sum	Sum_Interbank_a	Sum_Interbank_abc	Capital	DepositsFED	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend_a	Other_Banks_Borrow_a	Other_Banks_Lend_abc	Other_Banks_Borrow_abc	Other_Banks_Liquidity
Sum_Interbank_a	1.000														
Sum_Interbank_abc	0.586	1.000													
Capital	0.202	0.189	1.000												
DepositsFED	0.058	-0.019	0.014	1.000											
RWA	-0.062	-0.201	-0.082	-0.118	1.000										
Liquidity	-0.161	-0.048	-0.040	-0.089	-0.500	1.000									
Loans	-0.115	-0.330	-0.278	-0.121	0.717	-0.644	1.000								
Deposits	-0.242	-0.408	-0.386	-0.052	0.126	-0.071	0.259	1.000							
ROA	0.019	0.022	0.261	-0.114	0.027	0.052	-0.106	-0.178	1.000						
Size	-0.150	0.056	-0.071	0.026	0.101	-0.008	-0.027	-0.058	0.025	1.000					
Other_Banks_Lend_a	-0.008	0.017	-0.005	0.003	-0.063	0.056	-0.068	-0.014	0.013	0.018	1.000				
Other_Banks_Borrow_a	0.068	0.040	-0.025	0.086	0.057	-0.060	0.027	0.065	-0.076	-0.058	-0.039	1.000			
Other_Banks_Lend_abc	-0.032	0.024	0.012	-0.073	-0.076	0.087	-0.097	-0.050	0.053	0.074	0.530	-0.122	1.000		
Other_Banks_Borrow_abc	-0.011	0.065	-0.027	-0.086	0.004	0.025	0.003	-0.069	0.022	0.040	0.216	-0.052	0.204	1.000	
Other_Banks_Liquidity	-0.096	-0.062	-0.062	-0.037	-0.203	0.159	-0.135	0.037	0.008	0.002	0.113	-0.195	0.072	0.039	1.000

Table B4 – Correlation matrix for the Bankscope data

	Interbank	Capital	RWA	Liquidity	Loans	Deposits	ROA	Size	Other_Banks_Lend	Other_Banks_Borrow	Other_Banks_Liquidity
Interbank	1										
Capital	0.0354	1									
RWA	-0.0966	0.2501	1								
Liquidity	0.0077	-0.1608	-0.1875	1							
Loans	-0.1653	0.0855	0.3152	-0.53	1						
Deposits	-0.2876	0.273	0.1983	-0.1619	0.1434	1					
ROA	0.0533	0.2861	0.0717	0.0035	-0.0623	0.1151	1				
Size	-0.042	-0.5276	-0.2862	0.2669	-0.2237	-0.4928	-0.0943	1			
Other_Banks_Lend	0.1782	-0.0845	-0.186	0.1425	-0.2778	-0.1558	-0.0021	0.1057	1		
Other_Banks_Borrow	0.1125	0.1158	-0.025	0.1256	-0.0989	-0.0785	0.0895	0.0737	0.3357	1	
Other_Banks_Liquidity	0.0116	-0.0699	-0.1364	0.2464	-0.2046	-0.1415	0.089	0.2632	-0.044	0.1674	1

FURTHER ROBUSTNESS CHECKS

NOT FOR PUBLICATION

(AVAILABLE UPON REQUEST)

Table E1 – Interbank market activity and bank capital: net lender vs. net borrower banks (II)

