Liquidity Coinsurance and Bank Capital*

Fabio Castiglionesi[†] Fabio Feriozzi[‡] Gyöngyi Lóránth[§]
Loriana Pelizzon[¶]

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Abstract

Banks can deal with their liquidity risk by holding liquid resources (self-insurance), by participating in the interbank markets (co-insurance), and by using flexible financing instruments, such as bank capital (risk-sharing). We propose a theoretical model to study how the access to an interbank market affects bank incentives to hold capital. A general insight derived from the model is that, from a risk-sharing perspective it is optimal for banks to postpone payouts to capital investors when they are hit by liquidity shocks that cannot be coinsured in the interbank market, in which case interbank activity is low. This mechanism predicts a negative relationship between a bank's activity in the interbank market and its bank capital that finds strong support in a large sample of US banks, as well as in a sample of European and Japanese banks taken from Bankscope.

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[†]CentER, EBC, Department of Finance, Tilburg University. E-mail: fabio.castiglionesi@uvt.nl.

[‡]CentER, Department of Finance, Tilburg University. E-mail: f.feriozzi@uvt.nl.

[§]University of Vienna and CEPR. E-mail: gyoengyi.loranth@univie.ac.at.

[¶]Univeristy Ca' Foscari of Venice. E-mail: pelizzon@unive.it.

1 Introduction

The management of liquid resources is an important concern for banks. Indeed, banks typically transform short-term liquid liabilities into long-term illiquid assets therefore they face a substantial amount of liquidity risk. A simple way to tackle this uncertainty is to hold liquid reserves, which amounts to self-insuring the liquidity risk. This clearly is costly for banks, as they could instead invest in more productive illiquid or risky assets. Alternatively, banks can participate into interbank markets, where they can exchange resources to coinsure their liquidity risk 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, not possible to coinsure. Second, interbank markets are typically over-the-counter markets and based on a limited number of pre-established connections. So, even an idiosyncratic liquidity shock may be impossible to coinsure in the absence of such pre-established connections.[1] Finally, as capital payouts are not fixed obligations, also the use of bank capital offers an opportunity to deal with the liquidity risk: by taking advantage of the flexible payout policy, 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 capital, interbank market activity, and portfolio choices which arises when banks face uncertain liquidity needs. In particular, we study to what extent the presence of an interbank market reduces a bank's incentives to hold (costly) capital and to invest into liquid assets. We proceed by first introducing a theoretical model to study banks behavior in the presence of interbank markets. The model allows us to gain insights into the risk-sharing role of bank capital, as well as to derive the empirical prediction of a negative relationship between bank capital and interbank market activity. Intuitively, this relationship arises because the optimal payout policy requires that banks postpone payouts to capital investors when they are hit by a liquidity shock that cannot be coinsured in the interbank market. We then show that this prediction

[1] Another reason why interbank markets might offer limited coinsurance opportunities is the presence of moral hazard or adverse selection problems (see for example Bhattacharya and Gale [6]).

[2] Alternatively, and similarly to the corporate finance literature, also in the banking literature bank capital is often considered to either act as a buffer protecting against solvency shocks, or mitigate risk-taking incentives (on this second function see, among others, Brusco and Castiglionesi [8], and Morrison and White [24]).

finds strong support in a large sample of US banks, and also in a sample of European and Japanese banks taken from Bankscope.

Following Gale [18], we model an economy with two banks that collect deposits from risk-averse depositors and capital from risk-neutral investors.[3] Banks have access to two investment opportunities: A short-term liquid asset (a storage technology) and a long-term illiquid asset. The two banks have different depositor bases and face uncertain liquidity needs. Most of the time their liquidity shocks are idiosyncratic, but they also face some probability of receiving a symmetric liquidity shock. The two banks participate in an interbank market which allows them to coinsure against idiosyncratic liquidity shocks. However, the interbank market is of little help in case of a symmetric shock. We refer to liquidity risk that cannot be coinsured in the interbank market as undiversifiable (liquidity) risk. The presence of undiversifiable liquidity uncertainty creates a scope for the use of bank capital as a risk-sharing device. That is, some of the undiversifiable risk can be transferred to risk-neutral investors.

We assume that collecting resources from risk-neutral investors is costly, so that banks would have no capital were the liquidity uncertainty purely idiosyncratic. Clearly, the optimal level of capital crucially depends on the level of liquidity uncertainty that cannot be coinsured 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 undiversifiable uncertainty reduces, this only happens for some parameters configurations. This is due to the fact that a reduction in undiversifiable uncertainty also has an effect on a bank's portfolio choices.

In particular, a lower level of undiversifiable uncertainty induces banks to reduce the investment in the liquid asset and, as in Castiglionesi et al. [9], 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 risk-neutral investors. An important insight that can be derived 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. 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

[3] We assume away any contractual imperfection and allow banks to offer fully contingent contracts to both depositors and investors. Notice that with this assumption the role of bank capital as a buffer against insolvency is immaterial, so it helps clarify its role as a risk-sharing device.

effects have in regressions explaining banks' capital structure (Gropp and Heider [20]).

Unfortunately it is difficult to empirically measure the bank-level undiversifiable liquidity risk. Therefore, to obtain testable empirical predictions, we make use of the following general insight of the model. Bank capital should not be paid in states of the world where the marginal utility of consumption for depositors is high. In particular, when an undiversifiable liquidity shock hits and liquidity needs are high in both banks, depositors' per-capita consumption tends to be low and its marginal utility high. Hence, it is optimal to postpone payouts to capital investors when interbank markets activity is low. The decision about when to realize a payout clearly affects the value of bank capital. Namely, when holders of bank capital are paid, the value of bank capital tends to drop. On the other hand, postponing payouts means higher future payouts to investors, and the value of bank capital should increase as a consequence. Because payouts to bank capital holders occurs (is postponed) when the 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 bank capital.

In the empirical part of the paper we test this prediction and we find that it is strongly supported by the data. The main results are obtained in a large sample of commercial banks in the US. We use their Call Reports to build a quarterly panel dataset spanning from the first quarter of 2002 till the forth quarter of 2010. In particular, for these banks 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 market. We consider the absolute value of the net positions in (a) as our main measure of interbank market activity. However, our results also hold when we add the absolute values of the net position in (b) and (c) to (a). 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.

To test our empirical prediction 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 and time fixed effects. We find strong evidence of a negative relationship, with both our measures of interbank activity. We run several robustness checks to assess the reliability of our findings, and we also replicate our results is a sample of European, UK, and Japanese commercial banks, obtaining yearly data from 2005 to 2009 from Bankscope. Overall, we consider that our evidence strongly support the view that an important role of bank capital is to help manage liquidity risk.

These findings would be difficult to rationalize with other mechanisms. For example, consider the incentive function of bank capital: to the extent that bank capital provide incentive to avoid excess risk taking, more capital should translate into lower insolvency risk, and should results 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 borrower banks.

Even if our paper does not directly address normative issues, our results might be relevant for the policy debate. Theoretically, we highlight the degree of undiversifiable liquidity risk that each bank faces as an important determinant of bank capital. Moreover, we provide evidence that is consistent with this insight. The current debate on bank capital regulation mainly emphasizes its incentive function (see, e.g., Squam Lake Report and Admati et al. [1]). Clearly, we do not intend to dismiss this important role of bank capital, but our results show that its risk-sharing role is at least as 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.

Our paper is related to both theoretical and empirical works in banking. On the theory side, the paper closest to ours is Gale [18]. He also considers the risk-sharing role of bank capital but, contrary to us, his analysis focuses on regulatory aspects. For this purpose, Gale [18] considers spot markets as a way to co-insure against the liquidity shocks. By modeling the interbank market as a device to decentralize the social planner solution, our framework is similar to Allen and Gale [4]. However, following Castiglionesi et al. [9], we assume that aggregate uncertainty is perfectly anticipated by economic agents. More importantly, we analyze the relationship between the liquidity insurance provided by the interbank market and by bank capital, which is outside the scope of the two previous contributions.[4]

[4] 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 taking the reverse is also possible (see Kim and Santomero [23], Furlong and Keeley [17], Gennotte and Pyle [19], Besanko and Kanatas [7] and Hellman et al. [22]). Among the recent contributions, Diamond

On the empirical side, our paper relates to two strands of the literature: one on bank capital and the other on interbank markets. Flannery and Rangan [13] and Gropp and Heider [20] look at the determinants of banks' capital holding. Flannery and Rangan [13] argue that the main cause of capital build-up of large US 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 [20] study the determinants of banks' capital structure and address the questions of whether these determinants 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 ([14], [15] and [16]) analyzes banks' screening and monitoring activity in the Federal Funds market, and the behavior of this market during Russia' sovereign default. Cocco et al. [10] 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. The novelty of our approach is to look at the co-determination of banks' capital holding and their interbank market activity. To the best of our knowledge, neither the theoretical nor the empirical banking literature has explicitly studied this relationship so far.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 analyzes the optimal risk-sharing allocation chosen by a social planner. 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 the 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. Sections 7 concludes. Appendix A contains the proofs, and Appendix B reports the detailed description of the variables and their unconditional correlations.

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and Rajan [12] 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.

2 The Model

The basic model is similar to Gale [18], and provides a rationale for the use of bank capital based on risk sharing. Consider a three-date economy ($t = 0, 1, 2$) with a single good available at each date for both consumption and investment. There are two assets: 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.

There are two banks $i = A, B$ in the economy, 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 [11], 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, that is, when a bank has high liquidity needs (i.e., $\omega^i = \omega_H$), the other bank has low liquidity needs with probability p. In this case there is in principle room for trading on an interbank market to diversify away the liquidity shock. However, with probability $1-p$ both banks face high liquidity needs and in this case the interbank market would be of little help. The economy is therefore characterized by 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 aggregate uncertainty on liquidity needs that is maximum when $p = 1/2$.[5] Notice that, as we assume $p \geq 1/2$, any increase in p represents a reduction in aggregate 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; then, 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,

[5] In fact, the aggregate liquidity shock can be measured by the average fraction of early consumers in the economy, and it 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 $p = 1/2$.

after the state S has been revealed, investors receive the consumption vector $(d_1^S, d_2^S) \geq 0$.[6] Therefore, a risk sharing contract, also called an allocation, offered by the bank is fully described by an array

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

As in Allen and Gale (2000), 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 represents a set of banks connected through an interbank market (to be explicitly introduced in section 4) 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. 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 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 the problem faced by a planner that chooses an allocation to maximize the sum of ex-ante expected utilities of depositors, maintaining investors at their reservation utility (i.e., the utility they can obtain by consuming their endowment at $t = 0$). The planner is unable to observe the preference shock of individual depositors but can observe banks aggregate liquidity shocks. Notice that total liquidity needs in the economy are the same in states HL and LH, and it is therefore optimal for the planner 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

[6] 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 $\{c_t^S\}_{S \in \mathcal{S}; t=1,2}$ and, similarly, risk neutral agents are all given the same contingent consumption plan $\{d_t^S\}_{S \in \mathcal{S}; t=1,2}$.

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 needs in the economy. The third constraint guarantees that investors get at least their reservation utility.[7] The planner's problem is therefore to choose a feasible allocation to maximize

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

Notice that in state H each banks'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

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

[7] 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 the planner's problem automaticaly satifies such incentives constraints. This means that the first-best allocation is also incentive efficient (see Proposition 1).

the excess demand can be cleared up with and 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 states 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. In the decentralized economy an allocation can only be achieved if it 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 demand for consumption is entirely satisfied using internal resources.[8] 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 at $t = 2$ it gets $(\omega_H - \omega_M)\, c_2^M$ as the fraction of early consumers in the other bank is ω_H (i.e., the state is M for sure).

We can now verify that the first-best allocation is feasible in the decentralized economy

[8] 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 economic distress at $t = 1$, with a strong pressure for immediate consumption, which however finds a frictionless (and efficient) solution in a reduction of per-capita consumption levels.

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 at both $t = 1$ 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 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).[9] 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.

[9] 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	$m_1^H - m_1^H = 0$	0	0	0	$m_1^H - m_1^H = 0$	0	0	0
HL	M	m_1^M	m_1^M	$-m_2^M$	0	$-m_1^M$	$-m_1^M$	m_2^M	0
LH	M	$-m_1^M$	$-m_1^M$	m_2^M	0	m_1^M	m_1^M	$-m_2^M$	0

5 First-Best Allocation

In this section we further characterize the first-best allocation and we study how both bank capital and interbank deposit markets play a role in achieving the optimal risk sharing. In a nutshell, interbank markets can only work when bank liquidity needs are asymmetric, that is in state M, but are of little help when both banks are hit by the high liquidity shock. 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 the 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*

$$c_1^H < c_1^M \leq c_2^M < c_2^H.$$

Moreover, $d_1^M \geq d_1^H = 0$; $d_2^H \geq d_2^M = 0$; and positive rollover either occurs in state M, in which case $c_1^M = c_2^M$, or it never occurs, in which case $c_1^M < c_2^M$.

This result is proved in the appendix 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 the liquidity uncertainty, but this turns out to be suboptimal because the use of bank capital is costly, in the sense that investors have a strong preference for time-zero consumption. In fact, when $c_2^H = c_2^M$, 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 we cannot exclude that the first-best level of capital is 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 abstracts from 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 parameter p can be interpreted in a variety of ways. (1) At the level of a single financial institution, p reflects the degree of connectedness to the overall interbank network; (2) At the country level, p is affected by the external position of the banking system; (3) at the level of the overall economy, it reflects the relative importance of regional (and diversifiable) shocks versus aggregate shocks. Intuitively, if p increases, the interbank market can be used more often to smooth the 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

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

Clearly, as $\rho_0 > R$ and $u'(c_2^M) > 0$, (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 constant relative risk aversion $\gamma = 2$. From panel (a) we can see that bank capital over total asset 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, the negative relationship between the level of bank capital and p is not a general property of the model though. This result can be explained since, as shown in Castiglionesi et al. [9] 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 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 constant relative risk aversion $\gamma = 2$. 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 everywhere 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 depends on 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, the net interbank position at $t = 1$. Notice that, as we are mainly interested in the level of liquidity coinsurance provided by the interbank market, it does not matter whether π_1^s is positive or negative (i.e., whether a bank is a net lender or a net borrower). Hence, we take its absolute value as a measure of interbank activity.

In order to develop a testable prediction we can consider what happens to the value of bank capital at $t = 1$, thought of as the value of (expected) future payouts to investors. Notice that, after the observation of the state s at $t = 1$, the uncertainty about future payouts is completely resolved, and the value of bank capital (in terms of $t = 1$ consumption) equals the expected payout at $t = 2$ divided by ρ_1. In this sense, the state s determines the value of bank capital at $t = 1$ and, as it also determines banks' net position in the interbank market on the same date, it ultimately induces a relationship between bank capital and interbank activity which is possible to investigate empirically. Table 3 displays the absolute value of the net positions in the interbank market together with the value of bank capital, both measured at $t = 1$ and as a function of the state. Notice that because the net position in the interbank market is in absolute value, the distinction between bank A and B is immaterial.

Table 3: Bank capital and net interbank position

State	$Cap^s_{t=1}$	$\lvert\pi^s_1\rvert$
H	$d^H_2/\rho_1 \geq 0$	0
M	$d^M_2/\rho_1 = 0$	$m^M_1 > 0$

It is now immediate to check from Table 3 that the following proposition holds.

Proposition 3 *The net position in the interbank market at $t = 1$, as measured by $\lvert\pi_1\rvert$, has a negative relationship with the level of bank capital at $t = 1$.*

We now turn to the empirical section of the paper where we test the existence of the negative relationship between bank capital and interbank market 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 as well as their capital. The interbank market is an Over-the-Counter market and detailed information on the corresponding transactions is not publicly available. Some information on banks' interbank activity can however 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.[10]

We collect quarterly balance-sheet data on the lending and borrowing positions of a given bank with respect the other banks. Therefore this information does not allow us to observe all the interbank flows throughout the quarter, or the positions towards individual banks. Nonetheless, it gives a picture of the overall position a bank has vis-a-vis other banks at the time of the quarterly balance-sheet closure, that we take as a proxy of the interbank activity during the quarter.

We build a quarterly panel dataset spanning from the first quarter of 2002 to the fourth quarter of 2010. In order to identify the activity of a bank on the interbank market we consider three different type of interbank transactions: (a) Unsecured interbank lending and borrowing with a maturity longer than one day (Interbank Deposits); (b) Securities purchased under agreements to resell and securities sold under agreements to repurchase (Repos and Reverse Repos) with a maturity longer than one day; (c) Lending and borrowing on the overnight Federal Funds market (which includes also overnight Repos).[11]

We take the absolute value of the difference between lending and borrowing positions normalized by total assets as the empirical counterpart of $|\pi_1|$, that is, as a measure of activity in the interbank markets. We use the absolute value since we are rather interested in the overall bank's activity in the interbank market than whether a bank is a net lender or a net borrower. A possible drawback of this measure is that a bank's net position in a given quarter might be affected by the net position in previous quarters, and this might produce a distorted assessment of the interbank activity during the quarter.[12] As a robustness check in Section 6.3 we consider the sum of the lending and borrowing positions in the interbank market as an alternative measure of interbank activity. Notice, however, 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,

[10] We consider the Call Reports for banks with foreign offices (FFIEC031) and for banks with domestic offices (FFIEC041). Call Report data are publicly available on the website of the Federal Reserve Bank of Chicago.

[11] In this Section we highlight the content of the relevant variables, a more detailed descriptions of how all the variables are computed can be found in Table B1 (panel A) in Appendix B.

[12] For example, if a bank has a positive net position at the beginning of a certain quarter, i.e., has been a net lender in the past, and during the quarter borrows an amount that exactly offsets the existent lending position, the resulting net position at the end of the quarter is zero, even if the bank has been active in the interbank market.

borrowing and lending positions at the same time.

As for bank capital, we consider a broad definition that includes equity and reserves as well as preferred stock and hybrid capital. Our model does not capture all the peculiarities and the different roles that bank capital may have. Instead, it focuses on its risk-sharing function, that is, on the possibilities it offers to deal with the bank's 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. Finally, we measure bank capital with its book value, and we exclude banks from the sample that do not report their interbank market exposure or capital.

Proposition 3 predicts a contemporaneous negative relationship between a bank's activity in the interbank market and the level of its capital. To test this relationship, we include a series of balance-sheets variables, normalized by total assets, to control for other factors that might induce a spurious correlation. The first variable that we include as a control is a measure of banks liquidity holdings, which comprises cash and government securities as well as money deposited with the FED. The amount of liquid assets is endogenously determined in our model, but we have no clear prediction on its contemporaneous relationship with either a bank's interbank market activity or its capital. Nonetheless, it clearly represents an important covariate.

Earlier literature on bank regulation stressed the role of bank capital in increasing bank solvency. Hence, more capital leads to lower default risk. At the same time, the riskiness of a bank may also affect its ability to borrow from the interbank market as shown by Afonso et al. [2]. Thus, to test the relationship between bank capital and interbank activity we control for bank risk characteristics. We consider two different measures of a bank's riskiness: first, the amount of its loans outstanding as stated in its balance sheet and, second, its risk-weighted assets as declared by the bank in the FFIEC report for determining capital requirements. The relationship between a bank's loan outstanding and its interbank market activity in principle is ambiguous. A larger loan portfolio may result in a larger need to borrow in the interbank market. A larger loan portfolio may however render the borrower more risky, hence it may result in a smaller supply of funds.