	Interbank_abc						Interbank_abc					
	Net Lenders (1)			Net Borrowers (2)			Net Lenders - Pre-Crisis (3)			Net Lenders - Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.080	0.055		-0.228	0.041	***	-0.145	0.068	**	-0.140	0.060	**
DepositsFED	-0.611	0.050	***	0.114	0.043	***	-0.718	0.136	***	-0.669	0.054	***
RWA	-0.054	0.019	***	0.039	0.023	*	-0.052	0.026	**	-0.061	0.023	***
Liquidity	-0.460	0.031	***	0.109	0.028	***	-0.566	0.040	***	-0.486	0.061	***
Loans	-0.493	0.030	***	0.033	0.037		-0.577	0.041	***	-0.555	0.046	***
Deposits	-0.024	0.016		-0.241	0.017	***	-0.012	0.017		-0.079	0.032	**
ROA	0.016	0.069		-0.030	0.070		-0.054	0.099		0.011	0.071	
Size	-0.017	0.006	***	0.006	0.003	*	-0.015	0.009	*	-0.020	0.008	**
Other_Banks_Lend_abc	0.017	0.020		-0.019	0.014		-0.004	0.026		0.009	0.036	
Other_Banks_Borrow_abc	-0.025	0.023		0.063	0.026	**	-0.013	0.030		0.056	0.040	
Other_Banks_Liquidity	-0.030	0.021		0.008	0.018		-0.039	0.031		-0.009	0.028	
Constant	0.754	0.086	***	0.048	0.051	***	0.814	0.129	***	0.878	0.118	***
N. of observations	31,682			31,132			18,184			13,501		
N. of clusters	2,533			2,385			2,020			1,745		
Sample period	2002 Q1: 2010Q4			2002 Q1: 2010Q4			2002 Q1: 2007Q2			2007Q3: 2010Q4		
Adjusted R-Squared	overall = 0.3726			overall = 0.2491			overall = 0.3540			overall = 0.4082		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample in split into net lenders and net borrowers in regressions (1) and (2), where net lenders (borrowers) are the banks with less (more) interbank liabilities than assets. In regressions (3) and (4) the sample of net lender banks is further split into pre-crisis period (2002Q1 – 2007Q2) and crisis period (2007Q3 – 2010Q4). The interbank market activity is measured in *Interbank_abc* as the absolute value of the net interbank position of individual banks normalized by total assets, including the unsecured borrowing and lending positions, as well as Repo and Fed Funds assets and liabilities. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E2 – Interbank market activity and bank capital: net borrower banks, crisis vs. pre-crisis period

	Interbank_a						Interbank_abc					
	Net Borrowers - Pre-crisis (1)			Net Borrowers - Crisis (2)			Net Borrowers - Pre-Crisis (3)			Net Borrowers - Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.181	0.044	***	-0.355	0.073	***	-0.106	0.060	*	-0.223	0.063	***
DepositsFED	-0.454	0.138	***	0.073	0.036	**	-0.170	0.104		0.256	0.042	***
RWA	0.058	0.026	**	0.132	0.069	**	0.016	0.030		0.072	0.033	**
Liquidity	-0.031	0.026		-0.026	0.033		0.173	0.041	***	0.193	0.037	***
Loans	-0.015	0.026		-0.178	0.107	*	0.129	0.048	***	0.103	0.045	**
Deposits	-0.210	0.035	***	-0.338	0.038	***	-0.228	0.025	***	-0.327	0.022	***
ROA	0.181	0.106	*	-0.084	0.078		0.036	0.143		-0.037	0.063	
Size	-0.013	0.008	*	-0.042	0.014	***	0.013	0.006	**	-0.017	0.006	***
Other_Banks_Lend_a	-0.034	0.076		-0.112	0.104							
Other_Banks_Borrow_a	0.680	0.624		0.240	0.297							
Other_Banks_Lend_abc							-0.015	0.016		0.005	0.028	
Other_Banks_Borrow_abc							0.036	0.021	*	0.016	0.025	
Other_Banks_Liquidity	-0.045	0.032		-0.046	0.031		-0.022	0.028		0.008	0.019	
Constant	0.334	0.118	***	0.891	0.206	***	-0.117	0.085		0.332	0.090	***
N. of observations	5,294			5,921			17,115			14,017		
N. of clusters	754			980			1,849			1,844		
Sample period	2002 Q1: 2007Q2			2007 Q3: 2010 Q4			2002 Q1: 2007Q2			2007 Q3: 2010 Q4		
Adjusted R-Squared	overall = 0.2145			overall = 0.1810			overall = 0.2055			overall = 0.1734		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample of net borrowers on the interbank market, i.e.,banks with more interbank liabilities than assets, is split into pre-crisis period (2002Q1 – 2007Q2) and crisis period (2007Q3 – 2010Q4). Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending position of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to Interbank_a. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E3 – Interbank market activity and bank capital: high vs. low activity banks