We also include the return on assets (ROA) as a further control, to capture the impact of a bank's profitability on both its capital and interbank activity. In fact, a bank's profitability clearly affects the need and the ability to participate in the interbank market and, at the same time, it also has an impact on the level of capital it holds. Furthermore, we also control for bank size that we measure with its total assets.

Finally, the activity of a bank in the interbank market can be clearly affected by the size of the market itself. Therefore, we use two proxies for the size of the interbank market a bank has access to. First, for each bank we calculate the total amount lent and borrowed in the interbank market by other banks located in the *same* State and normalize this number by their total assets. Second, for each bank we calculate the liquidity holdings by others banks located in the *same* State as the given bank and normalize it by their total assets.

Table 4 provides descriptive statistics for our main variables. The sample exhibits considerable heterogeneity in the cross-section. We use two measures for a bank's interbank market activity. IabsTA1 is calculated as the absolute value of the difference between the unsecured interbank lending (Deposits from banks) and borrowing (Deposits due to banks) positions, normalized by total assets. In IabsTA2 we add the Repo and Fed Funds positions, in absolute value and normalized by total assets, to IabsTA1. The average unsecured interbank market activity is 2.38% of total assets in our sample; this ratio is 5.63% if we also include Repo and Fed Funds (IabsTA2), with a median of respectively 0.92% and 3.15%. Notice that the dispersion is rather significant: IabsTA1 ranges from 0.03% for the 5th percentile to 8.71% for the 95th percentile, and if we include Repos and Fed Funds the dispersion is even larger (0.18% to 18.71%). The same applies to bank capital. On average bank capital is 10.8% of total assets but the standard deviation is 7.61%. Finally, notice that the mean of the total book assets is US$ 5,055 million and the median is US$ 566 million. The sample therefore includes large, medium and small banks.

[TABLE 4]

6.2 Results

To test for the existence of the negative relationship between the level of capital banks choose to hold and their interbank market activity, we use a regression panel approach to estimate the conditional correlation among these two variables, controlling for several possible confounding factors.[13] In the basic specification, we perform the following panel regression

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

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

where $Y_{i,t}$ represents the measure of interbank activity of bank i at time t, $CAP_{i,t}$ represents the level of capital held by bank i at time t, $X_{i,t}$ contains the control variables discussed above, and $\varepsilon_{i,t}$ is an error term. We also include time and bank fixed effects (d_t and d_i respectively) to account for unobserved heterogeneity across time and at the bank level 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.

[TABLE 5]

Regressions (1) and (3) in Table 5 show that interbank market activity is negatively related to bank capital after controlling for banks' risk exposures, liquidity holdings, size, and profitability. The coefficient is -0.096 in regression (1), where we only consider unsecured interbank activity (IabsTA1), and -0.08 in regression (3) where we also include Repos and Fed Funds (IabsTA2). These coefficients are significant at the 1% and 5% levels, respectively. The economic significance of these findings also seems relevant. For example, in regression 1 a one-standard-deviation increase in the amount of bank capital is associated with a reduction of 0.73% in interbank activity, which accounts for approximately 12.53% of its standard deviation.

Including the three proxies for the size of the interbank market (regressions (2) and (4)) does not affect our results. The variables capturing the total amount lent and borrowed by the other banks in the same US State (DT_TADueFrom and DT_TADueTo) have a positive but insignificant coefficient. The variable that proxies for the liquidity holdings by other banks in the same State has instead a negative and significant coefficient. This indicates that the interbank activity of a given bank reduces when other banks located in the same State retain more liquidity. Besides the main variables of interest, the control variables have the expected sign and some of them are also significant. In particular, the amount of liquidity held by banks is negatively related to the interbank market activity as well as the deposits at the Fed. Both these variables are significant at a 1% level.

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 subsamples of particular interest.

Crisis vs. pre-crisis period. The sample we have considered in the previous section comprises a crisis period. Indeed, from the third quarter of 2007, the interbank markets were affected by one of the strongest financial crisis ever recorded. Table 6 looks at the relationship between bank capital and interbank market activity separately for the pre-crisis and the crisis period. We define the pre-crisis period as the time period between the first quarter of 2002 and the third quarter of 2007, while the rest of the time series is considered as the crisis period. Our model does not deliver different predictions for crisis and non-crisis periods, it rather points to a general mechanism. However, the relationship between bank capital and interbank market activity might be affected in the crisis period by other factors that are not captured by our model. Table 6 shows that the predicted relationship is present both in the pre-crises and in the crisis periods. Even if the negative relationship between bank capital and interbank activity becomes more pronounced in the crisis period than in the non-crisis period, the coefficient of the bank capital variable is significant in both cases.

[TABLE 6]

High-activity vs. low-activity banks. Banks are heterogenous in our sample in terms of how active they are in the interbank market. One possible concern is that the negative relationship we find between bank capital and interbank market activity is mainly driven by banks with low level of activity in the interbank market. It could be that our results may depend too much on those banks with just a reduced number of relatively small loans outstanding. To address this concern we split our sample into two subsamples containing banks with interbank market activity below and, respectively, above the median. Table 7 shows that the negative relationship between bank capital and interbank market activity holds independently of the level of activity. When we use unsecured interbank market lending (IabsTA1) the coefficient measuring the correlation between bank capital and interbank market activity is significant at a 1% level, both for banks that are more active than the median and for those that are less active than the median. However, the value of the coefficient is much smaller for banks with low level of activity in the interbank market. Once we include both Repo and FedFunds positions (IabsTA2) the 1% significance of the coefficient only remains for banks with an interbank activity higher than the median. In this case, the coefficient for banks with low levels of activity in the interbank market becomes significant only at a 10% level.[14]

[TABLE 7]

Constrained vs. unconstrained banks. In our theoretical model regulation does not have any role. However, in practice banks face capital regulation. Hence, it is conceivable that banks that are close to the regulatory capital requirement might be unable to smooth payouts through the mechanism presented in our model. Table 8 provides regression results for banks that hold capital above 10% of their risk-weighted assets and for banks that hold capital below 10% of their risk-weighted assets. In regressions (1) and (2) we find that when we take unsecured interbank market lending (IabsTA1) the correlation coefficient between bank interbank market activity and bank is negative and significant. Moreover, the coefficient is smaller for banks that hold less than 10% capital than for those that are above this value. When we take our second measure of interbank market activity (IabsTA2), the coefficient remains negative and significant for both subsamples, but its significance is greatly reduced for those banks that are more capitalized.

[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 and Fed Funds markets, separately. We report summary statistics for these two markets in Table 9, and regression results in Table 10.[15]

[14] We also compare banks that are in the 75% percentiles in terms of their interbank market acitivity with those whose interbank market activity is below the 25% percentile. Our qualitative results do not change (results are available upon request).

[15] 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 only consider the Repo market the predicted negative relationship still holds, and the relevant coefficient is significant at a 1% level. However, when we only take transactions on the overnight Fed Funds market (regression (2)), the relationship between bank capital and interbank market activity turns positive and insignificant. One possible explanation for this result might be that banks use the overnight Fed Funds market mainly to deal with highly transitory liquidity shocks, but they use either the Repo market or the interbank-deposit market, where transactions have longer maturities, to face more persistent shocks. As payouts to investors are usually realized quarterly, it is less likely that the payout policy can be efficiently used to absorb highly transitory liquidity shocks, which motivates the transactions on the Fed Funds market. In this sense a flexible payout policy might be a poor substitute for the Fed Funds market. On the other hand, either a Repo or an unsecured loan with a maturity of, say, one to three months, can more naturally be substituted by an adjustment in the payout policy.

Finally, regression (3) in Table 10 reports the result when the sum of (net) activities in the unsecured interbank deposit market and in the Repo market is used as dependent variable. We look at the conditional correlation between bank capital and this variable controlling for the amount of Fed Funds sold and purchased. The latter variables capture a bank's activity on the Fed Funds market and are introduced to control for the potential substitutability between Fed Funds, Repos, and unsecured interbank deposits. Regression (3) shows that the amount of activity in the unsecured interbank and Repo markets negatively correlates with bank capital and the coefficient is significant at a 1% level. It is also the case that a larger 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. We now analyze the robustness of our results by considering the sum of the interbank borrowing and lending positions, instead of the absolute value of the net position. Summary statistics for this alternative measure of interbank activity are reported in Table 9. Table 11 shows that also in this case, the negative relationship between bank capital and interbank activity holds and is highly significant. Most of our control variables are still significant at a 1% level. As in previous regressions, none of the control variables capturing the size of the interbank market have a significant explanatory power, except for the amount of liquidity held by other banks in the same State in regression (2).[16]

[TABLE 11]

Bankscope data. Finally we perform a robustness check of our results by using data on non-US banks. Unfortunately, to our knowledge, there is no database available with quarterly balance-sheet information on banks. Bankscope provides yearly balance-sheet information for a large sample of banks around the world. We use this dataset to investigate interbank market activity for European, UK and Japanese commercial banks. We consider a sample of 877 banks for the period of 2005 to 2009. The data do not allow to distinguish between various forms of interbank markets such as unsecured interbank deposits and Repos. Hence, our interbank market activity variable (IabsTA) includes both.[17] Summary statistics are reported in Table 12, which shows that interbank activity in this sample of banks is on average 12.13% of total assets, almost double of what we observe for US banks. The level of capitalization is instead similar to the US figures but with a larger dispersion.

[TABLE 12]

The results of the panel estimation of equation (10) are reported in Table 13. As before, we include both bank and time fixed effects, and standard errors are clustered at the bank level. Given the limited time series variability the bank fixed effects are absorbing most of the explanatory power of our analysis. However, we still find a negative relationship between interbank market activity and bank capital, the coefficient of the variable IabsTA being -0.107 and significant at a 1.5%. Notice that a bank's interbank activity is here positively and significantly related to the overall interbank activity of the country it belongs to, as measured by DT_TADueFromB and DT_TADueToB. This result

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

[17] 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 of the same Appendix.

contrasts with what found for US banks where the overall activity at the State level was found to be insignificant. An explanation for this different result could be that interbank markets are much more integrated across states in the US than they are across countries in the Bankscope sample.

[TABLE 13]

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 co-insurance opportunities offered by interbank markets improve. Moreover, the model predicts a negative relationship between bank capital and interbank markets activity. We use the FFIEC quarterly dataset for US 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 bank's 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, which in turn should be taken into account in setting capital requirements.

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

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

and we denote with $C_t(y, e, d_1, d_2, \omega)$ the corresponding optimal consumption at t. Lemma 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 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 $C_1 \leq C_2$ *for all* (y, e, d_1, d_2, ω). *In particular given* $\widehat{y} = (\omega(R(1+e) - d_2) + (1-\omega)d_1) / (1 - \omega$ *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 Lemma2. 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 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 constant the level of capital and the payouts to investors, it would be possible to slightly increase the investment in the long asset without affecting 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

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

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

$$u'\left(c_1^s\right) \geq \eta\rho_1 \quad (21)$$

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

$$u'\left(c_2^s\right) \geq \eta \quad (23)$$

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

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 (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 $d_2^M \geq d_1^H + d_2^H$. On the other hand, (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 be positive rollover also 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 stat H. It follows that $c_1^H = c_2^H$ and (21) - (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 $c_2^M < c_2^H$. Remember that we either have $d_2^H > 0$ or $d_1^M > 0$. If $d_2^H > 0$, from (23) - (24) we obtain $c_2^M \leq c_2^H$ but the inequality is impossible as it would contradict (20). We therefore have $c_2^M < c_2^H$ and it is possible to check that this also implies $c_1^M > c_1^H$ with and without positive rollover in state M. A similar argument can be applied if instead we have $d_1^M > 0$, which completes the proof. ■

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 an 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 report 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]

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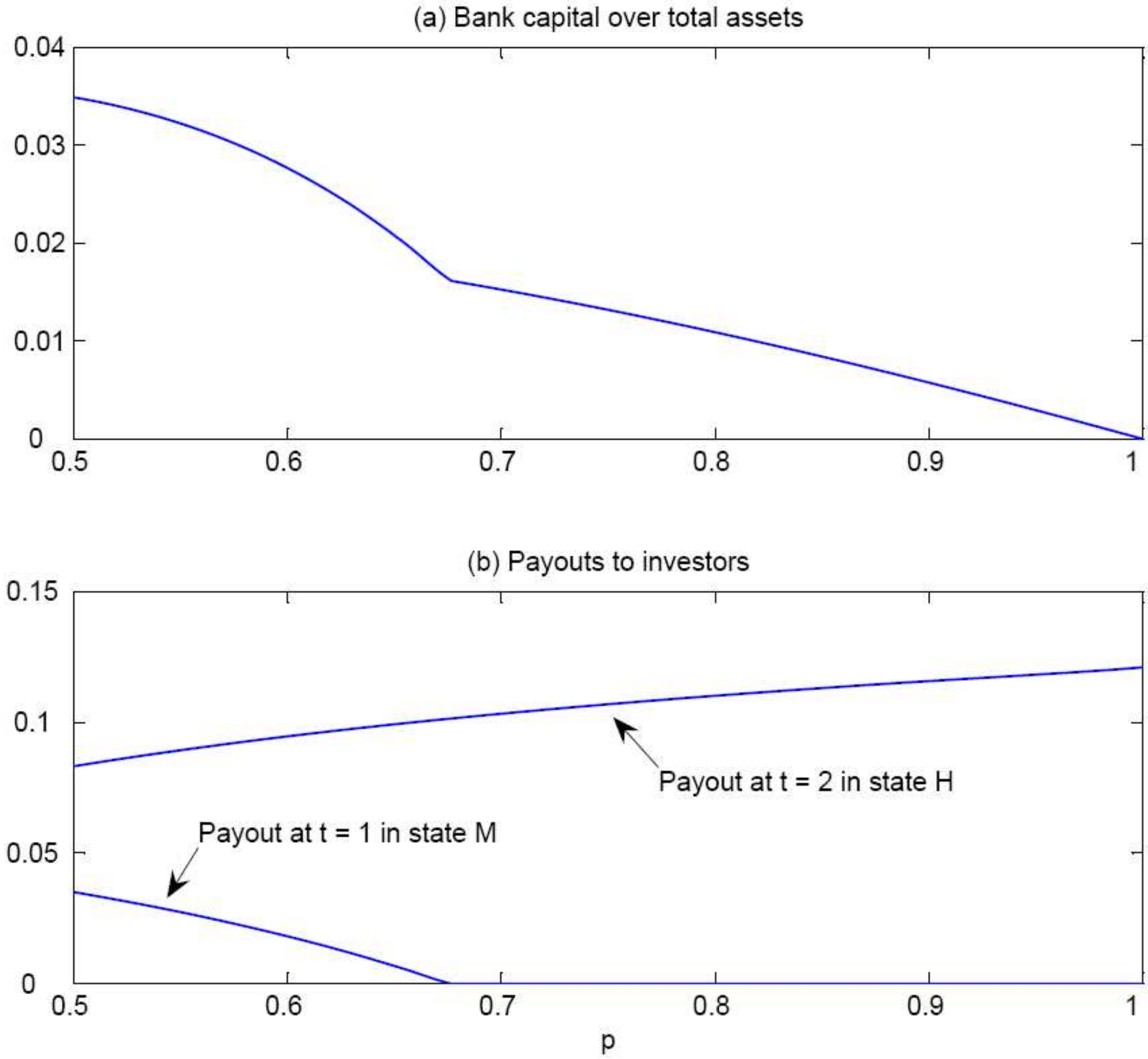
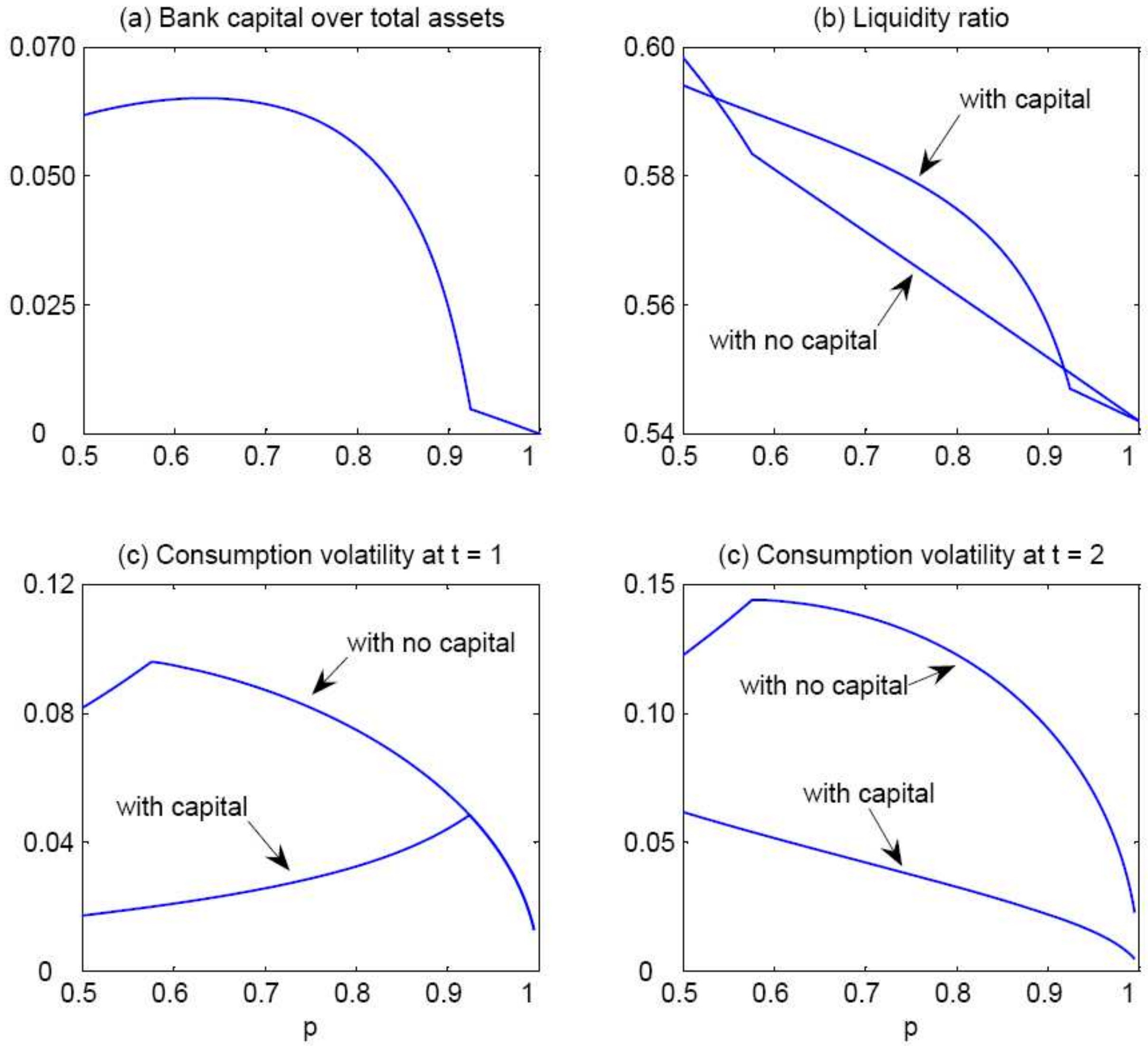
Figure 1 – Bank capital and payouts for different values of p



Note: This numerical example assumes constant relative risk aversion equal to 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 constant relative risk aversion equal to 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%
IabsTA1	2.38%	5.83%	0.03%	0.92%	8.71%
IabsTA2	5.63%	8.62%	0.18%	3.15%	18.71%
CapTA	10.80%	7.61%	6.54%	9.28%	17.81%
DepFEDTA	1.28%	3.62%	0.00%	0.19%	6.44%
RwaTA	72.37%	15.31%	45.94%	73.86%	92.95%
LiquTA	18.96%	13.00%	1.49%	16.81%	42.92%
LoansTA	66.62%	16.58%	34.63%	69.75%	87.06%
DepTA	59.86%	14.74%	35.66%	61.91%	78.60%
ROA	0.55%	1.47%	-0.64%	0.49%	1.63%
Size ($ million)	5′055	48′500	132	566	9′504
DT_TADepFromB1	1.27%	1.29%	0.35%	1.00%	3.14%
DT_TADueToB1	0.51%	0.51%	0.03%	0.37%	1.47%
DT_TADepFromB2	4.17%	3.33%	1.13%	3.18%	10.76%
DT_TADueToB2	6.71%	3.90%	2.57%	5.98%	13.06%
DT_TALiqAs	19.33%	6.66%	10.55%	18.25%	32.42%

Note: The sample consists of 66’674 observations from 2002Q1 till 2010Q4. Data is obtained from FFIEC repository database.