	Interbank_a						Interbank_abc					
	High Activity (>50°) (1)			Low Activity (<50°) (2)			High Activity (>50°) (3)			Low Activity (<50°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.128	0.046	***	-0.018	0.005	***	-0.127	0.050	**	-0.050	0.033	
DepositsFED	-0.129	0.030	***	-0.019	0.005	***	-0.487	0.060	***	-0.192	0.020	***
RWA	0.009	0.020		-0.003	0.002		-0.018	0.020		-0.015	0.010	
Liquidity	-0.192	0.022	***	-0.023	0.003	***	-0.361	0.029	***	-0.138	0.018	***
Loans	-0.205	0.031	***	-0.018	0.004	***	-0.446	0.028	***	-0.148	0.018	***
Deposits	-0.090	0.013	***	-0.004	0.001		-0.166	0.019	***	-0.011	0.005	**
ROA	-0.045	0.049		0.005	0.012		-0.007	0.070		-0.037	0.029	
Size	-0.012	0.004	***	-0.002	0.001	***	-0.016	0.005	***	-0.006	0.003	**
Other_Banks_Lend_a	0.057	0.063		0.000	0.005							
Other_Banks_Borrow_a	0.272	0.161	*	0.041	0.035							
Other_Banks_Lend_abc							-0.054	0.026	**	0.009	0.007	
Other_Banks_Borrow_abc							0.047	0.036		-0.005	0.009	
Other_Banks_Liquidity	-0.043	0.019	**	0.000	0.002		-0.045	0.028		-0.006	0.006	
Constant	0.430	0.061	***	0.063	0.009	***	0.781	0.080	***	0.253	0.037	***
N. of observations	33,305			33,037			32,762			33,580		
N. of clusters	1,807			1,504			1,751			1,560		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1836			overall = 0.0082			overall = 0.2905			overall = 0.0191		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample is split into high-activity and low-activity banks where high (low) activity banks have an interbank market activity above (below) the median. Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E4– Interbank market activity and bank capital: very high vs. very low activity banks

	Interbank_a						Interbank_abc					
	High Activity (>75°) (1)			Low Activity (<25°) (2)			High Activity (>75°) (3)			Low Activity (<25°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.240	0.061	***	-0.003	0.002		-0.007	0.014		-0.039	0.017	**
DepositsFED	-0.200	0.039	***	-0.002	0.004		-0.034	0.007	***	-0.146	0.023	***
RWA	-0.006	0.023		-0.001	0.001		-0.003	0.006		-0.007	0.006	
Liquidity	-0.269	0.034	***	-0.007	0.002	***	-0.041	0.004	***	-0.099	0.019	***
Loans	-0.287	0.042	***	-0.006	0.002	***	-0.036	0.006	***	-0.105	0.020	***
Deposits	-0.157	0.022	***	-0.002	0.001	*	-0.005	0.002	**	0.004	0.004	
ROA	-0.065	0.066		-0.012	0.007	*	0.000	0.013		-0.026	0.019	
Size	-0.023	0.006	***	-0.001	0.000		-0.002	0.001	*	-0.002	0.002	
Other_Banks_Lend_a	0.178	0.133		0.001	0.002							
Other_Banks_Borrow_a	0.361	0.290		0.042	0.021	**						
Other_Banks_Lend_abc							-0.004	0.007		-0.004	0.005	
Other_Banks_Borrow_abc							0.065	0.037	*	-0.005	0.008	
Other_Banks_Liquidity	-0.089	0.038	**	-0.002	0.002		-0.001	0.004		0.004	0.006	
Constant	0.751	0.097	***	0.020	0.007	***	0.081	0.017	***	0.146	0.029	***
N. of observations	16,484			16,643			49,858			16,613		
N. of clusters	986			764			2,325			796		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.2129			overall = 0.0001			overall = 0.0263			overall = 0.0116		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. We look separately at the subsample of banks with an interbank market activity above the 75th percentile (high-activity banks), and at the subsample of banks with an interbank market activity below the 25th percentile (low-activity banks). Interbank market activity is measured in *Interbank_a* as the absolute value of the difference between the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and as time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E5 – Interbank market activity and bank capital: crisis vs. pre-crisis period

	Sum_Interbank_a						Sum_Interbank_abc					
	Pre-Crisis (1)			Crisis (2)			Pre-crisis (3)			Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.081	0.023	***	-0.207	0.051	***	-0.269	0.047	***	-0.300	0.048	***
DepositsFED	-0.443	0.099	***	-0.212	0.032	***	-0.876	0.142	***	-0.720	0.035	***
RWA	0.005	0.018		-0.027	0.014	*	-0.053	0.020	***	-0.033	0.021	
Liquidity	-0.137	0.020	***	-0.235	0.036	***	-0.514	0.033	***	-0.539	0.042	***
Loans	-0.154	0.035	***	-0.238	0.034	***	-0.584	0.030	***	-0.620	0.039	***
Deposits	-0.044	0.009	***	-0.132	0.016	***	-0.131	0.015	***	-0.234	0.020	***
ROA	-0.068	0.055		-0.063	0.049		-0.041	0.090		-0.076	0.072	
Size	-0.008	0.003	**	-0.023	0.004	***	-0.006	0.005		-0.028	0.006	***
Other_Banks_Lend_a	0.016	0.015		0.026	0.040							
Other_Banks_Borrow_a	0.064	0.137		0.002	0.110							
Other_Banks_Lend_abc							-0.017	0.016		-0.002	0.023	
Other_Banks_Borrow_abc							0.025	0.018		0.037	0.025	
Other_Banks_Liquidity	0.001	0.011		-0.028	0.011	***	-0.029	0.023		0.002	0.015	
Constant	0.295	0.061	***	0.682	0.072	***	0.818	0.086	***	1.190	0.096	***
N. of obs	37,326			29,016			37,326			29,016		
N. of clusters	2,815			2,554			2,815			2,554		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.0928			overall = 0.1875			overall = 0.2933			overall = 0.2614		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample is split into pre-crisis period (2002Q1 – 2007Q2) and crisis period (2007Q3 – 2010Q4). Interbank market activity is measured in *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E6 – Interbank market activity and bank capital: high activity vs. low activity bank

	Sum_Interbank_a						Sum_Interbank_abc					
	High Activity (>50°) (1)			Low Activity (<50°) (2)			High Activity (>50°) (3)			Low Activity (<50°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.128	0.046	***	-0.018	0.005	***	-0.127	0.050	**	-0.050	0.033	
DepositsFED	-0.129	0.030	***	-0.019	0.005	***	-0.487	0.060	***	-0.192	0.020	***
RWA	0.009	0.020		-0.003	0.002		-0.018	0.020		-0.015	0.010	
Liquidity	-0.192	0.022	***	-0.023	0.003	***	-0.361	0.029	***	-0.138	0.018	***
Loans	-0.205	0.031	***	-0.018	0.004	***	-0.446	0.028	***	-0.148	0.018	***
Deposits	-0.090	0.013	***	-0.004	0.001		-0.166	0.019	***	-0.011	0.005	**
ROA	-0.045	0.049		0.005	0.012		-0.007	0.070		-0.037	0.029	
Size	-0.012	0.004	***	-0.002	0.001	***	-0.016	0.005	***	-0.006	0.003	**
Other_Banks_Lend_a	0.057	0.063		0.000	0.005							
Other_Banks_Borrow_a	0.272	0.161	*	0.041	0.035							
Other_Banks_Lend_abc							-0.054	0.026	**	0.009	0.007	
Other_Banks_Borrow_abc							0.047	0.036		-0.005	0.009	
Other_Banks_Liquidity	-0.043	0.019	**	0.000	0.002		-0.045	0.028		-0.006	0.006	
Constant	0.430	0.061	***	0.063	0.009	***	0.781	0.080	***	0.253	0.037	***
N. of obs	33,305			33,037			32,762			33,580		
N. of clusters	1,807			1,504			1,751			1,560		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1836			overall = 0.0082			overall = 0.2905			overall = 0.0191		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample is split into high-activity and low-activity banks where high (low) activity banks have an interbank market activity above (below) the median. Interbank market activity is measured in *Sum_Interbank_a* as the sum of the absolute value of unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E7– Interbank market activity and bank capital: very high vs. very low activity banks