Table 5 – Interbank market activity and bank capital

	IabsTA1						IabsTA2					
	(1)			(2)			(3)			(4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
CapTA	-0.096	0.033	***	-0.096	0.033	***	-0.081	0.038	**	-0.082	0.038	**
DepFEDTA	-0.138	0.045	***	-0.139	0.045	***	-0.448	0.049	***	-0.449	0.049	***
RwaTA	0.001	0.013		0.000	0.013		-0.024	0.013	*	-0.024	0.013	*
LiquTA	-0.143	0.015	***	-0.144	0.016	***	-0.310	0.023	***	-0.310	0.023	***
LoansTA	-0.153	0.021	***	-0.153	0.022	***	-0.376	0.023	***	-0.377	0.023	***
DepTA	-0.060	0.008	***	-0.060	0.008	***	-0.107	0.012	***	-0.107	0.012	***
ROA	-0.072	0.043	*	-0.072	0.043	*	-0.082	0.052		-0.083	0.052	
Size	-0.009	0.002	***	-0.009	0.002	***	-0.015	0.003	***	-0.015	0.003	***
DT_TADepFromB1				0.017	0.018							
DT_TADueToB1				0.130	0.091							
DT_TADepFromB2										-0.019	0.013	
DT_TADueToB2										0.017	0.019	
DT_TALiqAs				-0.020	0.009	***				-0.031	0.013	**
Constant	0.318	0.041	***	0.324	0.041	***	0.649	0.051	***	0.658	0.052	***
N. of observations	66’674			66’674			66’674			66’674		
N. of clusters	3’325			3’325			3’325			3’325		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1627			overall = 0.1595			overall = 0.2708			overall = 0.2680		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. Interbank market activity is measured in IabsTA1 as the absolute value of the difference between the unsecured lending and borrowing positions of individual banks, normalized by total assets. IabsTA2 adds the Repo and Fed Fund positions to IabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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

	IabsTA1						IabsTA2					
	Pre-Crisis (1)			Crisis (2)			Pre-crisis (3)			Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
CapTA	-0.047	0.024	**	-0.190	0.062	***	-0.105	0.047	**	-0.155	0.049	***
DepFEDTA	-0.404	0.097	***	-0.243	0.065	***	-0.550	0.097	***	-0.485	0.056	***
RwaTA	0.001	0.017		-0.018	0.018		-0.029	0.016	*	-0.035	0.017	*
LiquTA	-0.133	0.020	***	-0.231	0.040	***	-0.356	0.031	***	-0.370	0.043	***
LoansTA	-0.147	0.035	***	-0.257	0.042	***	-0.430	0.034	***	-0.443	0.037	***
DepTA	-0.035	0.009	***	-0.124	0.017	***	-0.081	0.014	***	-0.193	0.019	***
ROA	-0.102	0.060	*	-0.089	0.053	*	-0.062	0.086		-0.107	0.058	*
Size	-0.006	0.003	*	-0.023	0.005	***	-0.013	0.005	***	-0.022	0.005	***
DT_TADepFromB1	0.015	0.014		0.021	0.043							
DT_TADueToB1	0.070	0.128		-0.042	0.112							
DT_TADepFromB2							-0.026	0.016		-0.011	0.024	
DT_TADueToB2							0.020	0.019		0.028	0.023	
DT_TALiqAs	0.006	0.010		-0.032	0.010	***	-0.052	0.020	***	-0.020	0.016	
Constant	0.255	0.059	***	0.669	0.093	***	0.686	0.078	***	0.893	0.087	***
N. of observations	3’7421			29’253			37’421			29’253		
N. of clusters	2’824			2’564			2’824			2’564		
Sample period	2002 Q1: 2007 Q3			2007 Q4: 2010 Q4			2002 Q1: 2007 Q3			2007 Q4: 2010 Q4		
Adjusted R-Squared	overall = 0.1319			overall = 0.1889			overall = 0.2654			overall = 0.2778		

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 – 2007Q3) and crisis period (2007Q4 – 2010Q4). Interbank market activity is measured in IabsTA1 as the absolute value of the difference between the unsecured lending and borrowing positions of individual banks, normalized by total assets. IabsTA2 adds the Repo and Fed Fund positions to IabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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: high vs. low activity banks

	IabsTA1						IabsTA2					
	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	
CapTA	-0.129	0.048	***	-0.019	0.004	***	-0.124	0.051	***	-0.048	0.029	*
DepFEDTA	-0.187	0.062	***	-0.018	0.005	***	-0.515	0.064	***	-0.190	0.020	***
RwaTA	0.005	0.021		-0.004	0.002		-0.020	0.021		-0.015	0.010	
LiquTA	-0.209	0.024	***	-0.023	0.003	***	-0.370	0.030	***	-0.139	0.018	***
LoansTA	-0.221	0.031	***	-0.018	0.004	***	-0.456	0.028	***	-0.151	0.018	***
DepTA	-0.099	0.014	***	-0.004	0.001	***	-0.172	0.019	***	-0.012	0.005	**
ROA	-0.085	0.057		0.004	0.012		-0.046	0.072		-0.041	0.028	
Size	-0.013	0.004	***	-0.002	0.001	***	-0.017	0.005	***	-0.006	0.003	**
DT_TADepFromB1	0.075	0.068		0.000	0.005							
DT_TADueToB1	0.199	0.165		0.038	0.035							
DT_TADepFromB2							-0.052	0.026	**	0.009	0.007	
DT_TADueToB2							0.045	0.036		-0.008	0.009	
DT_TALiqAs	-0.041	0.019	**	0.000	0.002		-0.046	0.028	*	-0.006	0.006	
Constant	0.470	0.069	***	0.062	0.009	***	0.812	0.082	***	0.255	0.037	***
N. of observations	33′571			33′103			32′996			33′678		
N. of clusters	1′817			1′508			1′761			1′564		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.2138			overall = 0.0081			overall = 0.3370			overall = 0.0190		

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 IabsTA1 as the absolute value of the difference between the unsecured lending and borrowing positions of individual banks, normalized by total assets. IabsTA2 adds the Repo and Fed Fund positions to IabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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

	IabsTA1						IabsTA2					
	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	
CapTA	-0.080	0.034	**	-0.831	0.201	***	-0.069	0.039	*	-0.768	0.175	***
DepFEDTA	-0.129	0.029	***	-0.040	0.085		-0.437	0.044	***	-0.117	0.088	
RwaTA	0.003	0.012		-0.043	0.051		-0.022	0.014		-0.032	0.049	
LiquTA	-0.138	0.015	***	-0.036	0.073		-0.307	0.024	***	-0.132	0.078	*
LoansTA	-0.149	0.022	***	-0.016	0.073		-0.375	0.024	***	-0.139	0.082	*
DepTA	-0.050	0.008	***	-0.416	0.065	***	-0.099	0.012	***	-0.385	0.063	***
ROA	-0.045	0.045		0.194	0.181		-0.048	0.057		-0.014	0.114	
Size	-0.008	0.002	***	-0.016	0.018		-0.014	0.003	***	0.003	0.017	
DT_TADepFromB1	0.007	0.015		0.718	0.536							
DT_TADueToB1	0.109	0.089		-0.245	0.783							
DT_TADepFromB2							-0.021	0.013		0.125	0.097	
DT_TADueToB2							0.017	0.019		-0.036	0.109	
DT_TALiqAs	-0.023	0.008	***	0.138	0.163		-0.032	0.013	**	-0.102	0.077	
Constant	0.291	0.039	***	0.564	0.233	**	0.639	0.053	***	0.484	0.240	**
N. of observations	65′039			1′635			65′039			1′635		
N. of clusters	3′308			531			3′308			531		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1631			overall = 0.3284			overall = 0.2647			overall = 0.2681		

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 IabsTA1 as the absolute value of the difference between the unsecured lending and borrowing positions of individual banks, normalized by total assets. IabsTA2 adds the Repo and Fed Fund positions to IabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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%
IRepoTA	2.38%	4.82%	0.00%	0.54%	9.51%
IFedFundTA	2.84%	5.46%	0.00%	1.14%	10.60%
I(Repo+Unsecured Lending)	3.90%	7.18%	0.07%	1.82%	13.59%
FedFAssTA	2.22%	4.91%	0.00%	0.40%	9.15%
FedFLiabTA	0.95%	3.65%	0.00%	0.00%	4.66%
DT_TADepFromRepo	2.30%	2.72%	0.47%	1.47%	7.35%
DT_TADueToRepo	4.23%	2.75%	1.11%	3.60%	8.89%
DT_TADepFromFed	3.09%	2.27%	0.84%	2.56%	6.91%
DT_TADueToFed	3.00%	3.26%	0.49%	2.24%	8.25%
DT_TADepFrom+Repo	2.30%	2.72%	0.47%	1.47%	7.35%
DT_TADueTo+Repo	4.23%	2.75%	1.11%	3.60%	8.89%
SIabsTA1	2.86%	6.31%	0.05%	1.18%	10.81%
SIabsTA2	8.57%	10.33%	0.62%	5.72%	26.22%

Note: The sample consists of 66’674 observations from 2002Q1 till 2010Q4. Data is obtained from FFIEC repository database.