	Sum_Interbank_a						Sum_Interbank_abc					
	High Activity (>75°) (1)			Low Activity (<25°) (2)			High Activity (>75°) (3)			Low Activity (<25°) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.273	0.060	***	-0.005	0.003	*	-0.018	0.015		-0.096	0.038	**
DepositsFED	-0.216	0.042	***	-0.001	0.004		-0.041	0.007	***	-0.336	0.048	***
RWA	-0.010	0.022		-0.002	0.002		-0.004	0.007		-0.009	0.010	
Liquidity	-0.301	0.036	***	-0.008	0.002	***	-0.049	0.005	***	-0.202	0.037	***
Loans	-0.305	0.041	***	-0.006	0.002	**	-0.042	0.007	***	-0.207	0.041	***
Deposits	-0.184	0.023	***	-0.002	0.001	*	-0.011	0.003	***	-0.026	0.012	**
ROA	-0.050	0.069		-0.014	0.008	*	-0.004	0.015		-0.082	0.031	***
Size	-0.028	0.007	***	-0.001	0.001		-0.003	0.001	*	-0.005	0.003	*
Other_Banks_Lend_a	0.217	0.143		0.004	0.003							
Other_Banks_Borrow_a	0.362	0.297		0.049	0.024	**						
Other_Banks_Lend_abc							-0.003	0.008		-0.013	0.010	
Other_Banks_Borrow_abc							0.051	0.045		0.006	0.013	
Other_Banks_Liquidity	-0.087	0.040	**	-0.003	0.002		-0.004	0.004		0.005	0.008	
Constant	0.874	0.105	***	0.026	0.008	***	0.099	0.019	***	0.325	0.053	***
N. of obs	16,484			16,643			49,858			16,613		
N. of clusters	986			764			2,325			796		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.2052			overall = 0.0000			overall = 0.0303			overall = 0.0397		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. We look separately at the subsample of banks with an interbank market activity above the 75th percentile (high-activity banks), and at the subsample of banks with an interbank market activity below the 25th percentile (low-activity banks). Interbank market activity is measured in *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E8 – Interbank market activity and bank capital: constrained vs. unconstrained banks