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

	Repos (1)			Fed Funds (2)			Repos+Unsecured (3)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
CapTA	-0.081	0.025	***	0.018	0.034		-0.154	0.036	***
DepFEDTA	-0.129	0.029	***	-0.342	0.036	***	-0.360	0.048	***
RwaTA	0.025	0.014	*	-0.047	0.012	***	0.012	0.017	
LiquTA	-0.038	0.018	**	-0.215	0.019	***	-0.240	0.028	***
LoansTA	-0.131	0.032	***	-0.189	0.025	***	-0.335	0.035	***
DepTA	-0.041	0.007	***	-0.029	0.008	***	-0.102	0.010	***
ROA	0.014	0.021		0.008	0.041		-0.070	0.046	
Size	0.001	0.004		-0.007	0.003	**	-0.010	0.004	***
DT_TADepFromRepo	-0.014	0.013							
DT_TADueToRepo	0.064	0.027							
DT_TADepFromFed				0.010	0.014				
DT_TADueToFed				0.003	0.012				
DT_TADepFrom+Repo							-0.023	0.014	
DT_TADueTo+Repo							0.039	0.039	
DT_TALiqAs	-0.008	0.009		0.003	0.010		-0.029	0.011	**
Fed Fund Asset /TA							-0.330	0.034	***
Fed Fund Liab / TA							-0.173	0.037	***
Constant	0.110	0.059	*	0.337	0.047	***	0.520	0.066	***
N. of observations	66′674			66′674			66′674		
N. of clusters	3′325			3′325			3′325		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1151			overall = 0.1251			overall = 0.1915		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. In regression 1 we consider banks' activity in the markek for Repos with maturities longer than one day. In regression 2 we take banks' activity in the overnight market, including overnight Fed Funds and overnight Repos. In regression 3 we take banks' activity on the unsecured interbank market and on the market for Repos with maturities longer than one day. In any case, the activity is measured as the absolute value of the difference between the lending and borrowing positions. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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

	SIabsTA1						SIabsTA2					
	(1)			(2)			(3)			(4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
CapTA	-0.111	0.032	***	-0.112	0.032	***	-0.252	0.048	***	-0.253	0.048	**
DepFEDTA	-0.148	0.045	***	-0.148	0.045	***	-0.704	0.036	***	-0.704	0.036	***
RwaTA	-0.001	0.014		-0.002	0.013		-0.019	0.018		-0.019	0.018	
LiquTA	-0.159	0.016	***	-0.160	0.016	***	-0.466	0.029	***	-0.467	0.029	***
LoansTA	-0.163	0.021	***	-0.164	0.021	***	-0.536	0.026	***	-0.536	0.026	***
DepTA	-0.073	0.009	***	-0.073	0.009	***	-0.163	0.013	***	-0.163	0.013	***
ROA	-0.070	0.043	*	-0.070	0.043	*	-0.085	0.072		-0.087	0.072	
Size	-0.011	0.003	***	-0.011	0.003	***	-0.014	0.004	***	-0.014	0.004	***
DT_TADepFromB1				0.024	0.020							
DT_TADueToB1				0.127	0.096							
DT_TADepFromB2										-0.015	0.014	
DT_TADueToB2										0.029	0.021	
DT_TALiqAs				-0.023	0.009	**				-0.019	0.016	
Constant	0.366	0.043	***	0.373	0.044	***	0.857	0.061	***	0.862	0.061	***
N. of observations	66′674			66′674			66′674			66′674		
N. of clusters	3′325			3′325			3′325			3′325		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1639			overall = 0.1598			overall = 0.3111			overall = 0.3087		

Note: The estimates are based on a panel regression of the interbank market activity on bank capital. Interbank market activity is measured in SIabsTA1 as the sum between the unsecured lending and borrowing positions of individual banks, normalized by total assets. SIabsTA2 adds the Repo and Fed Fund positions to SIabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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%
IabsTA	12.134%	0.1554	0.007	0.0660	0.4598
CapTA	8.83%	0.0465	0.031	0.0786	0.1802
RwaTA	72.741%	0.5996	0.246	0.6239	1.2146
LiquTA	2.635%	0.0762	-0.010	0.0000	0.1713
LoansTA	66.012%	0.2147	0.139	0.7062	0.9066
DepTA	62.217%	0.2274	0.195	0.6608	0.8920
ROA	68.445%	1.4820	-0.610	0.5700	2.2300
Size ($ million)	53'462	268'169	8	969	219'036
DT_TADueFromB	11.214%	0.0484	0.0580	0.1078	0.1702
DT_TADueToB	16.123%	0.0607	0.0606	0.1817	0.2270
DT_TALiqAs	23.696%	0.1139	0.0994	0.2236	0.5149

Note: The sample includes banks from the EU, UK, and Japan from 2005 till 2009. Data is obtained from Bankscope Database.

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

	(1)			(2)		
	Coeff.	Robust SE		Coeff.	Robust SE	
CapTA	-0.449	0.219	**	-0.449	0.219	**
RwaTA	0.001	0.002		0.001	0.002	
LiquTA	-0.264	0.110	**	-0.264	0.110	**
LoansTA	-0.219	0.100	**	-0.219	0.100	**
DepTA	0.110	0.089		0.110	0.089	
ROA	0.001	0.003		0.001	0.003	
Size	-0.020	0.025		-0.020	0.025	
DT_TADueFromB				0.216	0.085	**
DT_TADueToB				0.101	0.053	*
DT_TALiqAs				-0.042	0.027	
Constant	0.362	0.207	*	0.362	0.207	*
N. of observations	2'741			2'741		
N. of clusters	863			863		
Sample period	2005:2009			2005:2009		
Adjusted R-Squared	0.054			0.055		

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 lending and borrowing positions of individual banks, normalized by total assets. Definitions of other variables are given in Table B1 in Appendix B. The sample includes yearly data for banks from the EU, UK, and Japan from 2005 till 2009. All regressions include bank fixed effects as well as time dummies. For both model specifications we list regresion 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: US quarterly data from FFIEC

Variable	Description
IabsTA1	Interbank market activity measured as the absolute value of the difference between unsecured lending (Deposits from Banks) and borrowing (Deposits due to Banks) positions of individual banks, normalized by total assets.
IabsTA2	Interbank market activity measured as the absolute value of the difference between unsecured lending position + REPO Assets (Securities purchased under agreements to resell) + Fed Funds Assets (Fed Funds sold), and the unsecured borrowing position + REPO Liabilities (Securities sold under agreements to repurchase) + Fed Funds Liability (Fed Funds purchased), normalized by total assets.
CapTA	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.
DepFEDTA	Balances due from Federal Reserve Banks, normalized by total assets.
RwaTA	Risk weighted assets measured as (total assets, derivatives and off-balance sheet items multiplied for each risk-weight factors) + market risk equivalent assets – allocated transfer risk reserve and excess allowance for loan and lease losses, normalized by total assets.
LiquTA	Liquidity measured as available-for-sale securities, cash items in process of collection, unposted debits, and currency and coin, normalized by total assets.
LoansTA	Loans measured as the sum of loans for sales and loans and leases for investment (net of unearned income) normalized by total assets.
DepTA	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 (which includes 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 asset (US$ thousand).
DT_TADepFromB1	Total amount of unsecured lending position by the other banks per quarter and State, normalized by total assets.
DT_TADueToB1	Total amount of unsecured borrowing position by the other banks per quarter and State, normalized by total assets.
DT_TADepFromB2	Total amount of interbank lending position (unsecured+REPO+FED FUNDS) by the other banks per quarter and State, normalized by total assets.
DT_TADueToB2	Total amount of interbank borrowing position (unsecured+REPO+FED FUNDS) by the other banks per quarter and State, normalized by total assets.
DT_TALiqAs	Total amount of liquid assets hold by the other banks per quarter and State, normalized by total assets.
IRepoTA	Interbank market activity measured as the absolute value of the difference between Securities purchased under agreements to resell (REPO Assets) and Securities sold under agreements to repurchase (REPO Liabilities) positions, normalized by total assets.
IFedFundTA	Interbank market activity measured as the absolute value of the difference between Fed Funds sold (FedFAss) and Fed Funds purchased (FedFLiab) positions, normalized by total assets.

Table B1 – Variable Description (Cont.)

Variable	Description
I(Repo+Unsecured Lending)	Interbank market activity measured as the absolute value of the difference between unsecured lending (Deposit From Banks) + Securities purchased under agreements to resell (REPO Assets) and unsecured borrowing (Due To Banks)+ Securities sold under agreements to repurchase (REPO Liabilities) positions over total assets.
FedFAssTA	Fed Funds sold normalized by total assets.
FedFLiabTA	Fed Funds purchased normalized by total assets.
DT_TADepFromRepo	Total amount of lending position in the REPO market by the other banks per quarter and State, normalized by total assets.
DT_TADueToRepo	Total amount of borrowing position in the REPO market by the other banks per quarter and State, normalized by total assets.
DT_TADepFromFed	Total amount of lending position in the FED FUNDS market by the other banks per quarter and State, normalized by total assets.
DT_TADueToFed	Total amount of borrowing position in the FED FUNDS market by the other banks per quarter and State over total assets.
DT_TADepFrom+Repo	Total amount of interbank lending (unsecured+REPO) by the other banks per quarter and State, normalized by total assets.
DT_TADueTo+Repo	Total amount of interbank borrowing (unsecured+REPO) by the other banks per quarter and State, normalized by total assets.
SIabsTA1	Interbank market activity measured as the sum between unsecured lending and borrowing positions, normalized by total assets.
SIabsTA2	Interbank market activity measured as the sum between unsecured+REPO+FED FUNDS positions normalized by total assets.

PANEL B: EU, UK, and Japanese yearly data from Bankscope

Variable	Description
IabsTA	Interbank market activity measured as the absolute value of the difference between the lending and borrowing positions (unsecured+REPO) of individual banks, normalized by total assets.
CapTA	Capital measured as the sum of equity, preferred shares, hybrid capital accounted for as equity and retained earnings, normalized by total assets.
RwaTA	Risk weighted assets measured as tier 1 capital divided by tier 1 capital ratio, normalized by total assets.
LiquTA	Liquidity measured as trading securities, normalized by total assets.
LoansTA	The sum of customer, mortgages and retail, corporate and commercial, and government loans over total assets.
DepTA	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 asset (US$ millions).
DT_TADueFromB	Total amount of lending position in the interbank market by the other banks in the same country per year over total assets.
DT_TADueToB	Total amount of borrowing position in the interbank market by the other banks in the same country per year over total assets.
DT_TALiqAs	Total liquid assets hold by the other banks in the same country per year over total assets.

Table B2 – Correlation matrix for Table 5

	IabsTA1	IabsTA2	CapTA	DepFEDTA	RwaTA	LiquTA	LoansTA	DepTA	ROA	Size	DT_TA DepFromB1	DT_TA DueToB1	DT_TA DepFromB2	DT_TA DueToB2	DT_TALiqAs
IabsTA1	1.000														
IabsTA2	0.624	1.000													
CapTA	0.325	0.330	1.000												
DepFEDTA	0.046	-0.008	0.004	1.000											
RwaTA	-0.127	-0.259	-0.145	-0.120	1.000										
LiquTA	-0.145	-0.050	-0.062	-0.089	-0.482	1.000									
LoansTA	-0.190	-0.351	-0.297	-0.124	0.714	-0.624	1.000								
DepTA	-0.273	-0.377	-0.425	-0.055	0.153	-0.058	0.278	1.000							
ROA	0.045	0.046	0.261	-0.116	0.015	0.046	-0.116	-0.187	1.000						
Size	-0.025	-0.004	-0.009	0.009	0.015	-0.010	-0.065	-0.108	0.001	1.000					
DT_TADepFromB1	-0.003	0.014	0.000	0.002	-0.064	0.055	-0.067	-0.015	0.013	-0.015	1.000				
DT_TADueToB1	0.050	0.036	-0.018	0.085	0.055	-0.061	0.027	0.062	-0.076	-0.010	-0.038	1.000			
DT_TADepFromB2	-0.023	0.019	0.014	-0.072	-0.076	0.087	-0.096	-0.050	0.053	0.008	0.530	-0.123	1.000		
DT_TADueToB2	-0.005	0.057	-0.009	-0.086	-0.001	0.023	0.002	-0.072	0.027	0.009	0.216	-0.052	0.205	1.000	
DT_TALiqAs	-0.080	-0.057	-0.066	-0.038	-0.194	0.162	-0.131	0.042	0.010	-0.034	0.111	-0.196	0.071	0.038	1.000

Table B3 – Correlation Matrices for Tables 10 and 11

PANEL A: Repos	IRepoTA	CapTA	DepFEDTA	RwaTA	LiquTA	LoansTA	DepTA	ROA	Size	DT_TADepFromRepo	DT_TADueToRepo	DT_TALiqAs
IRepoTA	1.000											
CapTA	-0.025	1.000										
DepFEDTA	-0.042	0.004	1.000									
RwaTA	-0.191	-0.145	-0.120	1.000								
LiquTA	0.193	-0.062	-0.089	-0.482	1.000							
LoansTA	-0.257	-0.297	-0.124	0.714	-0.624	1.000						
DepTA	-0.188	-0.425	-0.055	0.153	-0.058	0.278	1.000					
ROA	0.015	0.261	-0.116	0.015	0.046	-0.116	-0.187	1.000				
Size	0.199	-0.100	0.027	0.109	-0.005	-0.015	-0.043	0.017	1.000			
DT_TADepFromRepo	0.040	0.020	-0.009	-0.075	0.062	-0.084	-0.047	0.023	0.080	1.000		
DT_TADueToRepo	0.188	-0.073	-0.062	-0.090	0.065	-0.043	-0.048	-0.014	0.038	0.347	1.000	
DT_TALiqAs	0.017	-0.066	-0.038	-0.194	0.162	-0.131	0.042	0.010	0.003	0.023	0.318	1.000

PANEL B: Fed Funds	IFedFundTA	CapTA	DepFEDTA	RwaTA	LiquTA	LoansTA	DepTA	ROA	Size	DT_TA DepFromFed	DT_TA DueToFed	DT_TA LiqAs
IFedFundTA	1.000											
CapTA	0.175	1.000										
DepFEDTA	-0.066	0.004	1.000									
RwaTA	-0.131	-0.145	-0.120	1.000								
LiquTA	-0.075	-0.062	-0.089	-0.482	1.000							
LoansTA	-0.193	-0.297	-0.124	0.714	-0.624	1.000						
DepTA	-0.209	-0.425	-0.055	0.153	-0.058	0.278	1.000					
ROA	0.017	0.261	-0.116	0.015	0.046	-0.116	-0.187	1.000				
Size	-0.022	-0.100	0.027	0.109	-0.005	-0.015	-0.043	0.017	1.000			
DT_TADepFromFed	0.049	0.000	-0.090	-0.056	0.081	-0.073	-0.029	0.057	0.023	1.000		
DT_TADueToFed	0.037	0.048	-0.038	0.084	-0.037	0.042	-0.035	0.033	0.005	-0.008	1.000	
DT_TALiqAs	-0.038	-0.066	-0.038	-0.194	0.162	-0.131	0.042	0.010	0.003	0.148	-0.253	1.000

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

PANEL C: Repos+Unsecured	IabsREPO	CapTA	FedF AssTA	FedFLiabTA	Dep FEDTA	RwaTA	LiquTA	LoansTA	DepTA	ROA	Size	DT_TADepFrom+Repo	DT_TADueTo+Repo	DT_TALiqAs
IabsREPO	1.000													
CapTA	0.265	1.000												
FedFAssTA	0.036	0.183	1.000											
FedFLiabTA	0.011	0.008	0.033	1.000										
DepFEDTA	0.018	0.004	-0.064	0.000	1.000									
RwaTA	-0.214	-0.145	-0.173	0.040	-0.120	1.000								
LiquTA	-0.006	-0.062	-0.067	-0.037	-0.089	-0.482	1.000							
LoansTA	-0.305	-0.297	-0.256	0.022	-0.124	0.714	-0.624	1.000						
DepTA	-0.340	-0.425	-0.095	-0.304	-0.055	0.153	-0.058	0.278	1.000					
ROA	0.046	0.261	0.001	0.037	-0.116	0.015	0.046	-0.116	-0.187	1.000				
Size	0.003	-0.100	-0.108	0.171	0.027	0.109	-0.005	-0.015	-0.043	0.017	1.000			
DT_TADepFrom+Repo	0.023	0.020	0.012	-0.006	-0.009	-0.075	0.062	-0.084	-0.047	0.023	0.080	1.000		
DT_TADueTo+Repo	0.087	-0.073	-0.019	-0.024	-0.062	-0.090	0.065	-0.043	-0.048	-0.014	0.038	0.347	1.000	
DT_TALiqAs	-0.051	-0.066	-0.014	-0.047	-0.038	-0.194	0.162	-0.131	0.042	0.010	0.003	0.023	0.318	1.000

PANEL D: Sum	SIabsTA1	SIabsTA2	CapTA	DepFEDTA	RwaTA	LiquTA	LoansTA	DepTA	ROA	Size	DT_TADepFromB1	DT_TADueToB1	DT_TADepFromB2	DT_TADueToB2	DT_TALiqAs
SIabsTA1	1.000														
SIabsTA2	0.613	1.000													
CapTA	0.300	0.263	1.000												
DepFEDTA	0.052	-0.020	0.004	1.000											
RwaTA	-0.100	-0.224	-0.145	-0.120	1.000										
LiquTA	-0.165	-0.061	-0.062	-0.089	-0.482	1.000									
LoansTA	-0.159	-0.354	-0.297	-0.124	0.714	-0.624	1.000								
DepTA	-0.273	-0.426	-0.425	-0.055	0.153	-0.058	0.278	1.000							
ROA	0.027	0.041	0.261	-0.116	0.015	0.046	-0.116	-0.187	1.000						
Size	-0.025	0.047	-0.009	0.009	0.015	-0.010	-0.065	-0.108	0.001	1.000					
DT_TADepFromB1	-0.007	0.017	0.000	0.002	-0.064	0.055	-0.067	-0.015	0.013	-0.015	1.000				
DT_TADueToB1	0.065	0.040	-0.018	0.085	0.055	-0.061	0.027	0.062	-0.076	-0.010	-0.038	1.000			
DT_TADepFromB2	-0.030	0.023	0.014	-0.072	-0.076	0.087	-0.096	-0.050	0.053	0.008	0.530	-0.123	1.000		
DT_TADueToB2	-0.007	0.067	-0.009	-0.086	-0.001	0.023	0.002	-0.072	0.027	0.009	0.216	-0.052	0.205	1.000	
DT_TALiqAs	-0.095	-0.065	-0.066	-0.038	-0.194	0.162	-0.131	0.042	0.010	-0.034	0.111	-0.196	0.071	0.038	1.000