	Sum_Interbank_a						Sum_Interbank_abc					
	Unconstrained (CapitalRatio>10%) (1)			Constrained (CapitalRatio<10%) (2)			Unconstrained (CapitalRatio>10%) (3)			Constrained (CapitalRatio<10%) (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.101	0.033	***	-0.836	0.267	***	-0.257	0.048	***	-0.873	0.256	***
DepositsFED	-0.113	0.023	***	-0.305	0.088	***	-0.700	0.036	***	-0.694	0.079	***
RWA	0.004	0.012		-0.092	0.048	*	-0.015	0.018		-0.113	0.063	*
Liquidity	-0.145	0.015	***	-0.220	0.080	***	-0.458	0.029	***	-0.569	0.079	***
Loans	-0.151	0.021	***	-0.152	0.081	*	-0.529	0.026	***	-0.477	0.108	***
Deposits	-0.061	0.008	***	-0.406	0.066	***	-0.156	0.013	***	-0.426	0.057	***
ROA	-0.011	0.040		0.170	0.188		-0.037	0.083		0.002	0.135	
Size	-0.009	0.002	***	-0.013	0.021		-0.013	0.004	***	0.005	0.018	
Other_Banks_Lend_a	0.013	0.017		0.850	0.652							
Other_Banks_Borrow_a	0.141	0.092		0.438	0.803							
Other_Banks_Lend_abc							-0.016	0.014		0.172	0.103	*
Other_Banks_Borrow_abc							0.032	0.021		-0.061	0.106	
Other_Banks_Liquidity	-0.026	0.009	***	0.262	0.185		-0.020	0.016		0.013	0.081	
Constant	0.321	0.038	***	0.654	0.263	**	0.831	0.062	***	0.861	0.255	***
N. of obs	64,862			1,480			64,862			1,480		
N. of clusters	3,298			517			3,298			517		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1448			overall = 0.2671			overall = 0.2798			overall = 0.6152		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. The sample is split into unconstrained banks, i.e., banks with regulatory capital in excess of 10% of risk-weighted assets, and constrained banks, i.e., banks with regulatory capital below 10% of risk-weighted assets. Interbank market activity is measured in *Sum_Interbank_a* as the sum of the absolute value of the unsecured borrowing and lending positions of an individual bank, normalized by total assets. *Sum_Interbank_abc* adds the Repo and Fed Fund positions to *Sum_Interbank_a*. Definitions of the other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.

Table E9 – Interbank market activity and bank capital: Alternative interbank-market selection

	Sum_Interbank_b (1)			Sum_Interbank_c (2)			Sum_Interbank_ab (3)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
Capital	-0.157	0.037	***	0.006	0.035		-0.254	0.035	***
DepositsFED	-0.167	0.031	***	-0.421	0.036	***	-0.437	0.038	***
RWA	0.023	0.014	*	-0.043	0.014	***	0.008	0.017	
Liquidity	-0.069	0.020	***	-0.244	0.020	***	-0.317	0.031	***
Loans	-0.150	0.030	***	-0.225	0.026	***	-0.399	0.033	***
Deposits	-0.055	0.008	***	-0.038	0.008	***	-0.127	0.011	***
ROA	-0.038	0.048		0.016	0.043		-0.070	0.063	
Size	0.006	0.003	*	-0.009	0.003	***	-0.008	0.004	**
Other_Banks_Lend_b	-0.009	0.016							
Other_Banks_Borrow_b	0.095	0.034	***						
Other_Banks_Lend_c				0.020	0.016				
Other_Banks_Borrow_c				0.001	0.013				
Other_Banks_Lend_ab							-0.026	0.015	*
Other_Banks_Borrow_ab							0.078	0.046	*
Other_Banks_Liquidity	0.003	0.012		0.001	0.010		-0.026	0.012	**
Fed_Fund_Asset							-0.389	0.032	***
Fed_Fund_Liability							-0.207	0.035	***
Constant	0.091	0.049	*	0.405	0.045	***	0.601	0.064	***
N. of obs	66,342			66,342			66,342		
N. of clusters	3,311			3,311			3,311		
Sample period	2002Q1:2010Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1986			overall = 0.1177			overall = 0.2012		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. *Sum_Interbank_b* is the banks' activity in the markek for Repos with maturities longer than one day. *Sum_Interbank_c* is the banks' activity in the overnight market, including overnight Fed Funds and overnight Repos. *Sum_Interbank_ab* is the banks' activity on the unsecured interbank market and on the market for Repos with maturities longer than one day. In each case, the activity is measured as the sum of the absolute value of the borrowing and lending positions. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects and time dummies. For each model specification we list regression coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.