Table B4 – Correlation matrix for the Banscope data

	IabsTA	CapTA	RwaTA	LiquTA	LoansTA	DepTA	ROAA	Size	DT_TADepFromB	DT_TADueToB	DT_TALiqAs
IabsTA	1.000										
CapTA	-0.020	1.000									
RwaTA	-0.069	0.214	1.000								
LiquTA	0.036	-0.164	-0.159	1.000							
LoansTA	-0.186	0.069	0.309	-0.485	1.000						
DepTA	-0.061	0.155	0.230	-0.218	0.540	1.000					
ROA	0.049	0.280	0.058	-0.032	-0.042	-0.094	1.000				
Size	-0.093	-0.223	-0.131	0.263	-0.214	-0.161	-0.063	1.000			
DT_TADepFromB	0.230	-0.072	-0.121	0.202	-0.265	-0.337	0.095	0.039	1.000		
DT_TADueToB	0.182	0.048	-0.069	0.144	-0.153	-0.076	-0.007	-0.017	0.580	1.000	
DT_TALiqAs	0.152	-0.140	-0.196	0.269	-0.366	-0.298	0.082	0.209	0.664	0.374	1.000

FURTHER ROBUSTNESS CHECKS

NOT FOR PUBLICATION

(AVAILABLE UPON REQUEST)

Table E1– Interbank market activity and bank capital: very high vs. very low activity banks

	IabsTA1						IabsTA2					
	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	
CapTA	-0.240	0.067	***	-0.004	0.002	*	-0.155	0.068	**	-0.040	0.015	***
DepFEDTA	-0.282	0.083	***	-0.002	0.003		-0.555	0.080	***	-0.143	0.024	***
RwaTA	-0.013	0.023		-0.001	0.001		-0.010	0.030		-0.006	0.006	
LiquTA	-0.292	0.036	***	-0.007	0.002	***	-0.409	0.041	***	-0.101	0.019	***
LoansTA	-0.310	0.042	***	-0.006	0.002	***	-0.524	0.034	***	-0.108	0.021	***
DepTA	-0.169	0.023	***	-0.002	0.001	*	-0.236	0.030	***	0.004	0.004	
ROA	-0.103	0.073		-0.012	0.007	*	-0.040	0.099		-0.031	0.020	
Size	-0.025	0.007	***	-0.001	0.000		-0.020	0.009	**	-0.002	0.002	
DT_TADepFromB1	0.231	0.146		0.001	0.002							
DT_TADueToB1	0.258	0.294		0.043	0.021	**						
DT_TADepFromB2							-0.082	0.050		-0.004	0.005	
DT_TADueToB2							0.072	0.065		-0.011	0.010	
DT_TALiqAs	-0.085	0.039	**	-0.002	0.002	**	-0.083	0.049	*	0.004	0.006	
Constant	0.813	0.106	***	0.020	0.006	***	0.986	0.143	***	0.148	0.029	***
N. of observations	16671			16678			16660			16680		
N. of clusters	995			767			990			800		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.2447			overall = 0.0002			overall = 0.3963			overall = 0.0105		

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 IabsTA1 as the absolute value of the difference between the unsecured lending and borrowing positions of individual banks, normalized by total assets. IabsTA2 adds the Repo and Fed Fund positions to IabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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: crisis vs. pre-crisis period (Sum)

	SIabsTA1						SIabsTA2					
	Pre-Crisis (1)			Crisis (2)			Pre-crisis (3)			Crisis (4)		
	Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE		Coeff.	Robust SE	
CapTA	-0.047	0.020	**	-0.201	0.032	***	-0.246	0.048	***	-0.306	0.054	***
DepFEDTA	-0.313	0.053	***	-0.168	0.022	***	-0.870	0.142	***	-0.737	0.038	***
RwaTA	0.002	0.012		-0.031	0.011	***	-0.054	0.020	***	-0.039	0.021	*
LiquTA	-0.123	0.014	***	-0.188	0.019	***	-0.516	0.033	***	-0.549	0.041	***
LoansTA	-0.122	0.019	***	-0.181	0.018	***	-0.587	0.031	***	-0.634	0.039	***
DepTA	-0.031	0.007	***	-0.113	0.012	***	-0.129	0.015	***	-0.242	0.020	***
ROA	-0.054	0.050		-0.079	0.042	**	-0.075	0.085		-0.105	0.074	*
Size	-0.005	0.003	***	-0.023	0.003	***	-0.006	0.005		-0.030	0.006	***
DT_TADepFromB1	0.007	0.013		0.040	0.037							
DT_TADueToB1	0.015	0.096		0.021	0.096							
DT_TADepFromB2							-0.018	0.016		-0.002	0.023	
DT_TADueToB2							0.025	0.018		0.030	0.025	
DT_TALiqAs	-0.001	0.009		-0.020	0.010	**	-0.029	0.023		0.002	0.015	
Constant	0.219	0.042	***	0.616	0.052	***	0.819	0.085	***	1.239	0.094	***
N. of obs	37’003			29’009			37’421			29’253		
N. of clusters	2’806			2’550			2’824			2’564		
Sample period	2002 Q1: 2007 Q3			2007 Q4: 2010 Q4			2002 Q1: 2007 Q3			2007 Q4: 2010 Q4		
Adjusted R-Squared	overall = 0.1661			overall = 0.1278			overall = 0.3175			overall = 0.2832		

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 – 2007Q3) and crisis period (2007Q4 – 2010Q4). Interbank market activity is measured in SIabsTA1 as the sum between the unsecured lending and borrowing positions of individual banks, normalized by total assets. SIabsTA2 adds the Repo and Fed Fund positions to SIabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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 activity vs. low activity banks (Sum)

	SIabsTA1						SIabsTA2					
	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	
CapTA	-0.168	0.046	***	-0.022	0.004	***	-0.324	0.068	***	-0.117	0.023	***
DepFEDTA	-0.207	0.064	***	-0.019	0.006	***	-0.777	0.049	***	-0.391	0.026	***
RwaTA	-0.021	0.017		0.003	0.004	*	-0.013	0.029		-0.025	0.011	**
LiquTA	-0.231	0.026	***	-0.029	0.003	***	-0.526	0.039	***	-0.255	0.025	***
LoansTA	-0.230	0.031	***	-0.025	0.004	***	-0.618	0.032	***	-0.264	0.024	***
DepTA	-0.124	0.015	***	-0.004	0.002	***	-0.254	0.021	***	-0.031	0.006	***
ROA	-0.075	0.061		-0.005	0.013		-0.036	0.111		-0.088	0.036	**
Size	-0.020	0.004	***	-0.001	0.001	***	-0.018	0.006	***	-0.006	0.003	**
DT_TADepFromB1	0.089	0.077		0.001	0.005							
DT_TADueToB1	0.188	0.173		0.028	0.036							
DT_TADepFromB2							-0.024	0.026		0.009	0.008	
DT_TADueToB2							0.067	0.038	*	-0.009	0.011	
DT_TALiqAs	-0.043	0.022	**	0.001	0.003		-0.023	0.033		-0.006	0.008	
Constant	0.616	0.068	***	0.052	0.011	***	1.060	0.101	***	0.410	0.045	***
N. of obs	33’042			32’970			33’340			33’334		
N. of clusters	1’802			1’506			1’749			1’576		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.1235			overall = 0.0116			overall = 0.3956			overall = 0.0369		

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 SIabsTA1 as the sum between the unsecured lending and borrowing positions of individual banks, normalized by total assets. SIabsTA2 adds the Repo and Fed Fund positions to SIabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion 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 (Sum)

	SIabsTA1						SIabsTA2					
	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	
CapTA	-0.271	0.067	***	-0.006	0.003	**	-0.358	0.090	***	-0.078	0.021	***
DepFEDTA	-0.302	0.082	***	-0.003	0.004		-0.797	0.064	***	-0.288	0.032	***
RwaTA	-0.012	0.021		0.000	0.002		0.010	0.041		-0.028	0.014	**
LiquTA	-0.336	0.040	***	-0.008	0.002	***	-0.598	0.046	***	-0.186	0.030	***
LoansTA	-0.335	0.041	***	-0.006	0.002	***	-0.699	0.041	***	-0.192	0.031	***
DepTA	-0.204	0.024	***	-0.003	0.001	***	-0.327	0.032	***	-0.002	0.006	
ROA	-0.101	0.074		-0.015	0.008	**	-0.058	0.141		-0.089	0.028	***
Size	-0.031	0.007	***	-0.001	0.000		-0.014	0.011		-0.003	0.003	
DT_TADepFromB1	0.239	0.150		0.004	0.003							
DT_TADueToB1	0.331	0.297		0.046	0.025	*						
DT_TADepFromB2							-0.054	0.042		0.012	0.009	
DT_TADueToB2							0.120	0.066	*	-0.001	0.012	
DT_TALiqAs	-0.082	0.042	**	-0.002	0.002		0.002	0.057		0.009	0.007	
Constant	0.954	0.109	***	0.023	0.007	***	1.135	0.169	***	0.268	0.046	***
N. of obs	16’664			16’709			16’651			16’693		
N. of clusters	999			765			950			801		
Sample period	2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4			2002 Q1: 2010 Q4		
Adjusted R-Squared	overall = 0.2450			overall = 0.0017			overall = 0.4729			overall = 0.0266		

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 SIabsTA1 as the sum between the unsecured lending and borrowing positions of individual banks, normalized by total assets. SIabsTA2 adds the Repo and Fed Fund positions to SIabsTA1. Definitions of other variables are given in Table B1 in Appendix B. All regressions include bank fixed effects as well as time dummies. For each model specification we list regresion coefficients, robust standard errors (clustered at the bank level), and significance levels. ***, **, and * respectively denote a significance level of 1%, 5%, and 10%.